

Multicriteria Multistakeholder Decision Analysis:  
Applications to Transportation Planning

by

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## ABSTRACT

Due to their magnitude and longevity, transportation investments can determine the long term success or failure of a transportation system. Thus, it is vital for decision-makers to have deep understanding of the alternatives available before they chose to invest. In this thesis, we examine the current state of the practice for transportation investment decisions. We draw upon the literature and this existing state of the practice to develop a new decision aid which we believe is an improvement over existing aids. We then apply this new decision aid to a transportation investment decision facing the East Japan Railway Company (JR East) and draw conclusions about the usefulness of our new tool.

Our decision aid, the CLIOSjre Process, is designed to help decision-makers compare multiple alternatives and make an informed transportation investment decision. The process examines the decision from multiple perspectives where each of these perspectives represents one of the priorities of the decision-maker. By considering each priority separately, the CLIOSjre Process provides a detailed understanding of each alternative. The CLIOSjre Process also combines these individual evaluations into a single overall evaluation of each alternative. This overall evaluation provides the decision-maker with an actionable ranking of the alternatives. In combination, these perspective-specific and overall evaluations of each alternative provide a detailed and holistic understanding of the decision facing the decision-maker.

Unlike many other decision aids, the CLIOSjre Process accounts for both the multistakeholder nature of transportation investments and the uncertainty inherent to these decisions. The multifaceted nature of the CLIOSjre Process examines each alternative from multiple perspectives. This approach better facilitates negotiation between stakeholders. In addition, the CLIOSjre Process formally identifies and addresses uncertainty in the analysis – the primary source of risk in transportation investment decisions. Thus, the CLIOSjre Process is a unique multicriteria, multistakeholder decision aid which addresses uncertainty.

We hope that this thesis provides the reader with a better understanding of the application, challenges, and opportunities of multicriteria multistakeholder decision aids.

Thesis Supervisor: Joseph Sussman  
JR East Professor of Civil and Environmental Engineering and Engineering Systems

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# 1 Introduction

In both the public and private sector, investment decisions often determine the long term success or failure of an organization. This duality of success and failure is especially true for transportation providers. Transportation providers which invest wisely in infrastructure (e.g. the East Japan Railway Company, Transport for London, and the Mass Transit Railway Corp. of Hong Kong) experience increasing ridership, increasing revenue, and a continually improving level of service for their customers. Organizations which do not invest wisely or are unable to make the necessary investments (e.g. the Washington Metropolitan Area Transit Authority, the National Railroad Passenger Corporation, and the Massachusetts Bay Transportation Authority) experience declining ridership, declining revenue, and declining level of service in the long term.

In light of the importance of these investment decisions, it is vital for decision-makers to have deep understanding of the alternatives available before they chose to invest. Often, decision-makers use decision aids to help them develop this deep understanding of the decision. In this thesis, we examine the current state of the practice for transportation investment decisions. We draw upon the literature and this existing state of the practice to develop a new decision aid which we believe is an improvement over existing aids. We then apply this new decision aid to understand the investment choices for the East Japan Railway Company (JR East) in the Northeast Corridor of the United States, and we use this case study to draw conclusions about the usefulness of our new decision aid.

In the following section, we provide a brief introduction to our decision aid: the CLIOSjre Process.

## 1.1 The CLIOSjre Process

Our decision aid, the CLIOSjre Process, is designed to help decision-makers compare multiple alternatives and make an informed transportation investment decision. The process examines the decision from multiple perspectives – referred to as CLIOSjre metrics – where each of these perspectives represents a single priority of the decision-maker. By considering each priority separately, the CLIOSjre Process provides a detailed understanding of each alternative. The CLIOSjre Process also uses a linear weighting scheme to combine the CLIOSjre metric evaluations into a single overall grade for each alternative (see Step 4 of the CLIOSjre Process described in Section 5.5). This overall grade for each alternative provides the decision-maker with an actionable ranking of the alternatives. Thus, the CLIOSjre Process provides a detailed and holistic understanding of the decision facing the decision-maker.

Transportation investment decisions often involve multiple stakeholders, and the CLIOS Process accounts for this as well. The multiple metrics of the CLIOSjre Process help the decision-

maker(s) consider the priorities of other stakeholders who have some authority in the investment decision. By presenting the analysis of the alternatives from multiple perspectives, the CLIOSjre Process facilitates negotiation among stakeholders in an investment decision; even if these stakeholders have competing objectives for a transportation investment, the transparency of CLIOSjre Process is designed to help the stakeholders understand other perspectives and find common ground.

In addition to addressing the concerns of multiple stakeholders, the CLIOSjre Process formally identifies and addresses uncertainty in the analysis. Uncertainty in long-term transportation investments is a significant source of risk. Thus, by working to understand this uncertainty, the CLIOSjre Process enables stakeholders to put their trust in the outcomes of the analysis. More information on the CLIOSjre Process is available in Chapter 5 where the process is described in detail.

---

In the remaining sections of this introduction, we provide context for our research (including a brief description of the CLIOS Process) to motivate our development of a new decision aid.

## 1.2 Context of Transportation Investment Decisions

Because of their scale and complexity, infrastructure investments involve many highly technical details, many competing objectives, and many stakeholders with different requirements for the investment. In this thesis, we say that these projects exist as part of a complex, large-scale, interconnected, open, sociotechnical (CLIOS) system. We explain each element of this acronym below:<sup>1</sup>

### **Complex**

In complex systems, the many components of the system interact in nonlinear and stochastic ways. These interactions are difficult and sometimes impossible to understand and predict. The difficulty in predicting the development the system is precisely what makes it difficult to evaluate for an investment decision.

### **Large-Scale**

Large-scale systems have impacts which affect millions of people and entire regions of a particular nation or of the World. In addition, because these systems are so large, any change in the system usually outlives the change itself – the effects of a particular decision can reverberate throughout multiple decades, centuries, and occasionally millennia. The scope of these impacts mean that every investment decision has significant implications for the development of the region.

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<sup>1</sup> These descriptions are adapted from Sussman et al., 2009.

## **Interconnected**

Interconnected systems operate in the context of other CLIOS systems, and these CLIOS systems interact with one another. Even if it were possible to understand one of these CLIOS systems, this interconnection with other systems of comparable size and complexity makes it virtually impossible to anticipate the progression of a particular system.

## **Open**

Open systems explicitly include social, political, and economic aspects that lie beyond the typical technical or engineered boundaries of a system. These open systems involve negotiation between multiple stakeholders with competing values and requirements. These social, political, and economic aspects complicate the evaluation of any investment decision.

## **Sociotechnical**

Sociotechnical systems have very tight links between the social and technical aspects of the system. Thus, in order to understand the system, the social and technical aspects of the system must be evaluated jointly.

## 1.3 The CLIOS Process<sup>2</sup>

The CLIOSjre Process was developed as part of a larger research project for the East Japan Railway. This larger market analysis process – the JR East Market Selection Process – consists of a back-to-back CLIOS Process and CLIOSjre Process analysis. The value of the CLIOS Process is that it gives the decision-maker a deep knowledge of the CLIOS system context of the investment decision.

The CLIOS Process consists of three stages:

1. **The Representation Stage** wherein the CLIOS Process examines the CLIOS System structure and behavior. This stage provides an understanding of both the physical elements of the system and the institutional stakeholders involved in the system.
2. **The Design, Evaluation and Selection Stage** wherein the CLIOS Process identifies viable development paths for the CLIOS system (referred to as CLIOS bundles).
3. **The Implementation Stage** where the CLIOS Process predicts the how these development paths may be practically implemented and estimates the long-term effects of these changes to the CLIOS system.

In our CLIOSjre analysis of the Northeast Corridor of the United States (detailed in Chapter 6), we use inputs from the CLIOS Process to inform our CLIOSjre Process analysis. In combination, the CLIOS and CLIOSjre Processes provide a deep understanding of both the system and the decision facing the decision maker. With complexity and uncertainty an inherent part of CLIOS

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2 This description adapted from Sussman et al., 2009.

systems, it is exceptionally important to perform this careful analysis of each investment decision.

## 1.4 Organization of this Thesis

We have divided this thesis into seven chapters. Each chapter (including this introduction) provides a key piece of the puzzle for understanding our decision aid (the CLIOSjre Process) and its application. A brief description of the remaining six chapters is below:

**Chapter 2** reviews the existing research in this field. In particular, we examine the history of perspective-specific evaluation tools, multicriteria evaluation tools, and multistakeholder negotiation. In addition, we discuss the issue of uncertainty in evaluation. We identify four objectives which will guide our development of a decision aid, and we identify seven principles which will help us develop a robust tool that is useful in real-world transportation planning.

**Chapter 3** compares the existing research identified in Chapter 2 with the current transportation planning process at the federal, state, and local level in the United States. In particular, we discuss new planning processes in the Federal Transit Administration (FTA), the Virginia Department of Transportation (VDOT), and a small metropolitan planning organization (MPO) in Virginia. We examine where these planning processes succeed and where they fail, and we draw four lessons from these real planning processes that are applicable to our development of a decision aid.

**Chapter 4** develops a preliminary multicriteria, multistakeholder decision aid which addresses uncertainty. This decision aid is theoretically satisfying, but it proves to be difficult to implement in practice. We identify the problems with this decision aid, and we use these problems to motivate the development of the CLIOSjre Process in Chapter 5.

**Chapter 5** develops the CLIOSjre Process – a second multicriteria, multistakeholder decision aid which addresses uncertainty. Unlike the decision aid developed in Chapter 4, the CLIOSjre Process satisfies the four objectives and seven principles identified in Chapter 2. Further, this decision aid leverages the four practical lessons from Chapter 3 to improve its usability in real planning processes. We describe the CLIOSjre Process in detail and prepare the reader for the application of the process in Chapter 6.

**Chapter 6** is a case study of the application of the CLIOSjre Process to a transportation planning problem of interest. This application was sponsored by the East Japan Railway Company, and we apply the CLIOSjre Process to understand the company's investment alternatives in the Northeast Corridor of the United States. Through this application, we test the utility of the CLIOSjre Process and learn about the limitations of the process.

**Chapter 7** briefly summarizes the work of this thesis. As part of this summary, we identify the successes and limitations of the CLIOSjre Process. Building from these limitations, we identify

areas of future research and hypothesize about the future of transportation planning in both the public and the private sector.

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We hope that this thesis provides the reader with a better understanding of the application, challenges, and opportunities of multicriteria multistakeholder decision aids. We begin with a further introduction to the subject in Chapter 2.

## 2 Review of Existing Research in Alternatives Analysis

As discussed in Chapter 1, this thesis seeks to develop a more transparent and robust method for choosing among alternatives in transportation. In particular, we are interested in the potential of new data and new analysis approaches to produce more useful results. Our expectation is that better results will allow more objective decision-making for infrastructure investments in both the public and the private sector. In later chapters of this thesis, we examine the current state of the practice for transportation alternatives analysis. In this chapter, we examine the theoretical foundation of alternatives analysis. In addition, we identify the implications of past research on our methodological development.

To differentiate between the literature and the implications for our research, the implications are separated from the normal text in boxes like this one.

The theoretical foundation of our alternatives analysis draws from four distinct fields:

- Perspective-specific analysis
- Multicriteria decision analysis
- Multistakeholder negotiation
- Uncertainty in Analysis

In this chapter, we examine each of these research fields separately. In the sections below, we provide a brief introduction to each field and review the current literature.

**Terminology Note:** In this chapter, we use terminology which matches the available literature. This terminology is largely the same as in the other chapters: the *decision maker* is using a *decision aid* to compare *alternatives*. However, in this chapter, we use the literature term *criteria* in place of the term *metric*. These two terms (criteria and metric) refer to the same component of the decision aid.

### 2.1 Perspective-Specific Analysis

Perspective-specific analysis – often described by a name which is specific to a particular area of interest (e.g. Financial Analysis) – is a mature field of research with an innumerable number of tools, processes, and frameworks for analysis of a decision. These tools range from very qualitative (e.g. Porter Five Forces Analysis) to very quantitative (e.g. Financial Analysis). A key feature of these tools is that they identify a specific perspective and seek to understand the decision from that perspective. For example, Porter Five Forces Analysis focuses on the five types of competition in the market. This analysis provides a thorough understanding of competition in the market, but Porter Five Forces does not address other perspectives that may be



relevant for the decision (e.g. financial viability). Although these tools are often-used in practice, they are ill-equipped to provide a complete picture of a decision.

We use these perspective-specific tools as a foundation for our analysis in Chapters 4, 5, & 6. These perspective-specific tools provide our analysis with a deep understanding of the decision in a particular area of interest. They provide detailed input into the broad view of the decision provided by our multicriteria decision analysis. Below we examine several of these tools to understand their original and utility.<sup>3</sup> We focus on the tools that will later be used in their original or a modified form in our analysis of Chapter 6.

### **Benefit-Cost Analysis<sup>4</sup>**

Benefit-Cost Analysis (BCA) is a quantitative approach to estimating the economic value of a particular alternative. In BCA, all of the projected project benefits and costs are estimated and compared. A BCA usually includes all of benefits and costs of a project, not just the benefits and costs to the decision maker. Thus, BCA is particularly useful for estimating the economic value of a project to society.

In BCA, the projected benefits and costs of the project are measured in dollars or converted into dollar-equivalent values. For example, if one of the benefits of a project is that it will reduce the fatality rate on the transportation system, these lives saved are converted into a dollar value using a statistical estimate of the value of a human life. This purely financial approach to valuing a project can be controversial, and there remains a debate in the literature on the correct financial value to use for some of the qualitative benefits and costs of a project.<sup>5</sup>

A robust benefit-cost analysis will usually predict the spread of costs and benefits over time. This allows the analyst to discount effects that are far in the future and arrive at an accurate estimate of the net present value of the alternative. In addition, by predicting the spread of costs and benefits over time, the analyst can estimate other financial measures of value for the project (e.g. discounted cash flow and the internal rate of return). These measures provide the decision-maker with additional information to compare this alternative with other alternatives.

### **Financial Analysis<sup>6</sup>**

Financial Analysis is a quantitative approach to estimating the value of a particular alternative. Financial analysis is analogous to benefit-cost analysis in that the analyst estimates the benefits

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3 The description of each of these analysis tools is based on an internal MIT report by our research team. Sussman et al., 2014.

4 This description influenced by the work of Campbell & Brown, 2003.

5 For example, the statistical value of a human life varies by as much as an order of magnitude. For more on this subject, see de Blaeij et al., 2002.

6 For an example of financial analysis in the context of transportation projects, see the World Bank railway reform toolkit, 2011.

and costs of a project throughout time in financial terms. However, unlike benefit-cost analysis, financial analysis focuses exclusively on the benefits and costs that are directly relevant to the decision-maker. Thus, financial analysis does not include the indirect benefits and costs of the project which may affect other people or groups.

Financial analysis enables a decision-maker to compare the project with other projects using straightforward measures of financial performance (e.g. return on investment, discounted cash flow, and internal rate of return). This makes financial analysis very useful for investors and other financially-driven decision-makers. However, as mentioned above, financial analysis does not capture the indirect benefits and costs of a project. Especially for transportation projects, these indirect benefits can be an order of magnitude greater than the direct benefits and costs captured in a financial analysis.<sup>7</sup> Failure to include these indirect benefits can be a primary weakness of financial analysis.

### **Real Options Analysis<sup>8</sup>**

Real Options Analysis is a method for quantifying the value of current alternatives which provide future flexibility. In particular, real options analysis estimates the financial value of a present alternative for investment where this investment provides the decision-maker with an additional option to take action in the future (which would otherwise be unavailable or prohibitively expensive).

An iconic example of a real option in action is the 25 de Abril Bridge in Lisbon, Portugal. During engineering of the bridge, the government decided to provide additional structural support for a rail link underneath the bridge. This rail link, though not part of the original construction, could be added to the bridge at a future date. The upfront investment in additional structural support created the option for future construction of the rail link at a lower cost than building it outright. Real options analysis could have estimated the value of this option at the time of bridge construction.<sup>9</sup>

Real options analysis is often used to estimate the value of additional investment today which enables future expansion. However, there are many types of options that can be evaluated with real options analysis:

- the option to shrink the size of a project (e.g. if demand is lower than expected)
- the option to change the scheduling of the project (e.g. delay or hurry opening the project depending on market conditions)

---

7 For an example where the indirect benefits of a project outweigh the direct benefits, see our financial analysis and benefit-cost analysis of the Northeast Corridor of the United States in Chapter 6 and the Appendix.

8 This description influenced by work of de Neufville, R., 2003.

9 This history of the 25 de Abril Bridge is based on a presentation by Joana Costa to our research group on November 25, 2015.

- the option to adjust project operations (e.g. adjust the scale of operations or style of operations without modifying the infrastructure)

Thus, real options analysis allows a decision-maker to estimate the value of flexibility when the future is uncertain.

### **Environmental Impact Analysis<sup>10</sup>**

Environmental Impact Analysis is the qualitative and quantitative process of estimating the impacts of a project on the local built environment and natural environment. This process was developed in the mid-20<sup>th</sup> Century in response to transportation projects (in particular, highway projects) which were planned without regard to the local environment. Environmental Impact Analysis became an official part of the federal transportation planning process in 1970 with the National Environmental Policy Act. This law requires an environmental review of all projects (transportation and otherwise) which use federal funds.

An environmental impact analysis estimates the impact of a project on a long list of local environmental conditions (including, but not limited to, wetlands, parkland, water resources, local communities, developed land, and undeveloped land). The analysis of each of these resources is always context-specific and usually results in a qualitative list of impacts or a quantified estimate of the scope of the impacts.

### **Porter Fives Forces Analysis<sup>11</sup>**

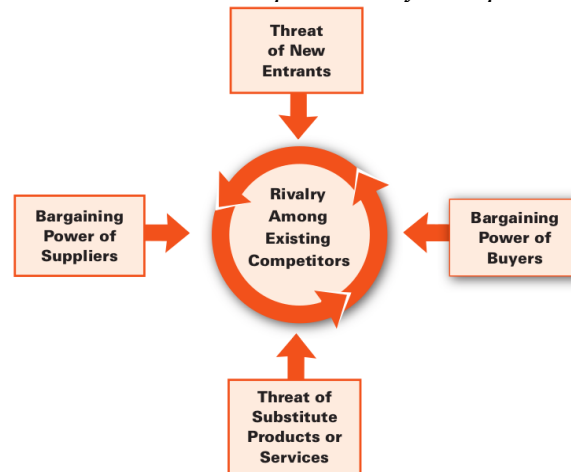
Porter Five Forces analysis is a qualitative analysis process which was developed by Professor Michael Porter at the Harvard Business School in the late 1970's to help analysts understand how competition shapes a particular industry. Michael Porter identifies five forces that affect competition in the market (shown in Figure 2-1).

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10 This description influenced by the work of the International Association for Impact Assessment, 1999, and Clark & Canter, 1997.

11 For more on this subject, see the original text by Porter (1979) or his more recent publication in the Harvard Business Review (2008).

Figure 2-1. Porter's Five Forces that Shape Industry Competition (Porter, 2008, p. 80)



Through examination of these five forces, an analyst is better equipped to understand the competition in the market. By applying Porter Five Forces Analysis to several business investment alternatives, an analyst can compare the alternatives and identify which alternative is most desirable from the perspective of competition.

### **Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis<sup>12</sup>**

SWOT Analysis is a qualitative analysis process with an obscure history (though usually credited to Albert S. Humphrey at SRI International). Like Porter Five Forces Analysis, SWOT Analysis is a framework for examining the circumstances surrounding a new business venture. SWOT analysis identifies four areas of interest:

- Strengths – the attributes of a company which may give it an advantage in the market
- Weaknesses – the gaps in expertise or liabilities of a company which may disadvantage the company in the market
- Opportunities – the circumstances in the market which are favorable toward the company
- Threats – the circumstances in the market which may disadvantage the company in the market

A SWOT Analysis can contain many of the same insights as a Porter Five Forces Analysis. Thus, the two processes are sometimes used to complement one another as they reframe the same information. Alternatively, the two processes can be seen as suitable replacements for each other when there is not time or interest in completing both.

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With this brief introduction to several perspective-specific analysis tools, we now turn to multicriteria decision analysis to understand how the results of these individual perspective-

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<sup>12</sup> For more information on SWOT analysis, see Humphrey, A., 2005.

specific tools can be combined into a broader understanding of the decision.

## 2.2 Multicriteria Decision Analysis

Multicriteria decision analysis (MCDA) – also known as multicriteria decision-making (MCDM), multicriteria decision aids, and multicriteria optimization – is a rich field of research which has grown significantly since the 1970s. This research field has developed a broad range of tools which combine the results of multiple perspective-specific analyses into a more holistic picture of a decision. Although this research has shown promising results in theoretical application to real decisions (including transportation investment decisions), multicriteria decision analysis tools have seen limited application to formal decision processes in the public or private sector.

Our development of a multicriteria, multistakeholder decision aid relies heavily on this field (see Chapters 4 & 5 for more on this decision aid).

Multicriteria decision analysis is useful because aligns with the way that real stakeholders make decisions. As stated by the field's de facto founder, Bernard Roy (*Multiple Criteria Decision Analysis*, 2005, p. 40-41),

*“Even when [a decision aid] is provided for a single decision maker, it is rare for her or him to have in mind a single clear criterion [for evaluating her or his alternatives]. ... it is necessary to take into consideration various points of view ... for example, finance, human resources, environmental aspects, delays, security, quality, ethics, etc. By considering each pertinent point of view separately, independently from the others, it is generally possible to arrive at a [clearer understanding of the decision-maker's preference.]”*

Thus, multicriteria decision analysis embraces the complexity of human decision-making and leverages this multicriteria understanding to yield more robust decisions.

With the goal of enabling a more robust decision-making process, multicriteria decision analysis is founded on a few core objectives. Benedetto Matarazzo and Jean-Marc Martel suggest the following three objectives for multicriteria decision aids (*Multiple Criteria Decision Analysis*, 2005, p. 254):

- **Transparency** – the decision aid should be easy for the decision-maker to understand so that the decision-maker is confident in the results of the process.
- **Accuracy**<sup>13</sup> – the decision aid should faithfully represent the the decision-maker's preferences; it should not impose an external bias.

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<sup>13</sup> The name of this objective has been changed from the 'faithfulness' objective of Matarazzo and Martel for clarity, but the purpose of the objective remains the same.

- **Flexibility** – the decision aid should include as much information from the decision-maker as possible, and it should be easy to adapt the decision aid to new input.

In light of limited application of MCDA to real decision processes as of 2016, we also aspire to a fourth objective in our development of a new decision aid:

**Usability** – the decision aid should be straightforward to implement for someone with no previous knowledge of the decision aid.

## *Review of Existing Methods*

With these four objectives in mind, we now review particular methodologies of MCDA and the practical limitations of these methodologies. MCDA methodologies fall into three general categories:

- Outranking Methods
- Multiattribute Utility and Value Theory Methods
- Non-Classical MCDA Approaches

Although our research draws from all three types of MCDA, of particular interest to our research are outranking methods as they are theoretically satisfying. The most well known family of outranking methods is the ELECTRE family of methods; we examine these methods in the next section.

### *The ELECTRE Family of Methods*<sup>14</sup>

The ELECTRE family of MCDA methods are very popular among researchers. In part, this is because ELECTRE methods are theoretically satisfying; ELECTRE methods use an outranking algorithm which objectively identifies the best alternative among a set of alternatives. This algorithm is based on binary outranking relations (i.e. statements which define one alternative to be strictly better than another). For some ELECTRE methods, it is necessary to define a relationship between all the available alternatives by comparing each pair of alternatives. Although this ensures that the final selection is objectively better than all the other alternatives without ambiguity, the process of comparing each pair of alternatives can be prohibitively time-consuming for the decision-maker.

According to José Figueira, Vincent Mousseau, and Bernard Roy (*Multiple Criteria Decision Analysis*, 2005, p. 168),

*“ELECTRE methods are relevant when facing [decisions] with the following characteristics:*

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<sup>14</sup> This description of the ELECTRE family of methods is based on *Multiple Criteria Decision Analysis*, 2005, p. 186.

1. *“The decision-maker wants to include in the model at least three criteria. However, aggregation procedures are more adapted in situations when decision models include more than five criteria (up to twelve or thirteen). ...*
2. *“Actions are evaluated (for at least one criterion) on an ordinal scale or on a weakly interval scale. These scales are not suitable for the comparison of differences.*
3. *“A strong heterogeneity related with the nature of evaluations exists among criteria (e.g., duration, noise, distance, security, cultural sites, monuments, ...). This makes it difficult to aggregate all the criteria in a unique and common scale.*
4. *“Compensation of the loss on a given criterion by a gain on another one may not be acceptable for the [decision-maker]. Therefore, such situations require the use of noncompensatory aggregation procedures.*
5. *“For at least one criterion the following holds true: small differences of evaluations are not significant in terms of preferences, while the accumulation of several small differences may become significant.”*

There are a growing number of ELECTRE family methods. Modified forms of the ELECTRE method add veto conditions which allow a single criteria to eliminate an alternative if the alternative does not meet a minimum threshold according to that criteria (*Multiple Criteria Decision Analysis*, 2005, p. 174, and Rogers & Bruen, 1998). Other versions of the ELECTRE method adjust the methodology to address uncertainty (Shanian et al., 2008, and Figueria & Roy, 2002). Still others adapt the ELECTRE process to address possible interdependence between the criteria (Figueira et al., 2009).

As mentioned above, ELECTRE methods require a great deal of time from the decision maker. For many decision analyses (including our analysis for the East Japan Railway Company as discussed in Chapter 6), this intensive one-on-one time with the decision-maker is not realistic. Despite their theoretical utility and other advantages, it is impossible for us to use an ELECTRE family method directly in our research. Instead, we draw on some elements of the ELECTRE methods to develop our own decision aid (see Chapters 4 & 5).

### *Other Relevant MCDA Methods*

Although there are a number of other MCDA methods which have some relevance to our research, we focus here briefly here on two additional methods which are particularly relevant: Analytic Hierarchy Process and PROMETHEE VI.

## **Analytic Hierarchy Process<sup>15</sup>**

Analytic Hierarchy Process (AHP) is a multiattribute utility theory method where the ranking of alternatives is developed using a fundamental scale which spans the possible extremes for each criteria. AHP develops these criteria scales by asking the decision-maker to make numerical comparisons between the alternatives (i.e. “according to this criteria, alternative 1 is twice as valuable as alternative 2”). These numerical comparisons allow the analyst to develop a scale for each criteria and identify where each alternative falls along that scale. By analyzing these criteria scales, the analyst is able to draw conclusions about the overall value of each alternative and identify the single best or set of best alternatives.

Unfortunately, like the ELECTRE Process, AHP is derived from a set of pairwise comparisons between the alternatives. Soliciting this input from the decision-maker is a time-consuming endeavor. In addition, AHP does not provide any straightforward methods for combining the preferences of multiple stakeholders. Thus, although we draw on some elements of AHP for our decision aid (in particular, the notion of a criteria scale), we cannot use the process directly in our analysis of transportation alternatives in Chapter 6.

## **PROMETHEE VI<sup>16</sup>**

The PROMETHEE VI Sensitivity Tool is a component of the PROMETHEE IV Process. This tool allows the decision-maker to state the bounds of their preferences rather than a specific value to represent their preferences. For example, rather than stating that “alternative 1 is twice as valuable as alternative 2,” the decision-maker could state that “alternative 1 is at least 1.5 times as valuable as alternative 2, but no more than three times as valuable.” This preference flexibility recognizes that our understanding of relative value is often not well defined; a range of values are usually a better representation of the decision-maker's preferences than a single value.

Although we are unable to use the PROMETEE VI method directly in our decision aid, this notion that a range of values could represent the decision-maker's preference inspired our development of Critical Preference Analysis in Chapter 4 and the CLIOSjre Process in Chapter 5.

## *Applications of MCDA*

Although MCDA has not seen widespread use, there are number of research applications of MCDA to real problems. The ELECTRE family methods have been adapted for use in environmental evaluations (Rogers & Bruen, 1998) and for evaluation of decentralized energy

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15 This description is based on *Multiple Criteria Decision Analysis*, 2005, p. 374.

16 This description is based on *Multiple Criteria Decision Analysis*, 2005, p. 213.



systems (Papadopoulos & Karagiannidis, 2008). Other MCDA methods have been applied to power allocation in distribution networks (Tomoiağă et al., 2013), vendor selection (Hsu et al., 2012), agriculture planning (McCown, 2002), and siting of transshipment ports (Ding & Chou 2013).

MCDA has also seen research applications in a few transportation contexts. Roy, Présent, and Silhol applied a modified ELECTRE III process to identify the more effective renovation schedule for Paris metro stations (1986). Roy and Hugonnard also applied the ELECTRE IV method to rank line extension projects on the Paris metro (1982). Jacek Zak applied the ELECTRE III method to optimize system development and crew sizing for a fictitious public transit system (2011). And other MCDA methods have been applied to optimize route selection of high-speed rail projects in Texas (Sperry et al., 2013) and Malaysia (Saat & Serrano, 2015). Despite this multitude of research applications, there remain very few applications of these MCDA tools in official planning processes.

### *Implications for our Multicriteria Decision Aid*

Despite the multitude of decision aids and theoretical applications with the field of MCDA, there are no methods currently available which fit the needs of our application for the East Japan Railway (described in detail in Chapter 6).<sup>17</sup> There are, however, a number of key insights from MCDA (in addition to the ideas identified above) that are important background for our development of a new decision aid.

### **The Importance of Criteria Independence**

To quote Denis Bouyssou again (*Multiple Criteria Decision Analysis*, 2005, p. 124),

*“Independence, or at least weak independence, is an almost universally accepted hypothesis in multiple criteria decision making. It cannot be overemphasized that it is easy to find examples in which [the assumed independence of criteria] is inadequate.”*

He goes on to describe a very accessible example of seemingly independent criteria which violate this rule of true independence:

*“If a meal is described by [two criteria], main course and wine, it is highly likely that most gourmets will violate independence, preferring red wine with beef and white wine with fish. Similarly, in a dynamic decision problem, a preference for variety will often lead to violating independence: you may prefer Pizza to Steak, but your preference for meals today (first [criterion]) and tomorrow (second [criterion]) may well be such that (Pizza, Steak) is preferred to (Pizza, Pizza), while (Steak,*

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<sup>17</sup> For more information on these limitations and the necessity for a new process, see Chapters 4 & 5.

*Pizza) is preferred to (Steak, Steak). ”*

In our research, we have been careful to identify independent criteria for analysis. Where the criteria in our analysis are not truly separable, we have worked to address this interdependence and mitigate its effect on our results.

### **The Difficulty of Non-Linear Preference**

To recast multiple criteria into a single overall ranking of alternatives, it is necessary to combine the criteria using a weighting scheme or other combination method (like the outranking algorithm in the ELECTRE Process). Recalling our four original objectives of multicriteria decision analysis (transparency, accuracy, flexibility, and usability), we are quick to observe that the choice of combination process directly impacts our success on all four objectives. One convenient combination process is a linear weighting scheme (described in the box below). This combination process is easy to understand, but it is not the most accurate in representing the decision-maker's preferences.

To illustrate the accuracy issues with a linear weighting scheme, we again draw an example from Denis Bouyssou (*Multiple Criteria Decision Analysis*, 2005, p. 116):

*“Consider for instance an individual expressing preferences for the quantity of the two goods he consumes. ... a fairly rational person, consuming pants and jackets, may indeed prefer [3 pants and no jacket] to [no pants and 3 jackets] but at the same time prefer [3 pants and three jackets ] to [six pants and no jackets]. This implies that these preferences cannot be explained by a [linear weighting scheme].”*

In our research (detailed in Chapters 4 & 5), we opt for a linear weighting scheme to combine the multiple criteria. In other words, we use a series of weights to combine the individual criteria into an overall evaluation of each alternative:

$$\text{Overall Evaluation}_{\text{Alternative 1}} = \text{Criteria 1 Evaluation}_{\text{Alternative 1}} * \text{weight 1} + \text{Criteria 2 Evaluation}_{\text{Alternative 1}} * \text{weight 2} + \text{Criteria 3 Evaluation}_{\text{Alternative 1}} * \text{weight 3} \dots$$

This approach performs well according to our four original objectives: the linear weighting scheme is transparent and flexible. In addition, and perhaps more importantly, this linear weighting scheme is easy for a new analyst to pick up and use without much training. As ostensible proof of this usability conjecture, we observe several examples of a linear weighting scheme in current use in public planning in Chapter 3. However, the choice of a linear weighting scheme has negative implications on the accuracy of our decision aid. By assuming a linear weighting scheme for our decision aid, we restrict its ability to represent more complex preferences and thus reduce the accuracy of the decision aid. However, we argue that the increased transparency, flexibility, and usability

of the linear model outweighs the loss in accuracy.

With a firm foundation in multicriteria decision analysis, we now turn to multistakeholder negotiation and its derivatives (e.g. multistakeholder tradespace negotiation) to better understand the multiple stakeholder environment.

## 2.3 Multistakeholder Negotiation<sup>18</sup>

Multistakeholder negotiation is a rich field of research which is designed to facilitate decisions which involve multiple stakeholders. The research has seen widespread practical application, especially in cases where the stakeholders have similar ideals but disagree on the proper implementation of a solution. Our research draws from the work of a number of different public policy negotiators, in particular the work of Harvard Negotiation Project using the concept of principled negotiation.

Principled negotiation operates on the assumption that successful negotiation is usually fruitful for both parties; a successful negotiation leaves both parties better off. Operating on this premise, the Harvard Negotiation Project posits five key principles (Fisher, Ury, & Patton, 2011):

- **Separate the People from the Problem:** Negotiation is more effective when the participants have a personal relationship outside the negotiation. The negotiation should be framed as a joint problem-solving exercise, not a competition.
- **Focus on Interests, not Positions:** Negotiation is more effective when the participants focus on their interests rather than a particular outcome. Positional negotiation often results in stalemate; interest-based negotiation tends to explore a greater range of potential solutions.
- **Invent Options for Mutual Gain:** As negotiation is a joint problem-solving exercise, all participants should work to identify areas where there might be compromise or mutual benefit. Participants should grow the pie before dividing it.
- **Insist on Using Objective Criteria:** For negotiation to be successful (especially when the participants have a long-term relationship), all parties must feel like they got a good deal. Thus, it is necessary to use a objective or pseudo-objective criteria to develop a reference point for the agreement. This enables participants to be confident in the result.
- **Know your Best Alternative to Negotiated Agreement:** When participants identify their best possible outcome and insist on that outcome, the negotiation often leads to

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<sup>18</sup> This section of the chapter draws from the work of Movius & Susskind, 2009, Susskind, 2014, and Fisher, Ury, & Patton, 2011.

stalemate. Instead, participants should identify their Best Alternative To Negotiated Agreement (BATNA) and work together to identify solutions which are better than the BATNA for both parties. Although the parties rarely disclose their BATNA to each other, knowledge of their own BATNA forces the parties to focus on their own gains relative to the BATNA.

### *Multistakeholder Negotiation and Decision Analysis*

These five principles have direct relevance on our multicriteria, multistakeholder decision analysis. To quote Bernard Roy (*Multiple Criteria Decision Analysis*, 2005, p. 40),

*“[When decision analysis] takes place in a multi-actor decision making process, it is [exceptionally rare] for there to be a priori a single, well-defined criterion deemed acceptable by all actors to guide the process. This process is often not very rational. Each actor plays a more or less well defined role which gives priority to her or his own objectives and value system.”*

With multiple stakeholders, the already complex problem of multicriteria decision-making can become prohibitively difficult. Indeed, the Northeast Corridor of the United States is one such example – the sheer number of stakeholders and competing priorities has stalled significant progress for decades. These five principles from Principled Negotiation lend some order to a multistakeholder decision of otherwise unmanageable complexity. We describe the implications of each principle for our research below.

#### **Separate the People from the Problem**

A multicriteria, multistakeholder decision aid should focus the participants on cooperative problem solving rather than competitive negotiation. The decision aid should be targeted to the group as a whole and available to the whole group. By providing the same information to all participants, the decision aid can place all participants on an equal playing field. This perception will encourage all participants to consider themselves equal participants in the discussion.

#### **Focus on Interests, not Positions**

A decision aid should identify alternatives for the participants rather than limitations. The decision aid should help the participants think outside the box; the alternatives presented to the participants should be beyond what they would normally consider possible so that they are encouraged to think of creative solutions that lie beyond their normal constraints.

#### **Invent Options for Mutual Gain**

A decision aid should encourage participants to consider the perspective of other participants. This perspective-taking will help participants identify solutions which are beneficial to the other

stakeholders.<sup>19</sup>

### **Insist on Using Objective Criteria**

The criteria in a decision aid should be as objective as possible. Unnecessary debate about these criteria or the evaluation results will distract from the more important task of identifying a mutually beneficial solution.

### **Know your Best Alternative to Negotiated Agreement**

A decision aid should use the participants' BATNA as a reference point for negotiation. This reference point will ensure that participants compare all the possible solutions against this status quo solution. With the status quo as a reference point, the participants are more likely to identify solutions and avoid a stalemate.

Negotiation between the stakeholders is not directly addressed in our decision aid, the CLIOSjre Process; this negotiation between stakeholders takes place after the CLIOSjre Process is complete. However, the CLIOSjre Process is designed with negotiation in mind. In development of the CLIOSjre Process, we have worked to adhere to the five principles addressed above.

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The complexity of multicriteria analysis and multistakeholder negotiation make identification of a solution which satisfies all stakeholders exceedingly difficult. To compound this difficulty, we also must address the uncertainty of our evaluation. We address uncertainty in the following section.

## **2.4 Uncertainty in Analysis**

To understand how to address uncertainty in this thesis, we turn to a description of unanticipated accidents by Charles Perrow. In his 1984 book *Normal Accidents*, Perrow theorized a new way to think about accidents. This theory – Normal Accident Theory – proposes that tightly-linked complex systems (e.g. nuclear reactors) do not have accidents in the same way as unlinked linear systems (e.g. a building). Tightly-linked complex systems often fail in a dramatic unanticipated cascade; one small error leads to a catastrophic meltdown due to the tight connections and nonlinearities between system components. Normal Accident Theory concludes that accidents are an inevitable part of complex systems – they cannot be engineered out.

Normal Accident Theory suggests an analogous conclusion about planning for uncertainty: in tightly-interconnected complex systems, we cannot plan away our uncertainty about the system.

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<sup>19</sup> We accomplish this in our decision aid by providing each stakeholder with a range of perspectives to consider, some of which represent other stakeholders. See Chapter 5 for more.

For our analysis of transportation alternatives, the complexity of the system prevents us from eliminating uncertainty from our models of the future. Uncertainty will always be a dominant feature of such systems.

If uncertainty is a dominant feature of our analysis, what is the value of our analysis at all? To quote then-President Dwight D. Eisenhower (1957):

*“Plans are worthless, but planning is everything.”*

The value of our analysis is not to predict the future but to understand it. We must acknowledge and address uncertainty in our analysis.

In this thesis, we categorize uncertainty into two types:

1. Uncertainty about the present, and
2. Uncertainty about the future.

### **Uncertainty about the Present**

For each component of our analysis, there is uncertainty inherent in the methodology that we use. This uncertainty results from our inability to accurately measure the present. For example, our benefit-cost analysis (detailed in the Appendix) relies on two key quantities to estimate the public benefit of each alternative: the value of time and the value of a statistical life. However, there remains much disagreement in the literature over the value of these two quantities. This disagreement among informed professionals leads to an *uncertainty in how to accurately measure the present*. This is the first type of uncertainty.

### **Uncertainty about the Future**

Future technologies or future events may fundamentally change the value of the transportation alternatives that we seek to analyze in this thesis. Due to the complexity of our immense and tightly-interconnected transportation systems, it is impossible for us to estimate this uncertainty about the future in a robust fashion. Thus, we have a second type of uncertainty: *uncertainty in how to accurately predict the future*. In our analysis, we choose to address this uncertainty with scenario analysis – a separate tool designed specifically to understand future uncertainty. Although this scenario analysis cannot predict the future, this analysis helps us and the decision-maker understand possible risks and rewards in the future.

These two sources of uncertainty and our method for addressing them are described in more detail in Chapter 6.
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## **2.5 Implications for our Multicriteria, Multistakeholder Decision Aid**

In this chapter, we examined current research in perspective-specific analysis, multicriteria

decision analysis, multistakeholder negotiation and uncertainty. From these fields, we identified important objectives and principles for our research. These lessons are listed again below for reference.

## Objectives

- **Transparency** – the decision aid should be easy for the decision-makers to understand so that the decision-makers are confident in the results of the process.
- **Accuracy** – the decision aid should faithfully represent the the decision-makers' preferences; it should not impose an external bias.
- **Flexibility** – the decision aid should include as much information from the decision-makers as possible, and it should be easy to adapt the decision aid to new input.
- **Usability** – the decision aid should be straightforward to implement for someone with no previous knowledge of the decision aid.

## Principles

- **Criteria should be independent** to improve the accuracy of our decision model.
- **Criteria should be as objective as possible** to reduce unnecessary debate on the results of the criteria evaluations.
- **Focus the participants on cooperative problem solving** rather than competitive negotiation.
- **Identify opportunities for the participants** rather than limitations; encourage participants to think outside the box.
- **Encourage participants to consider the perspective of other participants** so that they can identify solutions which are beneficial to the other stakeholders.
- **Use the participants' BATNA as a reference point for negotiation** to reduce the chance of a stalemate.
- **Identify and understand all types of uncertainty** so that key stakeholders understand the risks that are present

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In the following chapter, we examine the current state of the practice in transportation alternatives analysis. In particular, we examine the planning process in the United States at the federal, state, and local level. In later chapters, we apply these lessons to develop a new multicriteria, multistakeholder decision aid and apply it to transportation alternatives analysis.

### 3 Comparative Analysis of Performance-Based Planning in the United States

As discussed in the preceding chapter, there are a wide variety of multicriteria decision aids which have been developed since the 1970s, and a number of the decision aids have been applied to theoretical transportation and infrastructure planning problems. Yet very few of these methodologies are implemented in everyday transportation planning processes.<sup>20</sup> This disconnect implies that there are practical barriers which prevent us from implementing these decision aids in real decision processes.

In this chapter, we examine the transportation planning process in the United States at the federal, state, and local level. In particular, we examine the planning processes at these three levels of government in the context of performance-based planning – an initiative to use more data and objective measurement in the US transportation planning process. In this chapter, we find that the planning processes in the US bear some resemblance to theoretical decision aids of Chapter 2. However, the processes at all three levels of government remain subject to political influence. This political influence occasionally prevents an objective or even pseudo-objective analysis of transportation investments, and political negotiation remains a dominant method for decision-making in transportation planning. In the final sections of this chapter, we discuss the analysis and decision-making surrounding the Route 29 corridor in Virginia. In addition, we draw lessons from the US planning processes which are useful in the subsequent chapters of this thesis.

#### 3.1 Brief History of Transportation Planning in the United States

With very few exceptions, transportation investments in the United States have always been under the purview of government agencies.<sup>21</sup> These government agencies collect taxes (often in the form of a fuel tax or property tax) and then allocate the funds to transportation (and other) projects based on the current and projected needs. As these infrastructure needs are difficult to estimate, allocation of the government funds remains a political process. The non-linear and self-reinforcing nature of transportation demand only exacerbates the political nature of these public investment decisions.<sup>22</sup>

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20 As we discuss in this chapter, the disconnect between theory and reality may close in the near future as data becomes more abundant and more reliable.

21 In the early history of the United States, the legal right of the federal government to fund infrastructure projects was a hotly contested issue. At the very end of his presidency, the fourth President of the United States (Madison) vetoed a major infrastructure funding bill as he believed it to be unconstitutional. Despite this initial debate, early infrastructure in the US was still largely funded by the public (for example, after Madison's veto of federal funding, the Erie Canal was funded by the State of New York).

22 For an excellent explanation of the complexity of transportation planning and its impacts on land use, see Jane Jacobs's iconic text *The Death and Life of Great American Cities*, 1961.



In an attempt to reduce the influence of politics on public infrastructure decisions, a number of efforts in the last five decades at the federal, state, and local level have worked to increase the objectivity of transportation investment decisions. The initial step toward a more objective decision-making process likely began with the National Environmental Policy Act of 1970 (NEPA). This law requires a full environmental analysis of all transportation projects funded by the federal government. Although these environmental analyses do not remove politics from the decision-making process, these analyses force government agencies to document the impacts of public investment decisions. This transparency improves the public accountability of all levels of government.

Another fundamental step toward more objective decision-making arrived with the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). This bill integrates funding for multiple modes of transportation infrastructure into one bill (in particular road funding and funding for public transit). The bill requires all transportation modes to be considered simultaneously in local transportation planning. Once again, these changes do not guarantee objectivity in the decision-making process, but the unified funding mechanisms allow the federal government to put in place competitive grant programs that ensure only the best projects nationwide are selected for federal funding. We describe these competitive grant programs in more detail in Section 3.2 below.

In 2012, the Moving Ahead for Progress in the 21st Century Act (MAP-21) added additional objectivity requirements for all projects funded with federal money. In addition to the requirements above, each state is required to report on the the status of their transportation infrastructure using a number of performance measures. These performance measures identify segments of the transportation system which are under-maintained, congested, or unreliable as well as other criteria of national importance. Although MAP-21 does not require states to use these performance measures in their planning processes, the federal reporting requirements add to the transparency of the planning process and further improve public accountability.

The MAP-21 reporting requirements offer states and local planning organizations the opportunity to use more objective planning processes to identify and prioritize transportation investments. These new planning processes are referred to as performance-based planning. Although many states have not embraced performance-based planning, a number of states have developed new methods for allocating transportation funds that make use of federal performance measures and more objective processes. In the sections below, we examine transportation planning at the federal level. In addition we highlight new performance-based planning processes at the state and local level which use the new federally-mandated performance measures.

## 3.2 Performance-Based Planning in Federal Grants

As mentioned above, the United States government funds many transportation infrastructure

projects at a national level. Most of this funding comes in the form of direct allocation to the states. These allocations must comply with federal rules (for example, the NEPA rules about environmental analyses). However, these funds are allocated directly to the states who then distribute the funds to projects according to their own formulae; there is no federal planning or approval necessary for these allocated funds.

A small portion of federal funds are distributed in the form of competitive grants. These grant programs target specific transportation modes (e.g. the Recreational Trails Program for public trail systems) and/or specific purposes (e.g. the New Starts program for new public transit systems). These grant programs are allocated at the federal level and must adhere to more strict planning requirements than funds allocated directly to the states. As these grant programs rarely cover the full cost of the transportation infrastructure (usually less than 50%), the federal funds must be supplemented by funds from state and local agencies. This multistakeholder funding allocation process results in significant complexity in the planning process.

### *Project Prioritization at the Federal Transit Administration*

Many of the federal competitive grant programs use a prioritization process to allocate funds. To illustrate this prioritization process, we examine the prioritization process for the Federal Transit Administration's (FTA) New Starts program below.

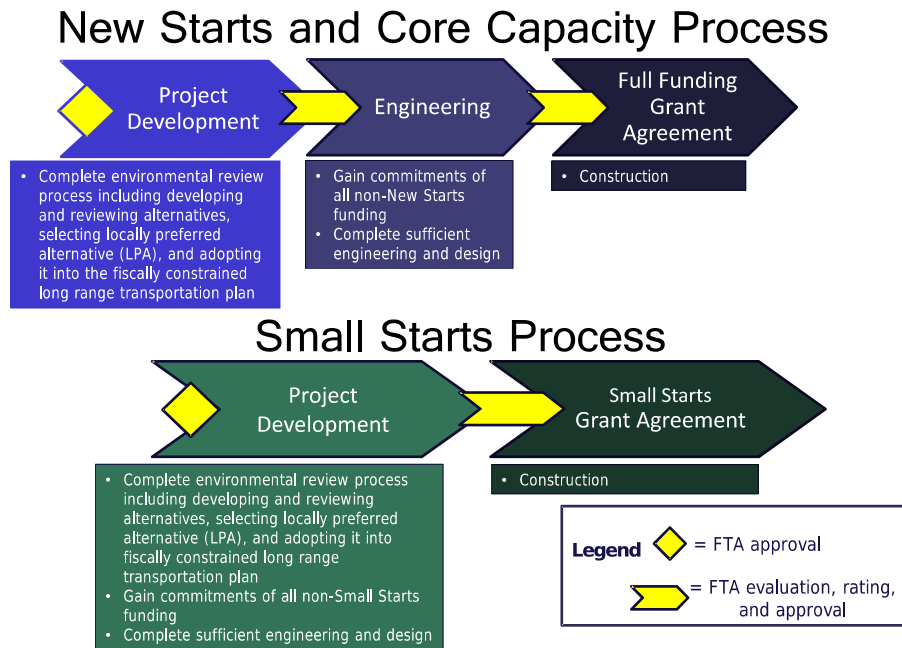
Since the FTA grant programs began in 1991 with ISTEA, the Federal Transit Administration has allocated funds to new public transit systems across the United States. This competitive grant program, New Starts, is targeted at new fixed-guideway public transit systems (e.g. subway, bus-rapid transit) that serve areas not currently served by fixed-guideway transit. Figure 3-1 shows the high-level allocation process for projects which apply to the New Starts program. The allocation process for New Starts begins with a pre-approval by the FTA to begin the federal planning and engineering process. The applicant (usually the state or local planning agency) then has a strict two-year deadline to complete project development and engineering. At the end of this planning and engineering process, the project is submitted to the FTA for final approval. At this point in the process, the project competes with other projects for FTA funds.

In theory, a project is allowed to enter the FTA allocation process with no advance planning. In practice, the two year approval window provided by the FTA means that most of the planning and stakeholder outreach and even some of the project engineering must be complete before the project is submitted to the federal allocation process. Thus, although this two-year window ensures that projects do not linger in the federal planning process, many projects will linger in state and local planning for many years or even decades before entering the federal process.<sup>23</sup> For a concrete example of a project lingering in state and local planning, see section 3.5 below.

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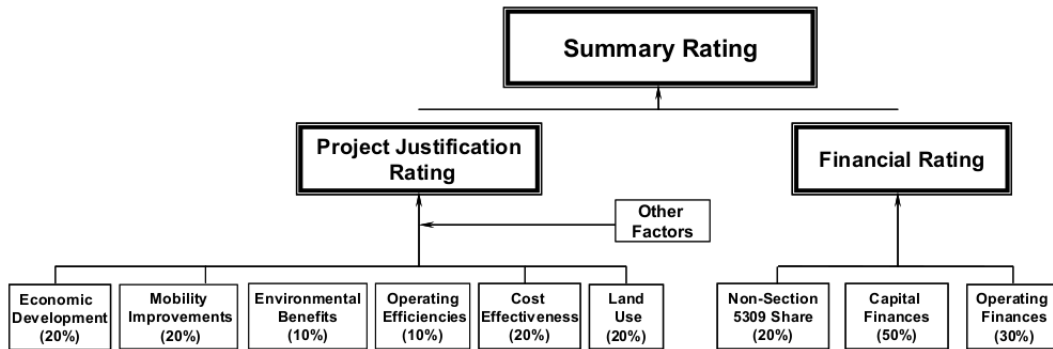
<sup>23</sup> Much of this background was provided by Laurie Hussey, a transportation planner who is intimately familiar with the process, in her presentation to students of the *Urban Transportation Planning* course in the fall of 2015.

Figure 3-1. Allocation Processes for FTA New Starts, Core Capacity, and Small Starts  
(Federal Transit Administration, 2013)



As mentioned above, a project which completes planning and engineering in the New Starts program is not guaranteed funding. The applicant requests for New Starts funding consistently exceed the amount of money available from the FTA (often by an order of magnitude). Since 1996, the FTA has used a weighted prioritization process to determine which projects receive New Starts funding. Figure 3-2 shows the weighting process for the New Starts program as of 2013. This prioritization process weighs together nine criteria which are important to the Federal Transit Administration (and by extension, the public). Six of these criteria are weighed together to produce a project justification rating which approximates the value of the project to the public. The three remaining criteria are weighed together to produce a financial rating for the project which approximates the financial viability of the project.

Figure 3-2. The New Starts Project Prioritization Process (Federal Transit Administration, 2013)



### *Politics in the Federal Allocation Process*

The New Starts linear weighting prioritization is designed to reduce the influence of politics on the allocation process. However, in practice, politics intervenes at several points of the process. The nine criteria in this analysis are evaluated on a five-tier scale from weak to strong. The analysis of these criteria require substantial professional judgment which is subject to review and debate. In addition, as the 'Other Factors' box in Figure 3-2 implies, additional factors (both substantive and political) are used to develop the project justification rating for each project. Thus, the individual criteria scores of a particular project and its ultimate summary rating remain subject to political influence.

In addition, once the individual criteria scores have been combined into a single summary rating for each project, many projects qualify for a 'high' or 'medium-high' summary rating. The large number of highly-qualified projects exceed the money available in the New Starts program. Thus, the final allocation decision between these 'high' and 'medium-high' rated projects is subject to both professional judgment and political influence.

As with the environmental review process required by NEPA, the FTA's weighted prioritization process cannot completely eliminate the of influence of politics from transportation planning. Instead the environmental review process and the FTA's prioritization process are designed to make the decision-making process more transparent. This transparency provides all stakeholders with the same information and increases the public accountability of the agency. We also pursue process transparency in our development of the CLIOSjre Process in Chapter 5, and we have worked to replicate the desirable features of the FTA's New Starts prioritization process.

### 3.3 Performance-Based Planning at the Virginia Department of Transportation

At the state level, transportation investment decisions are made using a wide variety of

allocations processes.<sup>24</sup> For our analysis, we focus on the funding allocation process in Virginia. We selected Virginia for two reasons:

1. In 2014, Virginia embarked on a new 'apolitical' project prioritization process for transportation projects the state. This new process is designed to reduce the influence of politics in the project allocation process. Thus, this new process is deemed worthy of study.
2. Virginia's demographics are relatively typical of a medium-sized state in the US: the state has both urban and rural portions, the state ranks 12<sup>th</sup> in the US by population, and the state is diverse. Thus, the conclusions we reach about Virginia's new planning process may translate to other states as well.

One difference between Virginia and other states is that the state does not have county road authorities. As a result, the Virginia Department of Transportation (VDOT) owns the vast majority of roads and other transportation infrastructure in the state. This gives VDOT a disproportionately powerful role in transportation planning in comparison to other similar states. This difference between Virginia and other states will make it more difficult to translate our conclusions to other states.

### *New Planning Process After HB 2*

In 2014, the Virginia legislature passed House Bill 2 which provided a new budget for the state transportation system. As part of this funding allocation, House Bill 2 requires a more systematic and objective funding allocation process. In the past, Virginia's transportation project allocations were developed by VDOT and approved by a specially appointed board, the Commonwealth Transportation Board (CTB). Historically, the Virginia CTB had achieved a reputation of irregular and unreliable funding allocations that were not consistent with the state's long-term transportation interests.<sup>25</sup>

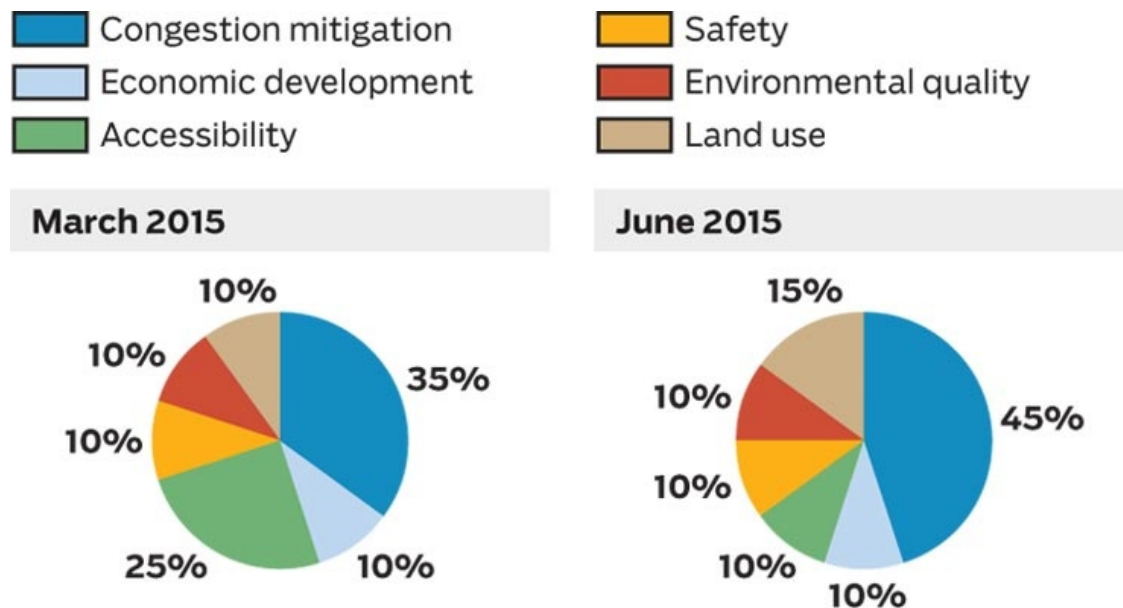
To reduce political influence in the funding allocation process, House Bill 2 mandates that VDOT rate all state-funded projects before presenting them to the CTB. This rating is determined by an set of six criteria: congestion mitigation, safety, economic development, environmental quality, accessibility, and land use. These six criteria are weighed together (in a similar fashion to the FTA New Starts rating process). Example weights for the state are shown in Figure 3-3. Once all the projects in the state are rated, the projects are ranked from best to worst and this ranking is presented to the CTB.

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<sup>24</sup> Indeed, a review of the decision-making processes at the state and local level could fill several masters theses.

<sup>25</sup> This understand is based on interviews with several transportation planners who work primarily in the state of Virginia. For an example of this politically-motivated planning, see Section 3.5.

Figure 3-3. Criteria Weights for the VDOT Prioritization Process. These weights were still under debate in summer of 2015 and changed between March and June (Commonwealth Transportation Board, 2015).



In this new planning process, the CTB retains the ability to select any of the transportation projects on the list (or other projects not on the list presented by VDOT). However, if the CTB does not choose the projects with the highest ranking, the CTB must provide a formal explanation for deviating from the official project ranking. The theory behind this process is that it ensures both VDOT and the CTB have incentives to provide an excellent list of projects for the state; if either group fails to prioritize the state's needs over politics, the other group may hold them accountable.

Although the first round of funding using this new allocation process will not be complete until summer 2016, we can draw insight from the framework in Virginia's new planning process.

### *Implications of the Virginia Process*

The new allocation process in Virginia is designed to produce a pseudo-objective ranking of all the available transportation projects in the state. Projects may be submitted to the state by any local or regional planning organization, and all reasonable projects will be evaluated by the staff at VDOT. These evaluations are reviewed by “an external peer review group, consisting of staff representatives from groups such as the Virginia Association of Counties (VACO), Virginia Municipal League (VML), and the Federal Highway Administration (FHWA)” (Commonwealth Transportation Board, 2015). Although it would be difficult for this external peer review group to find discrepancies without re-performing the analysis themselves, the layers of independent review (first by the peer review group and then by the CTB) reduces the chance that project

scores will be influenced by politics.

The weights for the six evaluation criteria remain a subject of ongoing debate in the state. As shown in Figure 3-3, in summer 2015 the weights for each of the criteria were shifted in favor of more emphasis on congestion mitigation and less emphasis on job accessibility. This shift in the weights likely indicates the presence of political interests advocating for an evaluation process which is biased toward their needs. Indeed, this bias was written into the original bill; House Bill 2 *requires* that congestion mitigation have the greatest weight of all the evaluation criteria. It remains unclear if this emphasis on congestion mitigation is the result of political interference or sound transportation policy.

As with the FTA New Starts allocation process, politics will remain an important part of transportation planning in Virginia. We discuss political interference in the planning process in more detail in Section 3.5 below. However, Virginia's new allocation process provides safeguards against fraud and corruption and provides incentives for both VDOT and the CTB to act in the state's best interest. Transportation planners and advocates within the state are outwardly optimistic that this new allocation process will result in a more predictable transportation funding process and, by extension, a more robust transportation system.

### 3.4 Performance-Based Planning at the Charlottesville-Albemarle Metropolitan Planning Organization

More objective transportation planning is taking hold at the local level as well. The motivation for more objective planning is different at the local level than at the state and national level. At the state and national level, the primary concern is that politicians will misuse their position in order alter transportation funding in a way that does not reflect the public interest. Although abuse of power remains possible in local transportation planning, an equally important planning difficulty arises from local opposition. Vocal minorities of the local population often stand in opposition to any change in the status quo. While at times this opposition spurs fruitful discussion, often local opposition delays and cancels effective transportation projects. This small but vocal subset of the population can inhibit the effectiveness of local and regional transportation planning.<sup>26</sup>

In the context of local planning, more objective project planning provides a firm point of reference for the local debate. Performance measures and other performance indicators help bound the debate in reality. This pseudo-objective point of reference pushes stakeholders toward productive contributions rather than obstructionism. By reframing the debate, performance-based planning refocuses the local efforts on productive policy rather than regressive debate.

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<sup>26</sup> These observations are based on conversations with local and regional transportation planners.

## *Performance Based Planning for Project Selection*

A small Metropolitan Planning Organization (MPO) in Virginia has experienced significant success with performance-based planning. The Charlottesville-Albemarle MPO (CA-MPO) is a small organization with only two permanent staff members. However, aided by a new performance-based planning process, the MPO was able to develop a long range transportation plan with significant community support in just a few years.

For its 2014 Long Range Transportation Plan, the CA-MPO decided to implement a new performance-based planning process. As the community has historically been very involved in the development of the CA-MPO long range plans, the CA-MPO staff anticipated significant pushback against this new process. Thus, CA-MPO was careful to enlist the community in the development of the process and the performance measures. By engaging the community in the process development, CA-MPO believed that the community would be more supportive of process outcomes. This belief was borne out in reality; although some in the community were unwilling to accept the new process, the vast majority supported the process outcome.<sup>27</sup>

The CA-MPO final planning process used sixteen performance measures to evaluate the transportation projects. As the MPO has limited data and a limited staff, they were unable to include all the performance measures desired by the public. The community expressed concern that the omission of certain performance measures (especially those related to accessibility, land use, and induced demand) would bias the selection process toward automobile-focused solutions. By adding performance measures which counteracted this bias and were easier to measure for the MPO, the CA-MPO was able to convince the public that any bias toward road-building was minor or nonexistent.

The final planning process developed by CA-MPO is a multi-step process:

1. The MPO evaluates a baseline scenario using the sixteen performance measures. For their 2040 plan, the MPO used the status of the transportation system in 2010 as the baseline. This baseline is used as a reference point for all other evaluations.
2. The MPO identifies possible transportation projects for the region.
3. The MPO evaluates each project separately against the baseline to estimate the percent change in all sixteen performance measures.
4. The MPO combines these projects into 'project scenarios'. The project evaluations for the projects in each scenario are summed to produce an evaluation for the full scenario.
5. The MPO presents the results of this evaluation to the public, and with the public's help, the MPO adjusts the project selection within each scenario to improve each scenario.

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<sup>27</sup> Based on interviews with the CA-MPO staff.



- The MPO board signs off on a final scenario selection, and the projects within this scenario are added to the long range transportation plan.

Figure 3-4 shows an example output of this process.

*Figure 3-4. Example Output of the CA-MPO Planning Process (Charlottesville-Albemarle Metropolitan Planning Organization, 2014)*

Performance Measurement	Base		Scenario 1A		Scenario 1B		Scenario 1C	
	Value	Unit of Measure	Value	% Change	Value	% Change	Value	% Change
<b>Mobility</b>								
Congestion (% of roads at LOS E or F)	14.1%	% of Roads	10.6%	24.6%	10.7%	23.9%	10.7%	24.1%
Congestion (hours of delay per day)	23,181.0	Hours	18,943	18.3%	19,162.7	17.3%	19,222	17.1%
Mode Share (percent of Trips)	759,319	Trips/Day	759,379	0.0%	759,473	0.0%	759,429	0.0%
Auto	88.1%	Percent of Trips	87.7%	0.5%	87.7%	0.5%	87.9%	0.3%
Transit	2.5%	Percent of Trips	2.9%	17.0%	2.9%	18.3%	2.7%	9.4%
Bike	2.7%	Percent of Trips	2.7%	-0.3%	2.7%	-0.2%	2.7%	0.1%
Walk	6.7%	Percent of Trips	6.7%	0.5%	6.7%	0.5%	6.7%	0.7%
Vehicle Mobility (vehicle miles traveled)	6,228,031.0	Miles/Day	6,167,134	1.0%	6,159,983	1.1%	6,166,174	1.0%
Vehicle Crashes (crashes per year)	2,865.0	Crashes/Year	2,837.0	1.0%	2,834.0	1.1%	2,837.0	1.0%
Bicycle Connectivity (% in largest connected area)	68.2%	% of largest area	80.2%	17.7%	85.3%	25.0%	85.3%	25.0%
<b>Economy</b>								
Access to Jobs (average travel time to work)	10.6	Minutes	10.4	2.0%	10.4	1.9%	10.4	1.8%
Transit Accessibility (total population within ¼ mile of transit stop) (2040)	67,185	People	71,276	6.1%	70,057	4.3%	69,677	3.7%
Transit Accessibility (total employment within ¼ mile of transit stop) (2040)	52,633	People	55,791	6.0%	55,239	5.0%	54,496	3.5%
<b>Environment</b>								
	Value	Unit of Measure	Value	% Change	Value	% Change	Value	% Change

### *Implications of the CA-MPO Process*

There are three unique features of this process that differ from the FTA New Starts allocation process and the VDOT allocation process.

First, the CA-MPO process evaluates the transportation projects together rather than individually. This approach allows the MPO and the public to understand the joint impact of the projects; thus, these project 'scenarios' are a more holistic approach to project evaluation. VDOT could modify their project selection process to mimic this feature of the CA-MPO. However, given that VDOT is responsible for an enormous list of projects, this scenario approach would require a significant amount of additional effort. In addition, as VDOT oversees largely disconnected areas of the state, the marginal benefit of this approach would likely be small. The FTA could also evaluate projects in its New Starts program in unison. However, as these projects are located across the United States, the value of this joint evaluation would likely be very small.

The second prominent feature of the CA-MPO process is that the process is iterative. By iterating through the process with minor modifications to the projects each time, CA-MPO is able to develop project scenarios which are better than the original three scenarios that were proposed. This iteration approach would have value for both VDOT and the FTA, and we use iteration to yield similar benefits in the CLIOSjre Process (see Chapter 5).

Finally, the CA-MPO process considers each performance measure separately and does not weigh them together. This differs from both the FTA New Starts and VDOT processes. By considering each metric separately, CA-MPO avoids a potentially contentious debate on how to weigh the performance measures together. However, as noted in Chapter 2, humans have difficulty parsing more than a few criteria for evaluation. With sixteen performance measures, it is likely that most of the participants in the planning process considered only a handful of performance measures in their decision. Reducing the complexity of the evaluation (either by reducing the number of performance measures or by combining them into a single overall rating) would likely benefit the CA-MPO Process.

To complete this background on the federal, state, local planning processes, we discuss below an example of political interference in the performance-based planning process: the Route 29 Corridor.

### 3.5 Politics in Performance-Based Planning: The Route 29 Corridor

In the 1970's, local and state governments identified a need for new transportation infrastructure along the Route 29 corridor near Charlottesville. Highlighted in Figure 3-5, this segment of the corridor had developed persistent traffic problems. In 1979 in response to this apparent need, VDOT developed a plan for a bypass road around a segment of Route 29 in Charlottesville. This plan for a bypass was not well-received by the city, and the proposed bypass plan was shelved for nearly a decade.

This bypass, the Western Bypass, became a long-running proposal to solve traffic in the area. A contentious relationship between the city and the state resulted in a complex political history for the bypass. In part because of this long history, the Western Bypass was grandfathered into the new planning processes of the CA-MPO and VDOT. When the project was abruptly canceled in 2014 near the end of CA-MPO's long range planning process, the cancellation forced the MPO to scramble to find appropriate replacement projects.

Below we review the history of the project and its impact on the CA-MPO process.

Figure 3-5. VDOT Congestion Estimates along Route 29 (Modified from Virginia Department of Transportation, 2016)



### *History of the Western Bypass*<sup>28</sup>

Nearly a decade after the initial proposal by VDOT, increasing traffic along the Route 29 corridor in Charlottesville provoked the state to formally study the need for a bypass in 1987. By 1990, VDOT adopted a plan for the bypass and begun the federally-mandated environmental review process. To reduce city and county opposition to the project, the state agreed to bundle several other transportation projects into the planned bypass. With the approval of the MPO, city, and county, the state began to acquire land along the proposed route of the bypass.

By 1995, the federal government had formally approved the bypass project. This approval released federal funds for the project, and Virginia's Commonwealth Transportation Board approved the project for engineering and construction. Due to local opposition to the intersection design, the city and county become opposed to the bypass once again. After several impact studies and lawsuits, the federal government required VDOT to reperform the environmental analysis in 2000.

Over the next several years, political heavyweights at the state level weighed in on either side of the bypass debate in hope of changing the course of the decision. By 2006, the bypass was again removed from the state's long range plan.

<sup>28</sup> The chronology of events in this section are based on the Charlottesville Tomorrow's interactive timeline (2012).

In the late 2000's the mayors of cities south of Charlottesville (the cities directly affected by the traffic on Route 29) presented their case to the state. Several cities claimed that they were unable to get businesses to locate in southern Virginia because of the traffic along Route 29 in Charlottesville. Once again, the bypass found its way into the statewide transportation plan despite strong opposition from Charlottesville.

In 2011, a statewide freight study identified the Route 29 corridor near Charlottesville as a significant bottleneck. In the official public comments of the report, the City of Danville (a city south of Charlottesville) called on the state to “Make bypass around Charlottesville, VA.” Political pressure forced Albemarle county to reconsider the bypass, and in an unexpected reversal of past position, the county supported the bypass in opposition to the City of Charlottesville. By mid-2012, over three decades after the bypass was originally proposed, the engineering and construction of the bypass was again underway.

In a last ditch effort to stop the bypass, a vocal opposition campaign identified alternate solutions that claimed to solve the same traffic problems as the bypass. This local campaign cast doubt on the necessity of the bypass, and in mid-2014 the federal government sent a letter to the state asking it to reevaluate the need for the bypass. This letter proved to be the final blow that ended the bypass: less than three months later, the bypass was canceled and was replaced by a set of alternate solutions to the traffic problem.

### *Implications for Performance-Based Planning*

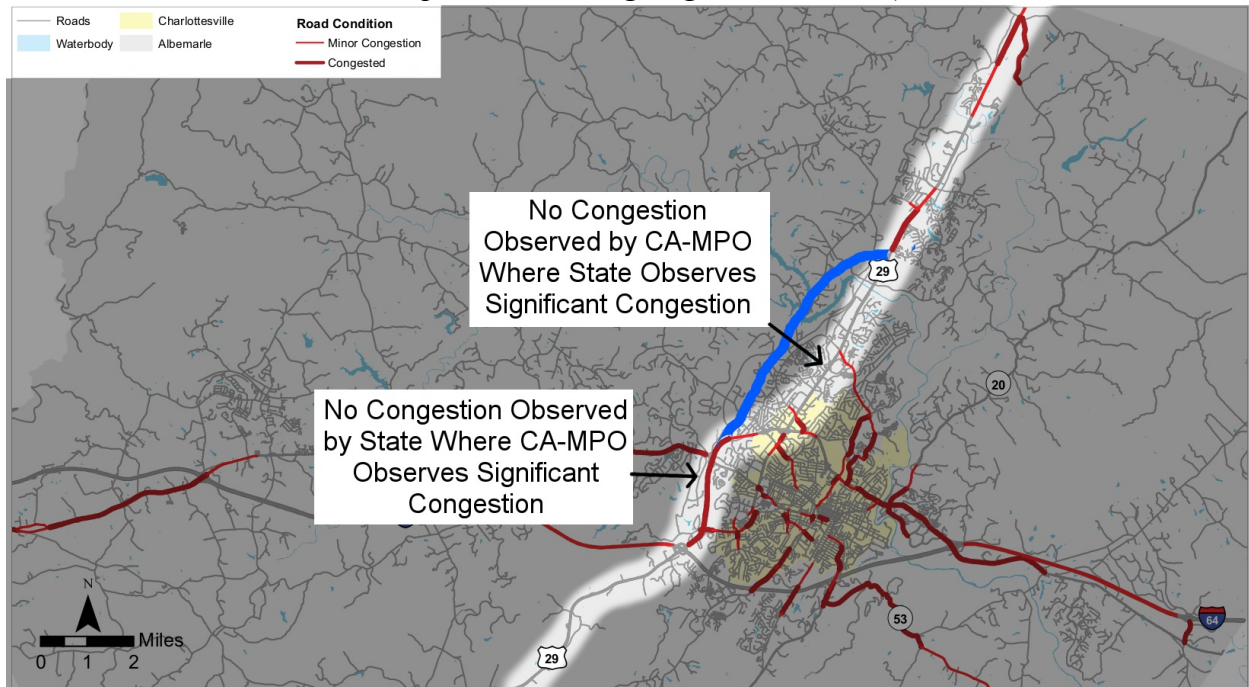
Whether the Western Bypass was a necessary solution to traffic on Route 29 falls outside the scope of our analysis. Rather, we observe that the planning process surrounding the bypass was simultaneously inefficient, ineffective, and detrimental to the credibility of the federal government, the state, and the local agencies. After 37 years of planning, study, engineering, review, debate, and acquisition of land, the residents of Charlottesville, Albemarle County, and southern Virginia remain without a solution to the traffic on Route 29 near Charlottesville. Although implemented late in the planning process, the new performance-based planning methods at the state and local level were ineffective at developing a rational solution to this problem. It remains to be seen if the alternate solutions implemented after the cancellation of the bypass will indeed solve the traffic on Route 29; unfortunately, there are no performance measures or data to validate their selection as a solution to the traffic.

We identify two reasons why politics rather than rational planning drove the decision-making along the Route 29 corridor:

First, the data available to the MPO (and likely the state as well) was not sufficiently granular to accurately measure the traffic problem along Route 29. Indeed, by contrasting the traffic estimates from CA-MPO in Figure 3-6 with the traffic estimates by VDOT in Figure 3-5, we observe that the data from CA-MPO shows no traffic along the section of road which has the

greatest congestion according to VDOT and vice versa. This disagreement between the two agencies suggests that the data was either insufficient or could be interpreted in multiple ways depending on the perspective of the agency.

*Figure 3-6. Congestion Estimates by CA-MPO (Modified from Charlottesville-Albemarle Metropolitan Planning Organization, 2014)*



The second reason for the political decision-making surrounding the Western Bypass was the disagreement between local and state needs. This fundamental disagreement in priorities combined with the lack of robust data created a perfect storm surrounding the project, a political storm that raged for nearly four decades. In addition to emphasizing the importance of robust data, the story of the Western Bypass emphasizes that performance-based planning (and indeed, multicriteria decision aids in general) cannot resolve fundamental disagreement. These methods are most effective when there is an agreement overarching goals and a disagreement in execution.

In the final section of this chapter, we reflect on the lessons learned from the federal, state, and local planning processes, and we apply these lessons to our work on the CLIOSjre process.

### 3.6 Implications for Performance-Driven Planning and the CLIOSjre Process

In our review of federal, state, and local performance-based planning, we identified several important features of these decision aids which can make them more or less useful. Below is a brief summary of these lessons.

- A key value of multicriteria decision aids is that they provide transparency in the decision-making process. In the case of the Federal Transit Administration's New Starts program, the primary motivation of their weighting scheme is provide transparency to improve the public accountability of their decision-making process. Whenever there are multiple stakeholders involved in a decision, transparency is critical to ensure that all (or at least most) of the stakeholders support the result of the process.
- Objective evaluation criteria and robust data to support those criteria are important features of any practical decision aid. When there are many stakeholders involved in a decision, a subset of those stakeholders will disagree with the individual criteria evaluations. This was the case for Charlottesville-Albemarle MPO when they were developing their long range transportation plan. Objective criteria and robust data make it difficult for disappointed stakeholders to hijack the process.
- Weighing multiple evaluation criteria into a single overall rating is useful as it reduces the complexity of the result for stakeholders. A single overall rating makes the evaluation result easier to compare and discuss. Unfortunately, the weighting process often becomes a point of contention among stakeholders as happened with the Virginia Department of Transportation's weighting system. We address this problem further in the next chapter: Development of a Multicriteria, Multistakeholder Decision Aid.
- Although multicriteria decision aids can help align the values of similar stakeholders, these decision aids are ill-equipped to resolve areas of fundamental ideological disagreement. As was the case with the Western Bypass, multicriteria decision aids cannot resolve long-standing disagreement.

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In the next chapter, we use the lessons from this review of federal, state, and local planning processes to develop a multicriteria, multistakeholder decision aid.

## 4 Development of a Multicriteria, Multistakeholder Decision Aid

As discussed in the preceding chapter, the alternatives analysis processes in the United States remains subject to political influence. Despite these pitfalls, transportation planners at the local, state, and national level continue to push for and implement more objective decision-making processes. Inspired by these efforts in the public sector, we set out to develop a more advanced decision-making aid which addresses some of the issues that currently plague the decision-making process. In particular, we set out to address the multistakeholder issue which is not addressed by decision processes currently in use by the public sector.

Our sponsor for this research is the East Japan Railway Company (JR East) – the largest passenger railway in the world by number of passengers. JR East hopes to expand the reach of the company beyond the borders of Japan, and our research team worked with JR East to help them understand the investment alternatives available to them. For more detail on these investment alternatives and the final form of our decision aid, the CLIOSjre Process, see Chapters 5 & 6.

In this chapter, we focus on the structure of the decision facing JR East and develop a method to resolve the multistakeholder issue. Although the method that we develop in this chapter, Critical Preference Analysis (CPA), was not put into practice by JR East, CPA provides a useful introduction to the analytical problem. In addition, this description of CPA motivates our development of the CLIOSjre Process in Chapters 5 which JR East does plan to put into use for their international investment decisions.

**Terminology Note:** Throughout this chapter, we use terminology as it is used in the CLIOS and CLIOSjre Processes. JR East (the *decision-maker*) is faced with a choice between one of many *bundles* (investment alternatives). In order to understand the merits of each bundle, our team analyzed these bundles using a number of *metrics* (value criteria). Each bundle is assigned a *grade* (from A to F) for each of the metrics. Informed by the decision-maker's preferences (JR East's preferences), a set of *weights* (referred to as a *strategy vector*) combines the individual metric grades into a single *overall grade* for each bundle. By comparing these overall grades as well as the metric grades, JR East arrives at a better understanding of the various investment alternatives and its investment decision for expanding into the international high-speed rail market.

### 4.1 Motivation

As stated above, the goal of CPA is to provide JR East with a better understanding of its investment decision. This understanding of the decision must be robust so that JR East can rely

on the outcome of the analysis. In addition, the model used to come to this result must be easy to understand so that JR East is confident in the result and can use the result to arrive at an investment decision.

Below is a summary of the context of CPA as applied to JR East:

- The decision-makers within JR East have multiple objectives they wish to accomplish. (These objectives are formalized as separate metrics in our process.)
- The preferences of the JR East are not known in advance of our analysis. They will be applied after the analysis is complete.
- The method used to reach this result must be transparent and easy to adjust to enable intracompany negotiation.
- The method used must produce a robust result that JR East can rely upon for this and other future investment decisions.

As discussed in Chapter 2, there is a large body of research focused on this type of decision problem. In particular, Multicriteria Decision Analysis (MCDA) research addresses this problem by presuming that the human decision-making process is the gold standard for decision-making; the research seeks to mimic and augment human decision making. Although this research contains an impressive array of decision models and processes, many models require a long series of back-and-forth interactions between the analyst (our research team) and the decision-maker (JR East). As mentioned in our list of constraints above, we will not have the opportunity for long sessions with the decision-makers within JR East.

In addition, although many of the MCDA processes designed to mimic and augment the human decision making process, most of these models are not easy to grasp for those not familiar with the research. Further, none of the models (as of the writing of this thesis) address the multistakeholder issue in a satisfying way. These limitations of the existing research motivated our development of CPA.

The creation of CPA also stems from the set of particular, though not unique, circumstances of our research. In our research for JR East, we must perform and deliver our analysis without knowledge of JR East's preferences. Simultaneously, the result of our analysis must accurately reflect the multifaceted business strategy of JR East. These seemingly contradictory requirements led us to develop CPA – a process which provides useful analysis that reflects JR East's priorities without advance knowledge of how JR East would rank these priorities.

As with other MCDA processes, we developed CPA as an augmentation to the human decision-making process. We posit that CPA is easier to understand than similar decision aids, and the process works well with multiple stakeholders. CPA enhances the accuracy of a decision without dramatically increasing the perceived complexity for the client. Thus, CPA produces a more robust result. As important, CPA is a transparent process which enables JR East to use the results



of the process in their intracompany negotiations.

## 4.2 Background

The combination of multiple metrics into a single ranking of the available bundles is well-studied in Multicriteria Decision Analysis. Many MCDA methods solicit detailed preference information directly from decision-maker. These methods are advantageous as they can capture an accurate picture of decision-maker preference without making assumptions on the underlying decision model.<sup>29</sup> Once all or most preference information is known, there are a litany of methods available that interpret this information to reach a robust and defensible result.

### *Limitations of Existing Methods*

Despite the advantages of these complex decision models, they have several significant limitations that prevent us from using them. In particular, when preference solicitation is not possible, these models are non-functional. In our case, there are four reasons we cannot use a complex decision model:

1. There are multiple decision-makers and many stakeholders. These stakeholders are not equally informed about the decision and need to be brought up to speed to provide an informed judgment. Further, prioritizing the opinions of each decision-maker would be a political (and inherently messy) procedure. Soliciting preferences from all these decision-makers and negotiating priority would require a significant amount of company time which is not available to our research team.
2. As evidenced by the discussion in chapter 3, preferences are not fixed. Even for a single decision-maker, preference is sensitive to time and context. Changes in the presentation of information may result in a difference in preference. This is a well-documented problem in preference modeling.<sup>30</sup> In addition, as more information becomes available over time, a single decision-maker's preference may change.<sup>31</sup> Thus, the preference solicited at the beginning of the analysis may not accurately reflect preference at the completion of analysis.
3. The decision-makers within JR East must be convinced of the method's validity in order to embrace the conclusion. Thus, the decision model of choice must be not only specific and transparent but also clear. The more complex MCDA methods take time to understand. This limitation is especially important when there are a large group of people involved in the decision, as is our case.
4. The decision is time-sensitive i.e. there is an opportunity cost of delay. In order to provide

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29 For more on these process, see the work of Meltem & Tsoukiàs, 2005.

30 For more about changing preference and their effect on decision-making, see Meltem & Tsoukiàs, 2005.

31 An iconic example of humans' changing preferences is described in Tversky & Kahneman, 1974.

a result to the decision-makers within a reasonable amount of time, the method employed must deliver a robust and defensible result quickly and be easily understood by the decision-makers. More complex decision models take more time to solicit preference (issue 1) and more time to communicate to the decision-makers (issue 3). Thus, these complex decision models are not a viable solution.

### 4.3 Proposed Solution

Given these issues, we are limited to a small selection of straightforward decision models. Rather than selecting the most robust model as the basis for CPA, we have chosen one of the most easy to understand: a linear decision model wherein each of the metric grades are weighed by a linear strategy vector to produce an overall grade. By enhancing this simple model with CPA, the linear decision model can capture some of the subtleties of a more complex decision model. In addition, the linear model remains clear and thus relatively easy to communicate to the decision-makers within JR East. Using this linear model and CPA, no preferences are solicited from the decision-maker in advance. This approach to the analysis resolves all four issues above.

#### *Critical Preference Analysis*

Below we present the initial version of Critical Preference Analysis. As discussed above, CPA is an augmentation to a linear decision model where each of the metric grades are weighed linearly together with a strategy vector. In this linear model, the preferences of the decision-maker are expressed in the strategy vector. Metrics with a larger weight in the strategy vector are more important to the decision-maker. These weights represent an implicit trade-off between the metrics i.e. how much of a loss in one metric the decision-maker would be willing to accept in order to achieve a gain in another metric. CPA makes use of this implicit trade-off to identify the key differences between two bundles.

Rather than working to identify the correct strategy vector which represents JR East, CPA seeks to provide as much information as possible about the choice of vector. In this way, CPA reduces the complexity of the choice for the decision-maker without making assumptions about the decision-maker's preferences. This provides the decision-maker (JR East) with information about how their choice of strategy vector will influence the final result. In addition, the improved information increases the transparency and ease of adjustment of the model (by allowing the decision-maker to try out different strategy vectors) and ensures that the final choice of strategy vector is robust.

#### *Details of the Analysis*

With the goal of presenting the decision-maker with a limited selection of strategy vectors, CPA relies on the observation that many strategy vectors will yield the same result. Many strategy

vectors will give the same bundle the highest grade. In other words, although there are an infinite number of weights that could be used to combine the metric grades, there are only a limited number of final outcomes. CPA reverse-engineers the decision model to identify which strategy vectors would result in same bundle receiving the highest grade (i.e. which strategy vectors would recommend the same final decision). By summarizing which strategy vectors yield in the same result, CPA provides a better understanding of the decision without assuming a particular outcome.

It is possible to perform an exhaustive sensitivity analysis to understand which strategy vectors yield the same result. However, it is easier (and faster) to focus on the boundaries where a slight change in the strategy vector flips the result from one bundle to another.<sup>32</sup> The linear decision model we selected for our analysis makes the calculation of these boundaries very straightforward. The entire analysis can be completed without becoming prohibitively lengthy.

To illustrate CPA, we define the decision problem in mathematical terms below. For those readers who prefer to learn visually, we recommend that you skip ahead to sub-chapter 4.4 where we outline the same process in geometric terms.

## Formal Setup

We are given a complete set of bundles

$$Bundles = \{A, B, C, D, \dots\}$$

where each bundle is completely described by a set of  $n$  metric grades

$$A = \{a_1, a_2, a_3, a_4, \dots, a_n\}, \quad B = \{b_1, b_2, b_3, b_4, \dots, b_n\}, \quad \dots \text{etc.}$$

( $a_i$  is the grade of bundle A according to metric  $i$ )

and a single strategy vector 'W' combines the metric grades into a single overall grade 'S' for each bundle.

$$W = \{w_1, w_2, w_3, w_4, \dots, w_n\}^T$$

$$S_a = AW, \quad S_b = BW, \quad S_c = CW$$

Our task for *each bundle* is to find the range of strategy vectors for which this bundle is the 'best choice' i.e. the strategy vectors such that this bundle has the highest overall grade in comparison to the other bundles. This problem is formulated below.

$$\forall i \in Bundles, \text{ Find } W \text{ s.t.}$$

$$S_i \geq S_a, S_b, S_c, \dots$$

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<sup>32</sup> This notion is inspired by the PROMETHEE VI 'human brain' model as described by Jean-Pierre Brans, 2005.

As mentioned above, the simplest solution to this problem (thought not necessarily the easiest) is to iterate through all possible strategy vectors. However, for each additional metric and bundle, this approach scales poorly. Even with only a modest number of metrics and bundles, this approach becomes computationally prohibitive. Indeed, a problem with 10 metrics and 10 bundles calculated to an accuracy of 1/100th (i.e. each weight could have any value between 1 and 100) would require 50 Exabytes just to store the results.<sup>33</sup> Fortunately, it is straightforward to solve this problem in a more computationally efficient way. We illustrate this process below.

## Two Bundles with Three Metrics

To illustrate the process, we first we describe a simple problem with only two bundles and three metrics. As discussed above, the linear decision model a linear boundary in strategy vector space. This boundary provides useful information about the decision facing the decision-maker, and it is relatively easy to calculate.

With two bundles and three metrics, our problem statement is thus (adapted from above):

$$\text{Bundles} = \{A, B\} \quad A = \{a_1, a_2, a_3\}, \quad B = \{b_1, b_2, b_3\}$$

Find the strategy vectors  $W$  s.t.

$$S_a \geq S_a, S_b \quad \text{and} \quad S_b \geq S_a, S_b$$

Based on the problem statement above, a single linear boundary exists where the overall grades of the two bundles will be equal ( $S_a = S_b$ ). To verify that this boundary exists, we must check that the bundles satisfy two conditions:

1. There must be at least one metric for which bundle A is better than bundle B or bundle A would never be recommended. Formally,  $\exists i \in (1, 2, 3) \text{ s.t. } (a_i - b_i) < 0$
2. The inverse must also be true. Formally,  $\exists i \in (1, 2, 3) \text{ s.t. } (a_i - b_i) > 0$

If these conditions are not satisfied, the boundary does not exist – one bundle is always superior to the other.<sup>34</sup> However, if these conditions are satisfied, the linear boundary where  $S_a = S_b$  completely defines our solution. This boundary is defined by a simple system of equations:

$$0 = x_1(a_1 - b_1) + x_2(a_2 - b_2) + x_3(a_3 - b_3)$$

$$1 = x_1 + x_2 + x_3 \quad (\text{normalization})$$

$$0 \leq x_i \quad \forall i \in (1, 2, 3) \quad (\text{no negative weights})$$

Strategy vectors on one side of this linear boundary will result in a higher overall grade for bundle A; strategy vectors on the other side of this boundary will result in a higher overall grade

<sup>33</sup> 4 bits per result and  $100^{10}$  results. This is the problem may seem large for a typical decision set, but this is the problem we were presented with for our work with JR East.

<sup>34</sup> For those familiar with MCDA, this is a formalization of the requirement that both bundles are non-dominated.

for bundle B. Thus, by understanding this boundary, we completely understand the decision facing the decision-maker. The knowledge of this boundary significantly reduces the complexity of the problem for the decision-maker; rather than selecting specific weights, the decision-maker only needs to choose which of two representative strategy vectors better matches his or her preferences. Thus, the amount of input from the decision-maker is reduced from a plurality of options to a binary decision as the result of CPA.<sup>35</sup> This process produces a robust result using a transparent model thereby satisfying our original requirements.

### Two Bundles with N Metrics

This method quickly scales to handle an arbitrary number of metrics. The boundary in the N-metric problem is a multi-dimensional plane rather than a line, but this boundary is still easily defined by

$$0 = \sum_{i=1}^N x_i (a_i - b_i)$$

$$1 = \sum_{i=1}^N x_i \quad (\text{normalization})$$

$$0 \leq x_i \quad \forall i \in (1..N) \quad (\text{no negative weights})$$

And the validity conditions are

$$\exists i \in (1..N) \text{ s.t. } (a_i - b_i) < 0$$

$$\exists i \in (1..N) \text{ s.t. } (a_i - b_i) > 0$$

As before, the results of CPA provide the decision-maker with a binary decision between two representative vectors.

### M Bundles with N Metrics

Although additional bundles do not scale as easily as additional metrics, we are confident that this method would scale reasonably within the framework above. As before, we begin by calculating the pairwise boundaries between individual bundles. For M bundles, we find

$M \frac{(M-1)}{2}$  pairwise boundaries using the generalized system of equations above.<sup>36</sup> For each of

these boundaries, we then discard those which are invalid (i.e. those that do not satisfy the general validity conditions above). From here, we identify where the boundaries intersect. In the

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35 A great deal of literature emphasizes that humans are better at binary decisions (Saaty, 2005). This feature of Critical Preference Analysis may be leveraged as the problem scales up to many bundles. See below.

36 For our ten metric and ten bundle example above, this results in 45 pairwise boundaries – a hassle for manual computation, but a straightforward calculation for any software.

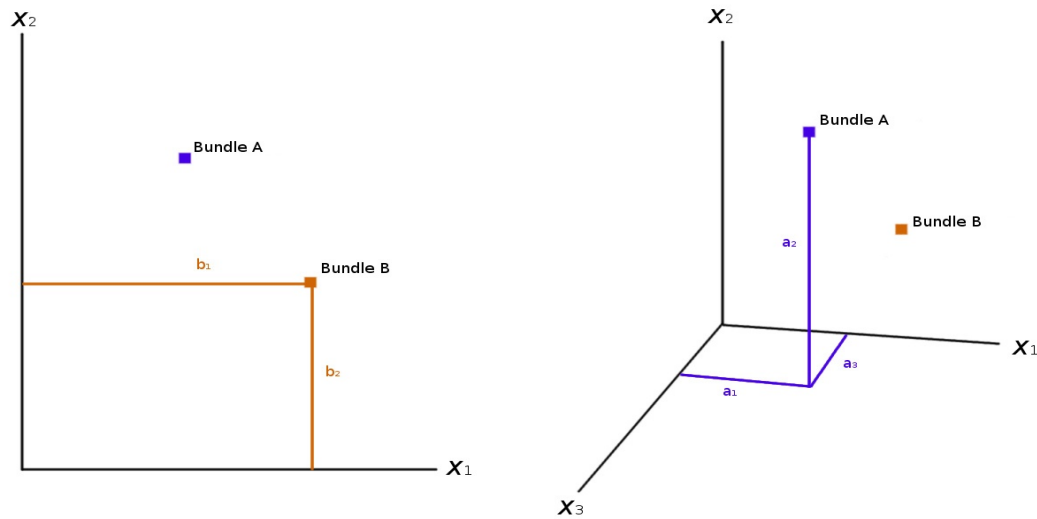
most general case, this produces as many as  $M^2 \frac{(M-1)^2}{4} - M \frac{(M-1)}{2}$  intersections between boundaries, though usually it produces in many fewer. The boundaries are then subdivided at the intersections, and the dominated boundaries are removed.

As in the case of with two bundles and three metrics, this process provides us with a complete understanding of the decision facing JR East. Without any need sensitivity analysis, we can definitively identify representative strategy vectors and present them to the decision-maker to decide between.

#### 4.4 Geometric Representation of Critical Preference Analysis

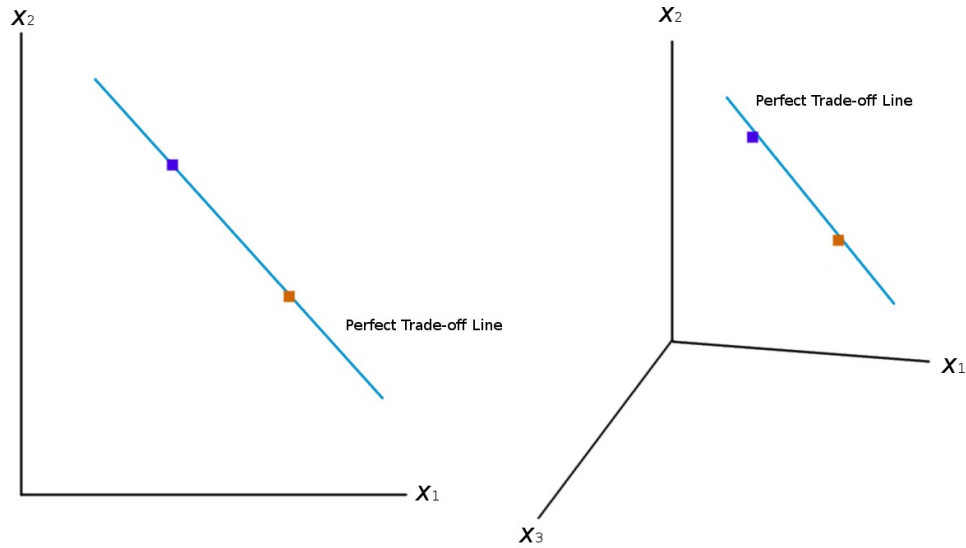
Critical Preference Analysis has a fairly simple geometric analogy, which is easy to visualize in two and three dimensions. The bundles are placed in metric space; their distance from each axis is determined by their metric scores.

*Figure 4-1. Bundles A and B in Two and Three Dimensional Metric Space*



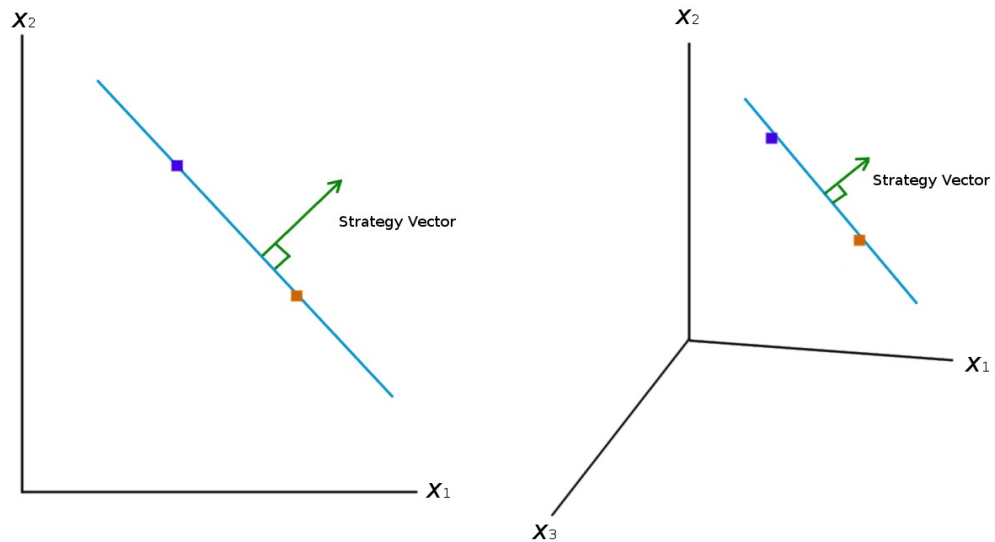
To find the decision boundary, we first find the line that passes through both bundles. This line represents a perfect trade-off between the bundles. For strategy vectors perpendicular to this line, the bundles are interchangeable.

Figure 4-2. The Perfect Trade-off Line between the Bundles



The strategy vector(s) that are perpendicular to this perfect trade-off line would recommend both bundles equally; in other words, they would be indifferent to the two bundles. These strategy vectors are at the boundary between the two bundles. Thus, to understand the boundary,

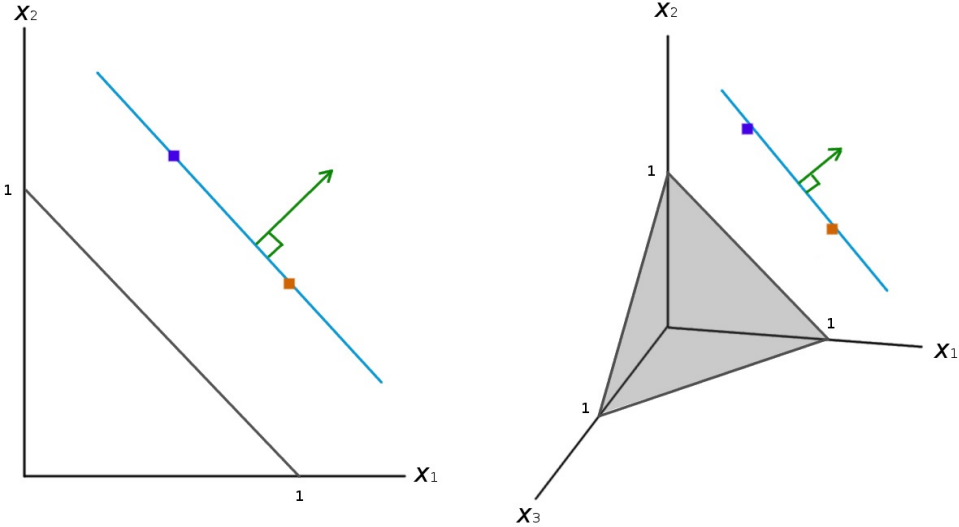
Figure 4-3. Strategy Vectors Perpendicular to the Trade-off Line



quantifying these strategy vectors is our goal.

The strategy vectors must be normalized so that their components add to one. In two dimensions, this defines a line of possible strategy vectors. In three dimensions, this defines a plane.

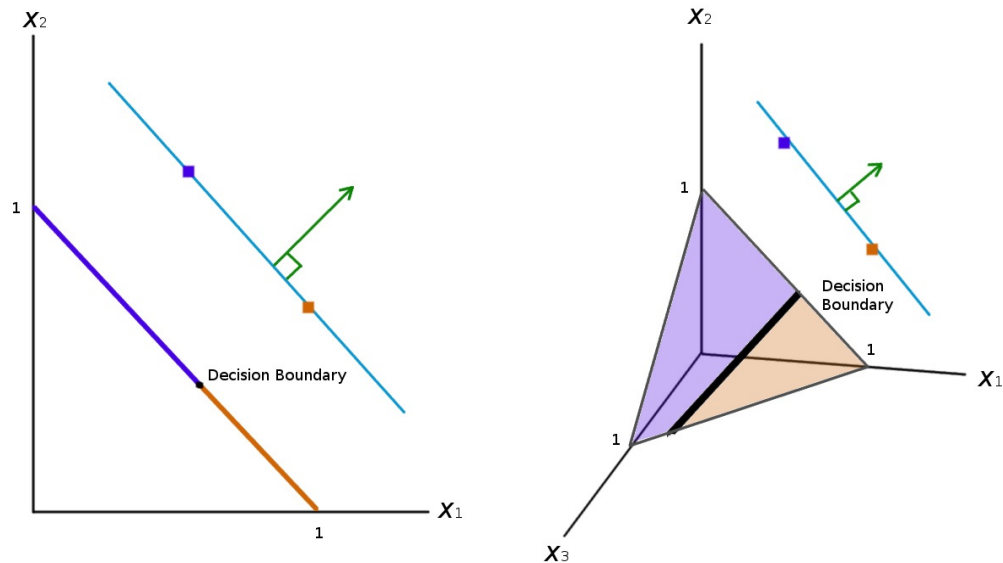
Figure 4-4. Visualization of the Range of Normalized Strategy Vectors



Finally, by finding the intersection of these perfect trade-off strategy vector(s) with the normalized range of strategy vectors, we define the decision boundary. On one side of this boundary, all the strategy vectors recommend bundle A. On the other side of this boundary, all of the vectors recommend bundle B. In two dimensions, this boundary is just a point (one strategy vector). In three dimensions, it is a line.



Figure 4-5. Visualization of the Decision Boundary



From the regions on either side of the decision boundary, a representative strategy vector can be identified. This representative vector represents the 'typical' strategy vector that would recommend the bundle (we discuss this typical strategy vector below). The decision-maker could then be presented with a simple binary choice between these two vectors. By choosing one of the two strategy vectors, the decision-maker could make an informed decision between the bundles in full confidence that all aspects of the bundles were taken into account.

## 4.5 Limitations of Critical Preference Analysis

Although Critical Preference Analysis has several practical advantages over the existing decision aids, there are drawbacks to the methodology. CPA has not yet been extended to more complex decision models. This prevents it from modeling non-linear human decision-making. Further, even if it were possible to extend the method to more complex decision models, it is not clear that the method would be a useful enhancement for complex models. These complex decision models are already difficult to understand, and the additional information provided by CPA may only exacerbate the problem.<sup>37</sup>

In addition, as we began to apply this new methodology to the decision facing JR East, we developed several fundamental concerns with CPA. Although CPA is easier to understand than many MCDA decision processes, we were not confident that we could communicate it to JR East

<sup>37</sup> For more detail on this problem, see Öztürk, Meltem, Alexis Tsoukiàs. "Preference Modelling." Multiple Criteria Decision Analysis: State of the Art Surveys: 27-71. Springer Science + Business Media, 2005.

during one of our meetings with the company. If JR East does not understand the process, the company will not feel comfortable using it in negotiation, and the process does not satisfy one of our key goals.

Second, an implicit assumption of CPA is that the bundles are mutually exclusive (i.e. only one of the bundles can be chosen). CPA could be extended to identify changes between the top two or top three bundles, but the additional complexity would make the result more difficult to understand. And the number of typical strategy vectors presented for the decision would become unmanageable.

Finally, and perhaps most importantly, there is no theoretical reason that the typical strategy vectors identified by CPA are useful points of reference. Although these typical strategy vectors are the mathematical average of all strategy vectors which 'choose' the same bundle (by giving it the highest grade of the available bundles), there is no guarantee that the average of these vectors are an appropriate preference representation for the decision-maker. On the contrary, as the typical vectors are simply the mean of possible strategy vectors, the typical vectors will tend to represent extreme preferences that put a great deal of weight on just one or two metrics. It is likely that these typical vectors would have no bearing on rational preference. Thus, although mathematically informative, these typical strategy vectors would not be useful for a real decision-maker.

Due to these substantial limitations to Critical Preference Analysis, we decided to refocus our efforts on a different decision aid. This new decision aid – the CLIOSjre Process – relies on the same linear decision framework as CPA. However, rather than pursuing a quantitative approach to improve the robustness of our analysis, the CLIOSjre Process develops a detailed qualitative process to improve the reliability and transparency of the process. We present the CLIOSjre Process in detail in the next chapter.

## 5 Development of the CLIOSjre Process

Although Critical Preference Analysis (CPA) allowed us to better understand decisions with multiple criteria, multiple stakeholders, and uncertainty, CPA did not provide results that would be useful for a typical decision-maker. CPA provided a robust mathematical understanding of the decision problem. But, as discussed in Chapter 4, this mathematical understanding was not easy to interpret, and thus the research team decided CPA would not be useful in our context. In this chapter, we present a new process – the CLIOSjre Process – which is nearly as mathematically robust as Critical Preference Analysis, much easier to understand, and thus more useful.

In the development of the CLIOSjre Process, we decided upon a linear weighting scale to combine the multiple value criteria of the decision-maker. Many analyses in Multicriteria Decision Analysis (MCDA) use a weighting function to combine independent value criteria into an overall value function. Our linear weighting scale proved much easier to understand than Critical Preference Analysis, and with several additions to this basic structure, we developed a robust process that successfully addresses multiple criteria, multiple stakeholders, and uncertainty.

The CLIOSjre Process was developed as part of a larger research project for the East Japan Railway Company. This larger market analysis process – the JR East Market Selection Process – consists of a back-to-back CLIOS Process and CLIOSjre Process analysis. For context, we introduce the larger JR East Market Selection Process below.

### 5.1 JR East Market Selection Process Value Proposition

The JR East Market Selection Process is designed to help JR East consider which international high-speed rail (HSR) markets it should pursue. Given the complex sociotechnical systems within which these markets exist, a deep understanding of each market is critical to making timely and prudent business decisions. The JR East Market Selection Process is designed to provide this deep understanding and aid in the final decision-making. The JR East Market Selection Process is divided into two processes:

1. The CLIOS Process applied to each HSR market from the perspective of the system.
2. The CLIOSjre Process applied to each market from the perspective of JR East.

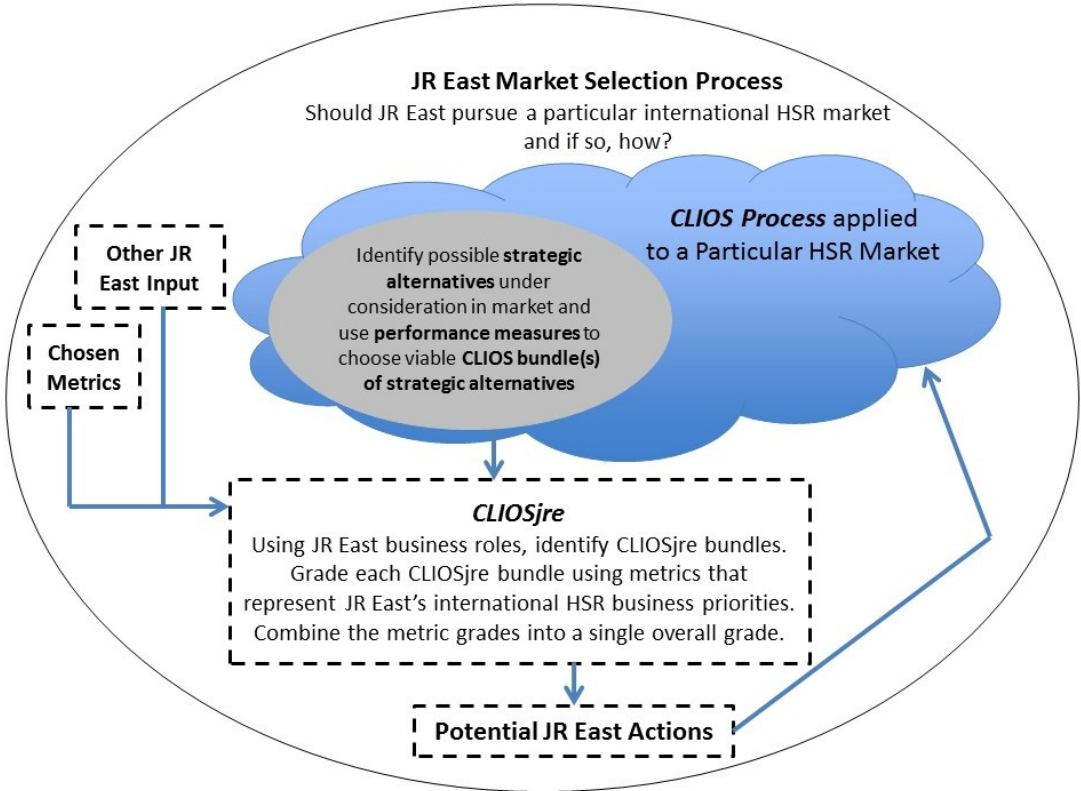
The value of 1) the CLIOS Process (introduced in Chapter 1) is that it gives JR East deep knowledge about a given market. In addition, it demonstrates to the stakeholders of the system and potential bidding partners that JR East has a serious interest in this market. Thus, the CLIOS Process provides an illuminating analysis for JR East and a marketing tool as well. Given the knowledge gained through the CLIOS Process, JR East can be a more sophisticated bidder and has a deeper understanding of the political and business climate of the HSR market.

The value of 2) the CLIOSjre Process (described in detail in this chapter) is that it provides a consistent, comparative framework for determining which of the available investment alternatives best fit JR East’s international business strategy. The process is designed to handle uncertainty within each market as well as uncertainty in JR East’s priorities. Most importantly, the CLIOSjre Process is designed to be transparent to facilitate negotiation and aid consensus between the multiple stakeholders within JR East.

The value of the overall JR East Market Selection Process is that it provides a regularized structure for information gathering and decision-making that can be applied to any international HSR market. The CLIOSjre Process is a key component of the JR East Market Selection Process, and in our discussions with the company, JR East has expressed great interest in using JR East Market Selection Process to inform their business decisions.

Figure 5-1 illustrates how the CLIOSjre Process fits within the context of the JR East Market Selection Process.

Figure 5-1. The JR East Market Selection Process



### 5.2 Terminology for the JR East Selection Process

The CLIOS and CLIOSjre Processes use a particular set of terminology explained in the following section.

- A *market* is a geographic area in which new or expanded HSR service is under consideration. Examples are the Northeast Corridor (NEC) of the United States and the proposed Kuala Lumpur-Singapore (KL-Singapore) HSR corridor.
- For each market, there will be one or more *CLIOS bundles of strategic alternatives*. These CLIOS bundles are development paths for the market that have been deemed feasible from the perspective of the system and the stakeholders of the market. These CLIOS bundles are outputs of the CLIOS Process.

An example of a CLIOS bundle for the NEC of the United States is

International-quality HSR on a new alignment with dedicated track,  
A vertically separated organizational structure with Amtrak as the operator, and  
Private funding for the infrastructure.

- During the *CLIOS Process*, each CLIOS bundle of strategic alternatives is evaluated by calculating various performance measures. Examples of performance measures include system safety, regional economic benefits, and financial viability.
- In the *CLIOSjre Process*, CLIOS bundles are evaluated from the perspective of JR East. The goal of this analysis is to help JR East decide which (if any) CLIOS bundles are interesting investment opportunities for the company. In order to achieve this understanding, we need additional information about the potential business role(s) for JR East in the market. Thus, each CLIOS bundle of strategic alternatives is translated from a CLIOS bundle to a *CLIOSjre bundle* by specifying the possible business roles for JR East. Each business role is an approach that JR East could take in the HSR market (e.g. turn-key system provider, technology provider, or operator). These CLIOSjre bundles are analogous to the investment *alternatives* in a typical decision analysis. In short,

$$CLIOSjre\ Bundle = CLIOS\ Bundle + JR\ East\ Business\ Role.$$

- Once translated from the CLIOS Process to the CLIOSjre Process, each CLIOSjre bundle is evaluated using *metrics*. Each metric captures an important indicator of value from JR East's viewpoint. These CLIOSjre *metrics* are analogous to the evaluation *criteria* in a typical decision analysis. CLIOSjre metrics include how the CLIOSjre bundle aligns with the strategic posture of JR East, JR East's ability to compete in this market, JR East's expected profit for this CLIOSjre bundle, and others.
- Each CLIOSjre bundle receives a *grade* for each metric based on inputs from the CLIOS Process and JR East.
- To calculate an *overall grade*, the CLIOSjre Process uses weights to linearly combine the metric grades. These weights collectively are the *strategy vector* that best exemplifies JR

East's international business strategy. The decision-makers are encouraged to try out multiple strategy vectors and compare the resulting overall grades.

- The metric grades, the overall grade, and a discussion of the result including assumptions and additional considerations are combined into an *assessment* of each CLIOSjre bundle. An example assessment sheet is shown in Figure 5-2 and Figure 5-3 on the next pages.

With each CLIOSjre bundle assessed by the CLIOSjre Process, JR East will be in a good position to make business decisions. Although JR East can choose between international HSR markets, the system stakeholders are the ones that will choose the development path (i.e. the CLIOS bundle) for the particular market. Thus, it is useful for JR East to complete the JR East Market Selection Process and develop a robust understanding of their possible investment decisions in order to be prepared for all possible outcomes. With this complete understanding of the market through the CLIOS and CLIOSjre Processes, JR East may take actions in order to 1) influence the CLIOS bundle selection of the system stakeholders, and 2) improve JR East's competitive position in the market.

The remaining sections of this chapter describe the CLIOSjre Process in detail. To illustrate the process with tangible examples, the CLIOSjre Process is described in the context of a particular HSR market: the Northeast Corridor of the United States. In addition, the CLIOSjre Process is described from the perspective of a particular decision-maker: JR East. To apply the CLIOSjre Process to a different investment decision, several components of the CLIOSjre Process would change (in particular, the CLIOSjre bundles and the CLIOSjre metrics). For clarity, we will discuss the CLIOSjre Process only in the context of the investment decision facing JR East.

### 5.3 Translating CLIOS Bundles to NEC CLIOSjre Bundles

As discussed above, the CLIOSjre Process builds from a CLIOS Process analysis of the HSR market. This CLIOS process application identifies CLIOS bundles (system development paths) and examines their performance in the HSR market. To use these CLIOS bundles in the CLIOSjre Process, we must add additional information about how JR East would pursue the HSR market. The CLIOSjre Process analyzes the system from JR East's perspective; thus, we must consider JR East's business role to understand the risks and benefits for JR East.

Compactly stated:

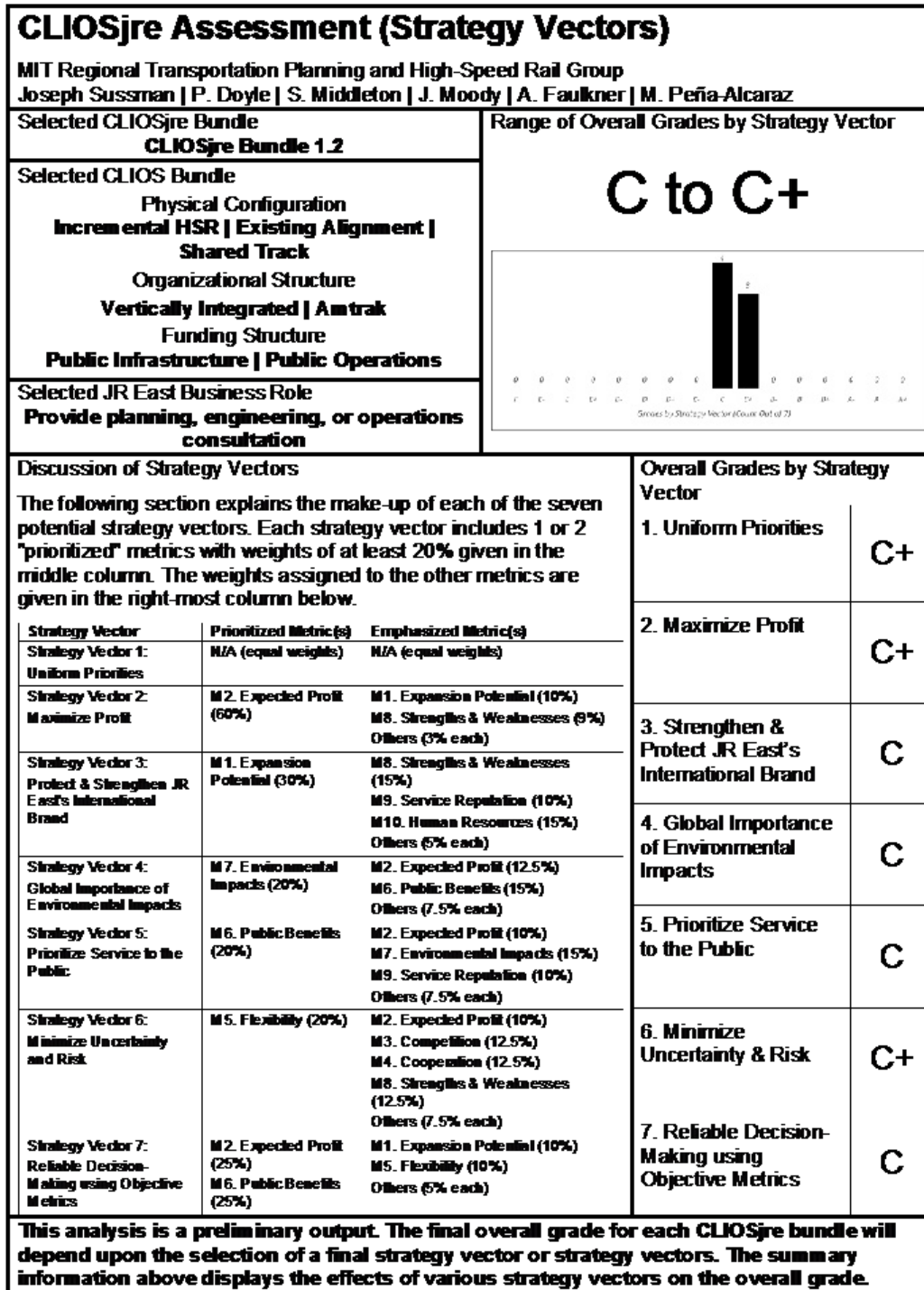
$$\textit{CLIOS Bundle} + \textit{JR East's Business Role} = \textit{CLIOSjre Bundle}$$

For each CLIOS bundle in the HSR market, JR East could have one of several business roles. To separately identify the benefits of each business role, we will enumerate all the plausible CLIOS bundle/business role combinations to produce a full set of CLIOSjre bundles. These CLIOSjre bundles will then be analyzed by the CLIOSjre Process.

Figure 5-2. Full Size Example Assessment from the CLIOSjre Process (Page 1)

<b>CLIOSjre Assessment (Metric Grades)</b>	
MIT Regional Transportation Planning and High-Speed Rail Group Joseph Sussman   P. Doyle   S. Middleton   J. Moody   A. Faulkner   M. Peña-Alcaraz	
Selected CLIOSjre Bundle <b>CLIOSjre Bundle 1.2</b>	Overall Grade  (see explanation on next page)
Selected CLIOS Bundle Physical Configuration <b>Incremental HSR   Existing Alignment   Shared Track</b> Organizational Structure <b>Vertically Integrated   Amtrak</b> Funding Structure <b>Public Infrastructure   Public Operations</b>	
Selected JR East Business Role <b>Provide planning, engineering, and operations consultation</b>	Individual Metric Grades and Measurement Error Ranges
<p>Discussion</p> <p>Like CLIOSjre bundle 1.1, CLIOSjre bundle 1.2 is based on the incremental HSR development of CLIOS Bundle 1. In this CLIOSjre bundle, JR East's involvement is limited to the provision of planning, engineering, and operations consultation to Amtrak on the NEC. Given JR East's long history of planning and executing HSR projects in Japan, we feel that the company is well positioned to assist on the planning of HSR in the Northeast. Similarly, the company is well-positioned to assist in the engineering and operation of HSR in the Northeast, although JR East may face intense competition from other international rail companies that also have experience as HSR consultants, particularly those that have experience in the United States or familiarity with incremental speed improvements rather than dedicated high-speed systems.</p> <p>This CLIOSjre bundle receives middle-ground grades in most metrics. The notable exceptions are Metric 6. Public Benefits and Metric 8. Strengths and Weaknesses. The bundle receives a grade of F in Metric 6 because the incremental improvements to passenger rail in this bundle offer a minimum of public benefits on the NEC. The bundle receives a grade of E in Metric 8 because the bundle aligns with some of JR East's weaknesses: lack of significant experience with shared right-of-way and mixed-speed traffic. Because of JR East's limited business role (and hence low risk) in this bundle, bundle 1.2 scores relatively well in Metric 5. Flexibility and Metric 9. Service Reputation. Because multiple partnerships might exist for JR East as consultants, the bundle also scores well in Metric 4. Cooperation. Due to the relatively even distribution of metric grades, this bundle receives an overall grade of C- to C+ under all strategy vectors.</p> <p><b>This bundle analysis is a preliminary output. The final overall grade for each CLIOSjre bundle will depend upon the selection of final strategy vector(s). The summary information on the next page displays the effects of various strategy vectors on the overall grade.</b></p>	Expansion Potential    Range Grade <b>C</b> D-B
	Expected Profit            Range Grade <b>C</b> D-C
	Competition                Range Grade <b>D</b> E-C
	Cooperation                Range Grade <b>B</b> E-B
	Flexibility                  Range Grade <b>B</b> B-A
	Public Benefits            Range Grade <b>F</b> F
	Environmental Impacts    Range Grade <b>B</b> B
	Strengths & Weaknesses    Range Grade <b>E</b> E
	Service Reputation        Range Grade <b>B</b> B
	Human Resources          Range Grade <b>D</b> D-C

Figure 5-3. Full Size Example Assessment from the CLIOSjre Process (Page 2)





Example: For international-quality HSR in the Northeast Corridor, JR East may 1) own and operate the system or 2) sell a turn-key system to another private operator (or have some other role e.g. design consulting). Although being owner/operator may provide higher profits to JR East, it will also come with higher risks than selling a turn-key system. The CLIOS bundle is the same in both cases but the CLIOSjre bundles include the particular business role. The business role of JR East will affect the value of the CLIOSjre bundle to JR East.

### *Business Roles of JR East*

To illustrate the CLIOSjre Process, we present below possible business roles of JR East. These business roles were developed jointly with the East Japan Railway Company, and they continue to be refined as JR East refines its understanding of the market. Although these business roles were constructed with the Northeast Corridor market in mind, these business roles would translate well to other HSR markets.

1. Do not become involved in the HSR market
2. Provide planning, engineering, or operations consultation (e.g. demand analysis, track design, or operations evaluation)
3. Maintain infrastructure under concession (owned by government/other owner)
4. Operate a system under concession (owned by government/other owner)
5. Operate a system by buying track capacity from a separate infrastructure manager
6. Provide HSR components (e.g. rolling stock)
7. Provide a turn-key system
8. Construct and operate a private system with infrastructure owned by JR East

## 5.4 Definition of the CLIOSjre Metrics

As with JR East's business roles, the CLIOSjre Metrics (i.e. value criteria) depend on the decision-maker and the particular decision at hand. To illustrate the typical scope of CLIOSjre metrics, we describe the CLIOSjre metrics for JR East's decision in the Northeast Corridor below. These metrics are presented in three sets: our preliminary list, our list after feedback from JR East, and our final list of metrics. These three sets emphasize that CLIOSjre metrics 1) much match the priorities of the decision-maker and 2) are developed by an iterative process. Through these multiple iterations, we believe that the CLIOSjre metrics for JR East's NEC investment decision properly represent the priorities of the company.

### *Preparing the CLIOSjre Process: Selecting Metrics*

Before we can use the CLIOSjre Process to evaluate the Northeast Corridor, we must identify the

metrics we will use to grade each CLIOSjre bundle. For JR East's investment decision, these same metrics will be used to grade all CLIOSjre bundles across HSR markets; this allows JR East to compare the CLIOSjre Process result from multiple markets. An essential input to the choice of metrics is JR East's priorities in their international HSR business. The multiple iterations of CLIOSjre metrics are provided below.

### **Preliminary List of Metrics (c. Spring 2015)**

**Metric 1. Strategic Posture:** How does this CLIOSjre bundle fit within the strategic posture and overall business model of JR East? This includes financial metrics as well as cultural similarities, geographic location, and political factors. Does this bundle facilitate future success for JR East in other HSR markets?

**Metric 2. Branding, Values, & Mission:** How does this CLIOSjre bundle align with JR East's international brand, corporate values, and mission? How does this CLIOSjre bundle contribute to JR East's international branding strategy?

**Metric 3. Competition:** What competition from other players does JR East face in this particular CLIOSjre bundle? How might JR East have a competitive advantage or disadvantage compared to other players? Factors would include JR East technology in comparison with that of competitors, pricing considerations, growth path opportunities, support after implementation, employment of domestic workforce, and geopolitical factors. An additional consideration is whether the system can afford what JR East is willing to sell.

**Metric 4. Joint Venture Partners:** Will JR East be able to find partners either among the stakeholders of the market or organizations outside the market? Will these partners be motivated work with JR East to develop this CLIOSjre bundle?

**Metric 5. JR East's Strengths and Weaknesses:** How does this CLIOSjre bundle align with JR East's strengths and avoid JR East's weaknesses in HSR system deployment?

**Metric 6. Political Support:** Does this CLIOSjre bundle have domestic support from political and economic leaders? Will this particular CLIOSjre bundle actually come to fruition?

**Metric 7. Social Benefit:** Does this CLIOSjre bundle make sense when one contrasts costs of developing the system with a) revenue and b) other benefits that may occur (e.g. economic development, reduced environmental impact)? The idea is that even with political support, a CLIOSjre bundle that does not create value for system stakeholders may not go forward.

**Metric 8. Expected Profit:** Does this CLIOSjre bundle hold reasonable expectation for profit for JR East and its partners in the short and long term?

**Metric 9. Human Resource Development:** Does this CLIOSjre bundle offer JR East employees

the opportunity to gain experience overseas? Does the CLIOSjre bundle offer JR East the opportunity to hire and train new employees from the country? This experience would benefit the employees as well as facilitate further expansion of JR East internationally.

**Metric 10. Flexibility:** Does this CLIOSjre bundle have sufficient flexibility to reduce JR East's risks (demand risk, macro risk, country risk, political risk, legal risk, technology risk, etc.) to an acceptable level?

### **New Metrics Suggested During Meetings with JR East**

In our meetings with JR East in February 2015, the company suggested additional metrics that should be considered as part of the CLIOSjre Process. Here we present the expanded list of metrics. This list of metrics is not mutually exclusive from the preceding list. For example, the environmental footprint of a particular CLIOSjre bundle could be captured within four metrics: M2. Branding, Values, & Mission, M6. Viability, M12. Sustainability, and M13. Environment. This double counting would skew the CLIOSjre Process results by creating a built-in bias (unless this bias is an accurate representation of JR East's priorities). We resolve the issue of double counting in the final list of CLIOSjre metrics below.

**Metric 11. Japan's National Strategy:** How does this CLIOSjre bundle align with the technology export strategy of Japan in rail and other sectors?

**Metric 12. Sustainability:** Does this CLIOSjre bundle promote a sustainable transportation system for the HSR market in terms of the economy, environment, and social equity? Does it improve the energy efficiency of the transportation system, reduce carbon emissions, and/or reduce maintenance and labor costs? Does this bundle promise equitable economic growth in the market?

**Metric 13. Environment:** Does this CLIOSjre bundle protect and improve the natural environment of the region that is developing the high-speed rail project? Will the long-term benefits of the HSR project (e.g. lower environmental footprint, dense development, consolidated travel patterns) outweigh the short-term costs (e.g. construction noise and pollution, ecosystem destruction)?

**Metric 14. Safety & Reliability:** Does this CLIOSjre bundle meet JR East's standards for safety and reliability? Will this CLIOSjre bundle improve safety and reliability over the existing transportation system?

**Metric 15. Society:** Does the CLIOSjre bundle improve the living, working, and travel conditions of the regional population? Will the long-term benefits of the HSR project (e.g. improved travel times, better access to the region, more employment opportunities) outweigh the short-term costs (e.g. displacement of residents, construction impacts, burden on the national budget)?

**Metric 16. JR East's Subsidiaries:** How will this CLIOSjre bundle benefit the subsidiary companies of JR East? Will this CLIOSjre bundle enable the growth of JR East's business lines (transportation, lifestyle business, IC card, rolling stock, etc.)?

### **Final Metrics Selected for the JR East Case Study of the CLIOSjre Process**

Based on the expanded list above, we developed a final list of CLIOSjre metrics for the JR East case study in the Northeast Corridor. These metrics are a combination of the original ten metrics proposed by the research team and the additional six metrics suggested by JR East. These final metrics are categorized to make them easier from the decision-maker to understand. As with the metrics above, each metric is defined by one or two key evaluation questions. Unlike the expanded list of metrics, these final metrics have very little double counting.<sup>38</sup> We will use these ten metrics to illustrate the CLIOSjre Process in this chapter and the following chapters.

#### *Financial Characteristics*

**Metric 1. Expansion Potential:** Does this bundle facilitate future success for JR East in other HSR markets? This metric considers brand exposure as well as cultural similarities, geographic location, and political factors.

**Metric 2. Expected Profit:** Does this CLIOSjre bundle hold reasonable expectation for profit for JR East and its partners in the short and long term?

#### *Market Characteristics*

**Metric 3. Competition:** What competition from other players does JR East face in this particular NEC CLIOSjre bundle? How might JR East have a competitive advantage or disadvantage compared to other players? Factors would include JR East's technology in comparison with that of competitors, pricing considerations, growth path opportunities, support after implementation, employment of domestic workforce, and geopolitical factors. An additional consideration is whether the market can afford what JR East wants to or is willing to sell.

**Metric 4. Cooperation:** Will JR East be able to find partners among the stakeholders on the CLIOS institutional sphere of the market given their selected business role in a CLIOSjre bundle? Will these partners be motivated to work with JR East to develop the CLIOSjre bundle?

**Metric 5. Flexibility:** Does this CLIOSjre bundle have sufficient flexibility to reduce JR East's risks (demand risk, macro risk, country risk, political risk, legal risk, technology risk, etc.) to an acceptable level?

**Metric 6. Net Societal Benefit:** Does this CLIOSjre bundle make sense for the public when one

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<sup>38</sup> For more detail on how we have avoided overlap between these metrics, see Chapter 6.

contrasts costs of developing the system with a) revenue and b) other benefits to society that may occur? Does the CLIOSjre bundle improve the living, working, and travel conditions of the regional population? Will the long-term benefits of the HSR project (e.g. improved travel times, better access to the region, more employment opportunities, economic growth) outweigh the costs accrued during construction (e.g. cost of constructing the system, displacement of residents, construction impacts) and other impacts during operations?

**Metric 7. Net Environmental Impact:** Does this CLIOSjre bundle protect and improve the natural environment of the region that is developing the high-speed rail project? Will the long-term local benefits of the HSR project (e.g. lower environmental footprint, dense development, consolidated travel patterns) outweigh the short-term local costs (e.g. construction noise and pollution, negative ecosystem impact)?

#### *JR East's Characteristics*

**Metric 8. Strengths and Weaknesses:** How does this CLIOSjre bundle align with JR East's strengths and avoid JR East's weaknesses in HSR system deployment? How will this CLIOSjre bundle align with the strengths of the subsidiary companies of JR East (e.g. Japan Transport Engineering Company's manufacturing expertise)? Will this CLIOSjre bundle build upon JR East's existing business lines (transportation, lifestyle business, IC card, rolling stock, etc.)?

**Metric 9. Reputation for Excellent Service:** Does this CLIOSjre bundle meet JR East's standards for safety, speed, and reliability? Will this CLIOSjre bundle improve safety, speed, and reliability over the existing transportation system? How does this CLIOSjre bundle align with JR East's international reputation for excellent service? Does the CLIOSjre bundle protect JR East's international brand?

**Metric 10. Human Resource Development:** Does this CLIOSjre bundle offer current JR East employees the opportunity to gain experience overseas? Does the CLIOSjre bundle offer JR East the opportunity to hire and train new employees from the country?

## 5.5 Definition of the CLIOSjre Process

The CLIOSjre Process is comprised of two major parts. The first part of the process sets up the CLIOSjre Decision Framework by gathering the necessary inputs from the CLIOS Process and from JR East itself. The second part operates the CLIOSjre Decision Framework to produce an assessment for all the CLIOSjre bundles within an HSR market (see Figure 5-2 and Figure 5-3). Below we describe the two parts of the CLIOSjre Process.

## *Part 1: Gathering Inputs*

Before running the CLIOSjre Decision Framework, we must gather the necessary inputs. The inputs for the CLIOSjre Process come from two sources:

- JR East Input
- Outputs of the CLIOS Process

### **JR East Input**

In order to make decisions that represent the interests of JR East, gathering input from JR East is critical. JR East's input informs three aspects of the CLIOSjre Process:

- the metrics are used in the CLIOSjre Process (described in Section 5.4 above),
- the business roles JR East is willing to take in a particular market (described in Section 5.3 above), and
- the strategy vector used to combine the metric grades into an overall grade (described in more detail later in this chapter).

### **Outputs of the CLIOS Process**

The second source of input for the CLIOSjre Process is the CLIOS Process. The contributions from the CLIOS Process are threefold:

- CLIOS Bundles of Strategic Alternatives
- The Performance Measures for each CLIOS bundle
- Qualitative Insights

#### *CLIOS Bundles of Strategic Alternatives*

The CLIOS bundles of strategic alternatives from the CLIOS Process are an essential input to the CLIOSjre Process. These CLIOS bundles outline the viable development paths for the market based on our understanding of the CLIOS system. Other CLIOS bundles which are not currently viable may also be included if they would be of interest to JR East.

#### *Performance Measures*

After generating a preliminary list of CLIOS bundles of strategic alternatives, the CLIOS Process uses a number of Ornaments (perspective-specific methods of analysis) to evaluate the performance of each CLIOS bundle. The ornaments rate each CLIOS bundle on how well it accomplishes the system goals (system safety, level of service, economic benefit, etc.). Through this evaluation, the performance measures enable the selection of the final CLIOS bundles of strategic alternatives for the market.

Once the final CLIOS bundles have been selected, the CLIOS bundles and associated performance measures feed into the CLIOSjre Process. Together with JR East Input and other CLIOS outputs, the performance measures determine the letter grade (A, B, C, D, E, or F) for each metric for each CLIOSjre bundle of strategic alternatives.

Example: The demand projections for a particular CLIOS bundle from the CLIOS Process will inform the evaluations of Metric 6. Net Societal Benefit and Metric 2. Expected Profit.

### Qualitative Insights

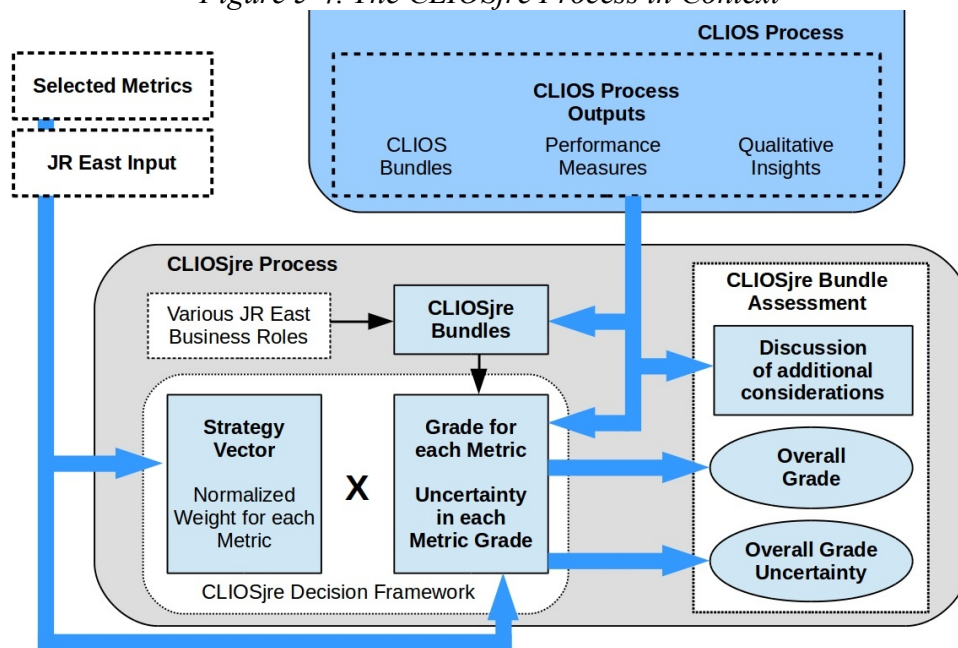
As part of the CLIOS Process, the R/HSR Group performed qualitative analyses that provide insight into the overall market. These additional analyses improve the understanding of the market and help determine metric grades for all the CLIOS bundles in a particular market.

Example: Predictive Coalition-Building Analysis – used in the CLIOS Process – will directly inform the evaluation of Metric 4. Cooperation.

## Part 2: Operating the CLIOSjre Decision Framework

Once we have all the inputs for the CLIOSjre Process and the metrics have been chosen, the research team operates the CLIOSjre Decision Framework. Operating the CLIOSjre Decision Framework produces a grade for each metric and an overall bundle grade. These grades are then combined with a discussion of each CLIOSjre bundle to produce an assessment for each CLIOSjre bundle (see Figure 5-4).

Figure 5-4. The CLIOSjre Process in Context



Operation of the CLIOSjre Decision Framework is composed of six steps. These steps evaluate each CLIOSjre bundle individually and produce an assessment for each (see Figure 5-2 and Figure 5-3). Once the entire CLIOSjre Process is complete for all CLIOSjre bundles for a particular market, these assessments can be compared to choose the appropriate action.

### *6 Steps of the CLIOSjre Decision Framework*

1. Determine Metric Grades for Each CLIOSjre Bundle
2. Check CLIOSjre Bundle Acceptability
3. Choose Strategy Vector
4. Calculate Overall Grade
5. Consider Overall Grade Measurement Error
6. Discuss Assumptions and Other Considerations

A description of each step follows.

#### **Step 1: Determine Metrics Grades for Each CLIOSjre Bundle**

The first step of the CLIOSjre Decision Framework is grading each CLIOSjre bundle using to each metric. To arrive at each metric grade, the CLIOSjre Process takes into account the performance measure values from the CLIOS Process, JR East's input, and additional qualitative knowledge about the CLIOSjre bundle from the CLIOS Process.

Although this step sounds straightforward, the synthesis of both qualitative information and quantitative information into a single grade poses a significant challenge. This synthesis must be a robust and as objective as possible. All methods of evaluation involve some degree of professional judgment. Thus, the R/HSR Group has worked to develop an evaluation method for each metric that provides a justifiable combination of the different types of information while remaining transparent to the reader. These metric evaluation methods are described in detail in Chapter 6.

#### *Mapping Metric Evaluation Results to Metric Grades*

In order to map each metric evaluation result to letter grade, we developed a method based on multi-criteria decision-making literature (especially the work of Mazurek, 2014). For each metric, we developed a spectrum of representative outcomes for each metric ranging from ideal (A) to failing (F).

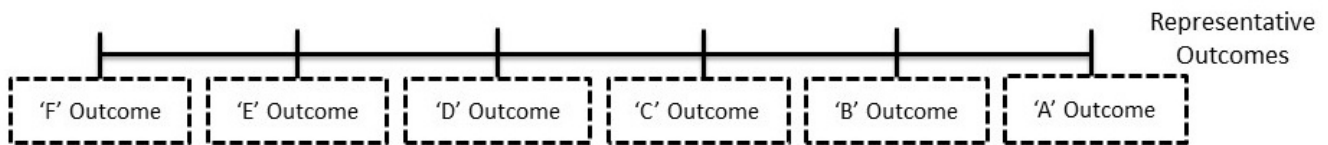
Example: For Metric 2. Expected Profit, an 'A' representative outcome has a return on investment (ROI) of 15% or more. In other words, pursuing a CLIOSjre bundle with an 'A' grade for Expected Profit would yield a 15% ROI. By contrast, an 'F' representative outcome has a negative ROI. This analysis approach relies on the assumption that all CLIOSjre bundles



will fall in between these two extremes.

These metric spectra are designed to capture the entire range of reasonable outcomes each metric. In between the extremes on the scale, we identify key representative outcomes that represent each letter grade. Figure 5-5 displays a visual representation of one metric spectrum.

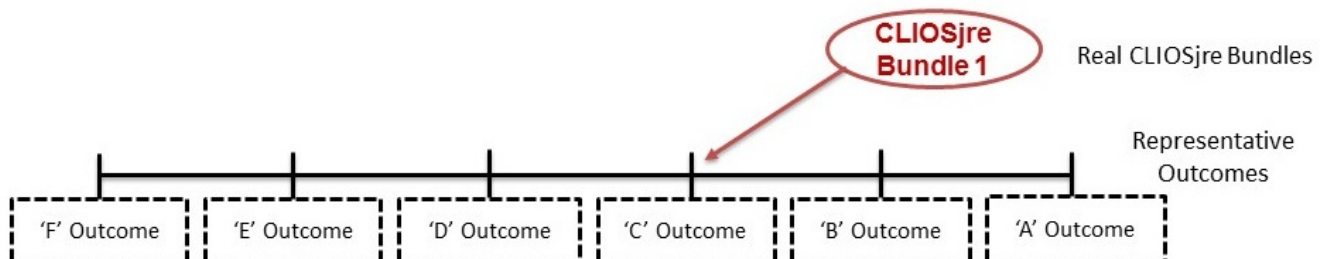
Figure 5-5. Developing a Spectrum of Representative Outcomes



Example: We will develop a spectrum for Expected Profit that imagines a set of representative outcomes that are more and less profitable. In this example, the 'A' outcome would have a ROI of 15%; the 'F' outcome would have a negative ROI.

Once this spectrum has been established for a metric, we place all the real CLIOSjre bundles for this market along this spectrum by comparing their evaluation result to the representative outcomes. Based on their location along the spectrum, the CLIOSjre bundles will then receive a grade for that metric. This process is repeated for all ten metrics and results in a metric grade for each CLIOSjre bundle for every CLIOSjre metric.

Figure 5-6. Placing a CLIOSjre Bundle on the Spectrum



Example: Once we have a spectrum for Expected Profit, we will compare the evaluation result for real CLIOSjre bundles with the representative outcomes to grade each real CLIOSjre bundle. In Figure 5-6, CLIOSjre Bundle 1 would receive the grade 'C' because it has a ROI that is closest to the 'C' representative outcome.

## Step 2: Check CLIOSjre Bundle Acceptability

Once the CLIOSjre bundle has been graded for each metric, we will determine if the CLIOSjre bundle meets a minimum standard of performance from JR East's perspective. CLIOSjre bundles

that do not meet the necessary minimum grades will be discarded without further analysis. The objective of this step is to ensure that only acceptable bundles are evaluated further. This will reduce unnecessary analysis in the evaluation of the market.

Example: Suppose a CLIOSjre bundle receives a grade of ‘D’ on Metric 2. Expected Profit. If JR East decides that, regardless of the other metric grades, this grade is unacceptable to JR East, this CLIOSjre bundle and other CLIOSjre bundles with a ‘D’, ‘E’, or ‘F’ on Expected Profit will be discarded without further analysis.

For our JR East Case Study (described in Chapter 6), we skipped this step of the CLIOSjre Decision Framework to provide JR East with a complete analysis of all seven CLIOSjre bundles.

### **Step 3: Choose Strategy Vector**

Once the unacceptable CLIOSjre bundles have been discarded, we determine the weights to combine metric grades into a single overall grade. As we explain in Step 4, the CLIOSjre Process adds the weighted grades to obtain the overall grade.

We now discuss how to develop a weighting scheme.

#### *Choosing Metric Weights*

In the CLIOSjre Process, each set of weights is called a *strategy vector*. The choice of strategy vector defines the overall grade of each CLIOSjre bundle. To ensure that the choice of strategy vector is representative of JR East’s priorities, we worked with JR East to identify the correct strategy vector. This strategy vector would allow us to determine a definitive overall grade for each CLIOSjre bundle in the market.

During our discussions with JR East, the company was reluctant to choose a single strategy vector to represent their priorities. In part, this reluctance reflected the multistakeholder reality of the company leadership; while some managing directors agree on the priorities of the company, their opinions typically (and understandably) diverge. Our linear weighting approach does not lend itself easily to decisions with multiple stakeholders. In the case of multiple stakeholders, it is unclear whether we should a strategy vector that represents one of the more senior stakeholders or the weighting that represents some 'average' stakeholder (i.e. taking into account multiple stakeholders but representing none of their views accurately). The research team agreed that choosing a single strategy vector to represent the company would be inappropriate.

Instead the research team identified several plausible strategy vectors using professional judgment. These strategy vectors represent different possible stances the company could take on its international business opportunities (e.g. an emphasis on expected profit, human resource development, branding, or a hybrid approach). These strategy vectors are not designed to represent any particular stakeholders within the company; this reduces the chance that a

stakeholder will become fixated upon one particular strategy vector. This multi-vector approach further encourages the stakeholders to negotiate over the weighting for the final strategy vector. In our preliminary discussions with JR East, they seemed quite satisfied with this approach as it allows them to gain a better understanding of the decision without committing to a particular strategy vector.

### *Fair Comparison Across Markets*

In order for the CLIOSjre Process to evaluate the relative merit of international HSR markets from JR East's perspective, we must develop a level playing field for comparison. One of our primary research questions is how the strategy vectors should change across HSR markets (if at all).

There are several ways to approach this issue. One approach is to use the same strategy vector for each market. This assumes that JR East has the same priorities in each market; but that may not be the case. Although identical weighting ensures equal comparison of the individual metrics, this may still not ensure an unbiased assessment for fair comparison across markets. An alternative method for comparing across international markets is to choose the strategy vector for each market separately. In this case, the strategy vector for the NEC would be different than the strategy vector for another market (e.g. KL-Singapore). Allowing the strategy vector to change across markets may make comparison of CLIOSjre bundles more difficult, but it may better reflect JR East's priorities across the different markets.

Example: Branding may be more important in the KL-Singapore market while Expected Profit may be more important in the Northeast Corridor of the United States. JR East could choose two separate strategy vectors to represent these different priorities in the two markets.

As the research team provided JR East with a set of strategy vectors for each market, we decided that it was not necessary to address the question of strategy vectors changing across markets. The set of strategy vectors presented to JR East are not a conclusive set, and if JR East believes other priorities are more relevant in a particular market, JR East can easily add to or adjust the existing strategy vectors.

### **Step 4: Calculate Overall Grade**

Once the weighting scheme has been established and the metrics have been graded, it is a simple matter to calculate the overall grade for each CLIOSjre bundle. After debating a number of potential formulae, the research team decided on an additive formula:

$$\text{Overall Grade}_{\text{CLIOSjre Bundle } i} = \text{Metric 1 Grade}_{\text{CLIOSjre Bundle } i} * \text{weight 1} + \text{Metric 2 Grade}_{\text{CLIOSjre Bundle } i} * \text{weight 2} + \text{Metric 3 Grade}_{\text{CLIOSjre Bundle } i} * \text{weight 3} \dots$$

We decided upon an additive structure for three reasons:

1. An additive structure is intuitive. This improves the transparency of the CLIOSjre Decision Framework for decision-makers.
2. An additive structure facilitates the selection of weights (Step 3) since the relative importance of metrics is easily observed.
3. Additive structures are widely used in the multi-criteria decision-making literature.<sup>39</sup> This allows the R/HSR Group to build on the results of previous research.

### **Step 5: Consider Overall Grade Measurement Error**

The CLIOSjre metrics are designed to be as objective as possible. However, any analysis requires some degree of professional judgment. To understand how our professional judgment might affect the metric grades of a particular CLIOSjre bundle, the research team worked to identify sources of measurement error in our analysis. Measurement error in our analysis arises because equally informed analysts could arrive at different conclusions using the same data and background information.

In Step 5 of the CLIOSjre Process, the research team attempted to identify sources of measurement error in our analysis. Some of these sources were easy to identify (e.g. the value of time or statistical value of a human life in our Benefit-Cost Analysis). These sources of measurement error arise from existing ambiguity in the literature and represents an ambiguity about the best method of analysis. Other sources of measurement error were more subtle and stemmed from our definition of metric spectrum or our approach to the metric analysis. For identifying measurement error, we assumed in this research that our evaluation method for the metric was correct.

Chapter 6 details our effort to quantify our measurement error for each CLIOSjre metric.

#### *Propagating Measurement Error to the Overall Grade*

With a range of measurement error for each CLIOSjre metric for each CLIOSjre bundle, it is important to propagate this measurement error to measurement error in the overall grade for each CLIOSjre bundle. By propagating this uncertainty through our linear weighting scheme, we aggregated the uncertainty in the metric grades into an overall grade uncertainty for each CLIOSjre bundle.

In the worst case scenario when we have no certainty about the letter grade for a particular metric, the metric grade could be anywhere between ‘F’ and ‘A’. This extreme measurement error does not prevent us from completing the analysis of the CLIOSjre bundle. By propagating this measurement error range through the linear weighting scheme of the CLIOSjre Process, this extreme uncertainty will be appropriately represented in the overall grade uncertainty.

To supplement this overall grade range, we will include a discussion of assumptions and

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<sup>39</sup> For examples of work with additive structures, see Ehrgott, 2005, and Keeney, 2013.

uncertainties within the CLIOSjre bundle assessment. We introduce these below.

## **Step 6: Discuss Assumptions and Additional Considerations**

In addition to the metric grades and overall grade for a particular bundle, each CLIOSjre Assessment will include a discussion section. This section will discuss the grades and present additional information that should be considered alongside the grades. Below we present a few examples of what may be covered in this discussion section.

### *Assumptions*

During the CLIOSjre Process, it will be necessary to make assumptions about the CLIOSjre bundle. These assumptions are necessary to fill in gaps in our information about the market (e.g. when the high-speed rail system will be developed) and gaps in our information about other stakeholders in the market (e.g. China Railway's approach to the market and how it may compete with JR East). This section of the assessment will detail these assumptions so that JR East understands what assumptions were inputs in our analysis.

### *Additional Considerations*

Some elements of each CLIOSjre bundle will be impossible to capture in the metric grades and overall grade. It will be necessary to make assumptions during our analysis of each CLIOSjre bundle. For example, each metric spectrum simplifies a range of evaluation results into just one of six possible metric grades. When we grade a CLIOSjre bundle using Metric 3. Competition, the choice of one of six grades simplifies the complex nature of competition. Additional details about competition that were revealed in the analysis but not captured in the metric grade would be detailed here.

This sixth and final step completes the CLIOSjre Decision Framework and the CLIOSjre Process. However, JR East has not necessarily arrived at a conclusion. In the final section of this chapter, we discuss how JR East can use the results of the CLIOSjre Process and additional factors that JR East may take into account in their decision.

## **5.6 Post-CLIOSjre**

With each CLIOSjre bundle graded by the CLIOSjre Process, JR East will be in a good position to move forward. JR East will have a detailed understanding of each CLIOS bundle and each CLIOSjre bundle within the HSR market. With multiple strategy vectors to analyze the CLIOSjre bundles, the stakeholders within JR East will be in a good position to understand their investment decision in the Northeast Corridor (or another market). These stakeholders can choose to pursue one or more CLIOSjre bundles, or stay out of the NEC HSR market altogether.

However, once JR East selects a CLIOSjre bundle to pursue, their success is not guaranteed. The

selection of the development path for the HSR system in the market (the CLIOS bundle) is done by the system stakeholders and not by JR East. JR East can hope to influence the decision toward development paths that are more attractive to JR East – where JR East can be more competitive. JR East can take actions intended to 1) influence the CLIOS bundle selected by the system stakeholders and/or 2) improve JR East’s competitive position in the market.

### *JR East Actions*

Because JR East is one of the institutional actors in the complex sociotechnical system surrounding the market, JR East's actions will affect the structure of the market. JR East's actions will affect the performance of a particular CLIOS bundle and its value to JR East as well as its value to other stakeholders. Depending on the complexity of the action and its impacts, it may be necessary to iterate between the CLIOS and CLIOSjre Processes to understand the effects of a particular action.

Example: In order to improve its competitive position, JR East could give a discount on the Shinkansen system in a particular market. This may improve the viability of the CLIOS bundle from the viewpoint of the system. However, offering this discount will likely lower the Expected Profit of the CLIOSjre bundle for JR East and therefore lower the overall grade. Iterating through the CLIOS and CLIOSjre Processes will help JR East understand the impact of this discount.

The R/HSR Group cannot independently assess what business actions JR East is willing to take. In addition, the actions available in one international market may not be available or useful in another. Furthermore, even within one market, certain JR East business roles within a CLIOSjre bundle could preclude or encourage certain actions. Nonetheless, we made a brief list of actions that JR East could use to improve their position in the market.

Example: If JR East is interested in a consulting business role for a particular market, then actions related to construction or operation do not make sense for that market.

### *List of JR East Actions*

We have identified a preliminary list of JR East actions below (in no particular order):

1. Offer a discount on the full featured Shinkansen or a discount on other services and components provided by JR East.
2. Offer an older model Shinkansen at a discounted price.
3. Offer a Shinkansen that has already been used in JR East’s operations.
4. Offer a complete, turnkey system but with less advanced capabilities than the full-featured Shinkansen at a discounted price.

5. Perform a demand study, right-of-way analysis, or other planning assistance.
  6. Offer low-interest loans for purchasing JR East products and/or services.
  7. Partner with an existing company in the market (or existing companies) to pursue the opportunity as a joint venture.
  8. Execute a combination of these actions.
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With a thorough understanding of the CLIOSjre Process and the context of the CLIOSjre Process in the larger JR East Market Selection Process, we now turn to a preliminary case study of the the CLIOSjre Process. In the next chapter, we apply the CLIOSjre process to JR East's investment decision in the Northeast Corridor of the United States. This case study will illustrate the operation of the CLIOSjre Process and allow us to identify strengths and weaknesses of the process..

## 6 Case Study of the CLIOSjre Process: Application to the Northeast Corridor of the United States

In the previous chapter, we described the CLIOSjre Process in detail. In this chapter, we apply the CLIOSjre methodology to a case study in the Northeast Corridor of the United States (NEC). The NEC is a heavily-used rail corridor stretching from Boston to Washington D.C. via New York City. Many who live and work along this transport corridor use the rail system, and the current rail system (in conjunction with highway and air transportation infrastructure) serves as a key backbone of the Northeast Megaregion.

The R/HSR Group was sponsored by the East Japan Railway (JR East) to study the company's investment options in the NEC. JR East – the largest passenger railway in the world – is an expert in rail operations and development. JR East provides more than 50 billion passenger-miles of commuter, conventional, and high-speed service in Japan. JR East is interested in investing time and resources in international HSR projects to expand their business to other countries. The scale of the Northeast Corridor makes it a particularly attractive opportunity for JR East. However, the company is considering several different ways of participating in the HSR market.

In order to help JR East understand its investment decision, the R/HSR Group applied the CLIOSjre Process to JR East's involvement in the NEC. As introduced in Chapter 5, the CLIOSjre Process provides a consistent, comparative framework for understanding a complex investment decision. JR East's investment in the NEC is the first proof-of-concept application of the CLIOSjre Process. This proof-of-concept application was very useful to refine our understanding of JR East's investment decision, and the application allowed us to improve the CLIOSjre Process.

This chapter summarizes the results of our CLIOSjre Process analysis of the NEC. This chapter includes a description of the decision facing JR East and a detailed application of all ten CLIOSjre metrics. The final section of this Chapter summarizes our conclusions for this CLIOSjre case study on the NEC. Greater detail on the CLIOSjre Process analysis of the NEC can be found in the Appendix.

The application of the CLIOSjre Process to the Northeast Corridor of the United States was a collaborative effort within the R/HSR Group by a team of researchers: Prof. Joseph Sussman, Joanna Moody, Scott Middleton, Dagin Faulkner, and the author. This chapter is based on original text from all five collaborators and is included with their permission. Although the author was not the primary author of all sections of this chapter, all sections contain substantial input from the author. Where the author was not the primary author of a section, we have noted the primary author in a footnote attached to the heading of the section.



## 6.1 The CLIOSjre Process Applied to the NEC

The CLIOSjre Process is the second of two processes in the overall JR East Market Selection Process. As discussed in Chapter 5, the CLIOSjre Process provides a consistent, comparative framework for determining which bundles of strategic alternatives in the NEC best fit JR East’s business strategy.

This CLIOSjre Process application is informed by a CLIOS Process application to the NEC completed previously by the R/HSR Group. As part of this CLIOS Process application, six CLIOS bundles of strategic alternatives were selected by JR East and MIT for evaluation (see Table 6-1). These CLIOS bundles identify different development paths that the NEC transportation system and its stakeholders may take.

*Table 6-1. Selected CLIOS Bundles of Strategic Alternatives for the NEC*

#	Final Physical System Configuration	Organizational Structure	Funding Mechanism
1	Incremental HSR – Existing Alignment – Shared Track	Vertically Integrated – Amtrak	Public Infrastructure – Public Operations
2	Incremental HSR – Existing Alignment – Shared Track	Vertically Separated – Amtrak	Public Infrastructure – PPP Operations
3	Piecewise <sup>40</sup> International Quality HSR – New Alignment – Dedicated Track	Vertically Integrated – Non-Amtrak single operator	Public Infrastructure – Private Operations
4	Piecewise International Quality HSR – Existing Alignment – Shared Track	Vertically Separated – Competing operators	PPP Infrastructure – PPP Operations
5	All-Over International Quality HSR – New Alignment – Shared Track	Vertically Integrated – Amtrak	PPP Infrastructure – Public Operations
6	All-Over International Quality HSR – New Alignment – Dedicated Track	Vertically Separated – Competing operators	PPP Infrastructure – Private Operations

### *Selecting CLIOSjre Bundles for the NEC*

The CLIOS bundles of strategic alternatives identified for the NEC (above) must be modified with additional information so that the CLIOSjre Process can evaluate the system from JR East’s perspective.<sup>41</sup> In particular, we must identify JR East’s business role for each possible CLIOS bundle to understand the risks and benefits for JR East.

### **JR East’s Business Roles**

For each NEC CLIOS bundle, JR East could have one of several business roles. The R/HSR

<sup>40</sup> We define 'piecewise' international quality HSR as international quality HSR which only covers part of the Northeast Corridor. In our analysis, we assume that a piecewise HSR system has international quality rail from Boston to New York and conventional rail from New York to Washington, D.C.

<sup>41</sup> This translation from CLIOS bundles to CLIOSjre bundles is discussed in greater detail in Chapter 5.

Group developed a list of possible JR East's business roles:

1. Provide a turnkey system
2. Provide HSR components (e.g. rolling stock)
3. Provide planning consultation (e.g. demand analysis)
4. Provide engineering consultation (e.g. track design)
5. Provide operations consultation (e.g. operations evaluation)
6. Operate a system under concession (owned by government/other owner)
7. Operate a system by buying track capacity from a separate infrastructure manager
8. Construct and operate a private system with infrastructure owned by JR East

Below is a description of each business role. These descriptions were originally developed by Scott Middleton and are included with his permission.

### **Provide a Turnkey System**

A turnkey system is a customized HSR system that is sold as a complete package to stakeholders in the market. In the context of the NEC, providing a turnkey system would mean that JR East builds a Shinkansen-like system in the Northeast for a regional transportation authority (e.g. Amtrak) or other entity to operate. As such, JR East would have no involvement in the operation of HSR in the NEC. Rather, JR East's role would be limited to the construction of the infrastructure and provision of the rolling stock. As a result, this business role is compatible with many operating structures: public or private operators, a vertically integrated or separated system, and multi-operator systems.

This business role would require a great deal of interaction with government agencies and land owners, as well as private sector stakeholders, particularly if the infrastructure funding mechanism is a public-private partnership. While Chinese and European firms have provided high-speed rail services in other nations, a turnkey high-speed rail system has never been implemented by any company in a foreign nation to our knowledge. As such, JR East would break new ground with this business role.

### **Provide HSR Components**

The R/HSR Group considers any subset or piece of a turnkey system to be an 'HSR component'. For this business role, JR East would provide one or many components of the new HSR system, but these components would interface with HSR system components designed and built by other companies.

The JR East subsidiary Japan Transport Engineering Company (J-TREC) has many decades of experience manufacturing rail vehicles for JR East and for other domestic and international

operators (including operators in the United States, such as the Metro-North Railroad and the MBTA). As such, JR East is well-positioned to provide trainsets to a prospective HSR system on the NEC. Other key components include special dedicated high performance track, advanced signaling systems, catenary systems, and station equipment.

An important consideration for this business role is Buy America provisions. These requirements mandate that many public contracts using federal money make every effort to use products designed and manufactured in the United States.<sup>1</sup> According to 49 U.S.C. Chapters 244 and 246, for example, the FRA may obligate funds for a rail project only if the steel, iron, and manufactured goods used in the project are produced in the United States. Similar rules apply to Amtrak for any articles over \$1 million in value, according to 49 U.S.C. § 24305. The Secretary of Transportation may waive these requirements for a number of reasons, including in cases where equipment cannot be bought within the United States or where domestic purchases will increase the cost of the project by more than 25 percent. It is possible that, in the case of international-quality HSR on the NEC, the U.S. DOT would choose to grant a waiver that would allow JR East (or its international competitors) to provide HSR components. However, such a waiver would be unprecedented; as of 2015, FRA has not approved any Buy America waivers involving FRA's high-speed and intercity passenger rail program. However, it is worth noting that a consortium of international companies (Alstom and Bombardier Transportation) manufactured the Acela Express trainsets currently in use on the NEC.

### **Provide Planning Consultation**

Given JR East's long history of planning and executing HSR projects in Japan, the company is well positioned to assist on the planning of HSR in the Northeast. Some areas of JR East's expertise will translate more directly or more readily to the American environment than others. For example, JR East's familiarity with demand analysis is directly applicable, while the public engagement process in the United States may differ markedly from what JR East is familiar with in Japan. Nonetheless, JR East could provide consulting in a range of areas under this business role:

- Travel demand analysis and economic evaluation
- Environmental assessments, environmental compliance
- Alternatives analysis
- Route alignment
- Stations and intermodal connections
- Systems integration
- Feasibility studies

## **Provide Engineering Consultation**

JR East is well positioned to assist in the engineering design of HSR in the Northeast. However, as with planning and operations consultation, JR East may face intense competition from other international rail companies that also have experience as HSR consultants. JR East could provide consulting in a range of areas under this business role:

- Track design
- Noise and vibration evaluation
- Structures, tunnels, and earthwork
- Tunnel aerodynamics and ventilation
- Safety assurance
- Project management
- Site-specific design challenges (i.e., topography)
- Mechanical and electrical systems
- Other engineering design issues
- Infrastructure upgrade and renewal

## **Provide Operations Consultation**

Given JR East's long history of providing world-leading HSR service with an impeccable record of safety and reliability, the company is well positioned to consult on HSR operations for stakeholders on the NEC. Specifically, JR East could provide consulting services in a range of areas:

- Operations evaluation
- Maintenance and asset management
- Train control
- Traction power optimization
- Signaling
- Telecommunications
- Safety assurance systems
- Training course development
- Human factors and ergonomics

## **Operate a System under Concession**

Under this business role, JR East would operate the HSR system (regardless of the physical system configuration) under concession. That is, JR East would run trains on track that is owned by the government or by a non-JR East private infrastructure owner. The trains themselves could also be owned by the government or by a non-JR East private infrastructure owner. Under this role, JR East would have no involvement in the construction of the HSR system. However, this role is compatible with the role “Provide HSR Components.” That is, JR East could both provide rolling stock and operate a system under concession, although this is not necessarily the case. In our analysis, we treat these two roles as fully separate.

This business role necessitates a public-private partnership mechanism for HSR operations. There is a great deal of variation in such a mechanism. However, the following conditions would be likely to apply. For one, JR East’s concession would last for a defined concession period. Depending on the arrangement with the system owner, JR East would likely retain fare revenue, but may be subject to restrictions on the fare and standards of performance (e.g. a minimum on-time performance standard). As a private concessionaire, JR East would likely have responsibility for asset maintenance and for financing further capital investment, since the condition of the assets would likely be JR East’s responsibility during the concession period. The rights to HSR infrastructure would most likely revert to the awarding authority at the end of the concession.

## **Operate a System by Buying Track Capacity**

Under this business role, JR East would operate part or all of the HSR system (regardless of the physical system configuration) by purchasing track capacity (i.e., operating timeslots) from a separate infrastructure manager (public or private). Essentially, JR East would purchase windows of time to run HSR service that could compete with or complement service provided by the primary operator. This arrangement would resemble the service provided by Nuovo Trasporto Viaggiatori (NTV) in Italy, which provides private open access HSR service that competes directly with the publicly-owned Trenitalia.

In this role, JR East would neither own nor construct any rail infrastructure. As a private operator, JR East would likely receive no subsidy from the public sector.

## **Construct and Operate a Private System**

This business role presents the most extensive and expensive option for JR East. Under this role, JR East would construct an entire HSR system (necessarily, piecewise or all-over international quality), as with the “turnkey system” business role. As with the turnkey system, the construction aspect of this role would require a great deal of interaction with government agencies and land owners, as well as private sector stakeholders, particularly if the infrastructure funding

mechanism is a public-private partnership. In addition, JR East would also operate the entire HSR system on the NEC in a vertically integrated fashion. Because JR East would have a great deal of ownership of the infrastructure system, JR East would likely fund a great deal of the cost of the system. In addition, operations funding may be fully private which would mean that JR East would assume much of the risk inherent in constructing and operating the system profitably.

### *Selecting A Subset of CLIOS Bundles for Evaluation*

Pairing all six CLIOS bundles and the eight possible business roles would yield far too many combinations for timely and complete evaluation of the CLIOSjre Process on the NEC. In addition, some combinations are simply not feasible (such as providing a turnkey system for an incremental HSR development path). Furthermore, many of these possible combinations are relatively similar, so the analysis of some of the combinations improves our understanding of the performance of others without additional analysis. To optimize the selection of CLIOS bundles and business roles, the R/HSR Group adopted factorial design and clustering methods (that were also used to select the six CLIOS bundles) to select the CLIOSjre bundles. The CLIOSjre bundles selected for evaluation are described below.

To narrow the scope of evaluation, the R/HSR Group considered which of the six CLIOS bundles (also called system development paths) might be most attractive for JR East involvement. Since one of the main decisions driving the overall level of investment and improvement in the system is the choice of HSR Quality, the research team decided to choose one CLIOS bundle that represents each of the three alternatives related to HSR Quality: Incremental HSR, Piecewise International Quality HSR, and All-Over International Quality HSR. By selecting one CLIOS bundle with each level of HSR Quality, we ensure that the resulting CLIOSjre bundles will cover the solution space so that JR East learns about all of the choices available.

After examination of the CLIOS bundles for Incremental HSR – bundles 1 and 2 – the R/HSR Group chose to advance bundle 1 for further consideration because it represents the status quo of the system. CLIOS bundle 1 can be paired with a “no (JR East) involvement” business role to represent the situation in which JR East does not become involved in the NEC market and the HSR system remains largely the same.

When considering the Piecewise International Quality HSR CLIOS bundles – bundles 3 and 4 – the R/HSR Group conjectured that JR East might be more interested in participating as a single operator or dedicated track (CLIOS bundle 3) rather than as one of a number of competing operators on shared, vertically separated track (CLIOS bundle 4). These aspects of bundle 3 align better with JR East’s strengths since the organizational and physical structure of the system is similar to that of the Shinkansen system in Japan. In addition, the competition on the same track in CLIOS bundle 4 would expose JR East’s brand to significant risk. JR East would have to use

its name to market for ridership, but would not have full control over the infrastructure and operations of the system. The research group felt that this risk makes CLIOS bundle 4 even less attractive given JR East's aversion to risk threatening the JR East brand.<sup>42</sup>

The final decision was between CLIOS bundles 5 and 6, which both represent All-Over International Quality HSR options. The R/HSR Group originally selected bundle 5 rather than 6 for two reasons. First, bundle 6 presented the same competing operator problems as bundle 4 and therefore carried the same brand risk and misalignment with JR East strengths. Second, bundle 5 contains shared track – a unique feature not present in bundle 3. The choice of bundle 5 thus allows us to discuss the implication of shared vs. dedicated track on an international quality HSR implementation.

Upon further review, the R/HSR Group decided that it would be advantageous to include a CLIOS bundle with vertical separation. Vertical separation provides a unique set of issues for JR East as well as other institutional stakeholders. The CLIOS Process and its stakeholder and scenario analyses have revealed that a vertically separated system on the NEC is not likely. However, if the NEC decides to separate the infrastructure from train operations, it would have significant impacts on JR East's potential involvement in the market because of JR East's limited experience with vertically separated systems. Thus, it is useful to examine this unlikely but significantly different scenario. As a result, CLIOS bundle 6 was also put forward for additional consideration since it not only allowed the R/HSR group to explore a vertically separated situation, but also pairs this with an all-over international quality HSR quality, which we conjecture is a primary investment interest of JR East.

In the future, the research team intends to expand this selection of CLIOS and CLIOSjre bundles to examine other possible combinations.

### *Combining Business Roles with the Selected CLIOS Bundles*

After selecting which CLIOS bundles would be most useful for our analysis, the research team combined these bundles with appropriate business roles. Note that not every possible combination of CLIOS bundles and business roles makes sense. In order to capture the effects of different business roles but to maintain a reasonable number of CLIOSjre bundles for evaluation, each selected CLIOS bundle (1, 3, 5, and 6) is paired with one or two business roles. These business roles were selected to be both feasible and representative of the many possibilities available to JR East. Although the research team cannot guarantee that our seven resulting NEC CLIOSjre bundles include the optimal selection for JR East, this broad selection of CLIOS bundles and business roles will ensure that JR East learns about all of the available choices.

Table 6-2 summarizes the seven resulting NEC CLIOSjre bundles (combinations of CLIOS

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<sup>42</sup> We discuss JR East's risk aversion in more detail in the evaluation of Metric 9. Reputation for Excellent Service later in this chapter.

bundles and business roles) that we studied in this analysis.

*Table 6-2. Recommended CLIOSjre bundles of strategic alternatives for the NEC*

<b>CLIOS Bundle</b>	<b>+</b>	<b>JR East Business Role</b>	<b>= CLIOSjre Bundle</b>
<b>CLIOS bundle #1</b> Incremental HSR – Existing Alignment – Shared Track Vertically Integrated – Amtrak Public Infrastructure – Public Operations		1. No involvement	<b>1.1</b>
		2. Provide planning, engineering, and operations consultation (e.g. demand analysis, track design, and operations evaluation)	<b>1.2</b>
<b>CLIOS bundle #3</b> Piecewise International Quality HSR – New Alignment – Dedicated Track Vertically Integrated – Non-Amtrak single operator Public Infrastructure – Private Operations		1. Provide a turnkey system	<b>3.1</b>
		2. Operate a system under concession (owned by government/other owner)	<b>3.2</b>
<b>CLIOS bundle #5</b> All-Over International Quality HSR – New Alignment – Shared Track Vertically Integrated – Amtrak PPP Infrastructure – Public Operations		1. Provide HSR components (e.g. rolling stock)	<b>5.1</b>
<b>CLIOS bundle #6</b> All-Over International Quality HSR – New Alignment – Dedicated Track Vertically Separated – Competing Operators PPP Infrastructure – Private Operations		1. Operate a system by buying track capacity from a separate infrastructure manager	<b>6.1</b>
		2. Construct and operate a private system with infrastructure owned by JR East	<b>6.2</b>

CLIOSjre bundles 1.1 and 1.2 are built from CLIOS bundle 1. The configuration of CLIOS bundle 1 (incremental HSR and entirely public financing and operations) makes it very difficult for JR East to have substantial involvement in the market. Thus, CLIOSjre bundle 1.1 represents the situation in which JR East does not get involved in the NEC market. Although this bundle will have no value for JR East, it is useful for comparison to the other CLIOSjre bundles. CLIOSjre bundle 1.2 represents minimal involvement by JR East – planning, engineering, and operations consultation. This hybrid of three JR East business roles is a highly likely combination for JR East’s involvement. Although CLIOSjre bundle 1.2 is likely of only modest interest to JR East, it is useful for comparison.

CLIOSjre bundles 3.1 and 3.2 are built from CLIOS bundle 3. This CLIOS bundle represents a future where public and private investment in the NEC slowly works to redevelop the HSR system. By taking a leading role in this CLIOS bundle, JR East stands to gain the most but at



high risk. CLIOSjre bundle 3.1 represents the opportunity for JR East to provide a turnkey system to the NEC with dedicated track (one of JR East's strengths). CLIOSjre bundle 3.2 represents the opportunity for JR East to provide operations to the system owner. These two CLIOSjre bundles will likely be profitable but come with substantial brand risk. They will be very informative for our analysis.

CLIOSjre bundle 5.1 is built from CLIOS bundle 5. This bundle represents a future where substantial public and private investment in the NEC creates an HSR system similar to those in Japan. This CLIOS bundle opens up an opportunity for JR East to be substantially involved in the market. CLIOSjre bundle 5.1 relates to JR East's ability to sell major components (e.g. rolling stock) to the market. Although it may be more advantageous for JR East to sell a turnkey system rather than major components if the market develops in the direction of CLIOS bundle 5, the choice of a different business role for CLIOSjre bundle 5.1 allows the research team to compare it with CLIOSjre bundle 3.1 and make observations about the relative advantage of each business role.

CLIOSjre bundles 6.1 and 6.2 are built from CLIOS bundle 6. This bundle also represents a future where substantial public and private investment in the NEC creates an HSR system similar to those in Japan. However, CLIOS bundle 6 advances a different ownership pattern than CLIOS bundle 5. With vertical separation, this CLIOS bundle opens opportunities for JR East to be involved in the market either on the infrastructure side or the operations side. CLIOSjre bundle 6.1 relates JR East's ability to become a private operator on infrastructure constructed and owned by someone else. This presents unique brand risk that does not appear in any other CLIOSjre bundles. CLIOSjre bundle 6.2 represents the opportunity for JR East to build its own infrastructure system in the NEC. This second bundle presents an additional host of challenges that will be interesting to evaluate including the potential for JR East to operate on its own infrastructure in parallel with other competing operators.

## 6.2 NEC CLIOSjre Bundle Evaluation

For the first proof-of-concept application of the CLIOSjre Process, the R/HSR Group limited the analysis to the seven CLIOSjre bundles selected above. The research team anticipates that this preliminary analysis will be expanded to include other combinations of CLIOS bundles and JR East business roles. However, for this preliminary proof-of-concept, these seven bundles will provide sound insight into JR East's decision and the CLIOSjre Process.

For this proof-of-concept for the CLIOSjre Process, the objective of this portion of the study is to determine the overall grade of each CLIOSjre bundle from the perspective of JR East for the seven selected NEC CLIOSjre bundles. Once the CLIOS and CLIOSjre Processes are complete for a particular market, the output is a set of CLIOSjre assessments, each similar to Figure 5-2 and Figure 5-3. These assessments help inform JR East's decision on whether or not to pursue

the market and, if so, how to pursue the market. In addition, these assessments may suggest actions that JR East could take to encourage the system stakeholders to pursue a certain bundle of strategic alternatives that is promising to JR East.

The assessment of the CLIOSjre bundles is based on the evaluation of the bundle using ten metrics. These metrics provide insight into different aspects of the CLIOSjre bundles that are of interest to JR East. These metrics were outlined in Chapter 5 earlier. A list of the final CLIOSjre metrics is included below for reference.

### **Financial Characteristics**

M1. Expansion Potential

M2. Expected Profit

### **Market Characteristics**

M3. Competition

M4. Cooperation

M5. Flexibility

M6. Net Societal Benefit

M7. Net Environmental Impact

### **JR East's Characteristics**

M8. Strengths and Weaknesses

M9. Reputation for Excellent Service

M10. Human Resource Development

These CLIOSjre metrics were selected based on JR East's stated business interests. The research team identified these interests in JR East's visioning documents, the presentations of top JR East officials, and feedback from JR East's International Department and Frontier Services lab who have been directly involved in the research. The research team believes these ten metrics are a robust and accurate depiction of JR East's top priorities as a company.

In order to provide a robust assessment of each CLIOSjre bundle using the CLIOSjre Process (as discussed in Chapter 2), the CLIOSjre metrics must satisfy two important properties:

1. The CLIOSjre metrics must be independent (i.e. there is no double-counting), and
2. The CLIOSjre metrics must address uncertainty.

We discuss these two important properties below.

## *Independence*

After calculating the metric grades for each CLIOSjre bundle, the CLIOSjre Process combines separate metric grades for each bundle into an overall grade for that CLIOSjre bundle. The calculation of an overall grade requires that either

- a) each metric grade is independent, or
- b) the strategy vector used to combine the metric grades corrects for any overlap between the metrics.

As many of the CLIOSjre metrics use a qualitative methodology to determine the metric grade, the independence of the metrics is not a strictly mathematical calculation. Rather, the research team worked to ensure that the same qualitative factors for analysis are not included in more than one metric. The research team was largely successful in ensuring the independence of the CLIOSjre metrics. We note important examples of this independence and several exceptions to this strict independence below.

### **Metric 1. Expansion Potential and Metric 8. Strengths and Weaknesses**

Metric 1. Expansion Potential focuses on the long-term development opportunities for JR East. In order to value these opportunities, Metric 1 focuses on external market characteristics that may relate to JR East's expansion potential. This is in contrast to Metric 8. Strengths and Weaknesses which focuses on JR East's own characteristics relevant to the market. This distinction between internal and external characteristics ensures that Metric 1 and Metric 8 examine different aspects of JR East's international business opportunities. These two metrics as defined do not overlap.

### **Metric 1. Expansion Potential and Metric 5. Flexibility**

As mentioned above, Metric 1. Expansion Potential focuses on development opportunities for JR East. Metric 5. Flexibility also examines expansion opportunities for JR East. However, Metric 5 focuses on expansion opportunities for JR East within the NEC HSR market while Metric 1 examines expansion opportunities into other HSR markets (other than the NEC). This distinction between in-market and out-of-market expansion opportunities ensure that Metric 1 and Metric 5 examine different aspects of JR East's international business opportunities. These two metrics as defined do not overlap.

### **Metric 1. Expansion Potential and Metric 10. Human Resource Development**

As mentioned above, Metric 1. Expansion Potential focuses on the long-term development of JR East's international business. In particular, Metric 1 seeks to understand how each CLIOSjre bundle for the NEC may enable future expansion for JR East into other HSR markets. Metric 1 examines the similarity between the NEC and other HSR markets, the alignment between the

business role in each CLIOSjre bundle and the available business roles in other HSR markets, and JR East's interest in the other HSR markets. In this analysis, Metric 1 does not directly address the new expertise and institutional knowledge the JR East will gain by pursuing each CLIOSjre bundle. However, the development of new institutional knowledge in a CLIOSjre bundle is likely correlated with JR East's expansion potential.

Metric 10. Human Resource Development estimates the new institutional knowledge that JR East will gain by participating in a CLIOSjre bundle. Thus, although Metric 1 and Metric 10 do not directly overlap, the two metrics will be correlated.

Although this correlation between Metric 1 and Metric 10 does not strictly conform to the independence property mandated by the CLIOSjre Process, the research team believes that this overlap is an appropriate representation of JR East's priorities. The company cares about Expansion Potential and Human Resource Development independently as separate company goals. Thus, although these two metrics are correlated, this correlation is an accurate depiction of the company's priorities. The selected strategy vector for the CLIOSjre Process need not correct for this correlation.

### **Metric 3. Competition and Metric 8. Strengths and Weaknesses**

Metric 3 Competition estimates the competition JR East will face in the CLIOSjre bundle. This competition is based on the other competitors in the market, potential substitutes for JR East's business role, suppliers for JR East's business role, and buyers for JR East's business role. Metric 3 does not consider the strengths or weakness of JR East.

By contrast, Metric 8 Strengths and Weaknesses estimates the alignment between the CLIOSjre bundle and JR East's current strengths and weaknesses. The metric focuses exclusively on JR East – no consideration is made for other competitors or substitutes in the market. However, the structure of the market opportunity is determined by the buyers and suppliers in the market. Thus, although not considered from the same perspective, it is likely that there is some correlation between the impact of buyer and suppliers in Metric 3 and the impact of buyers and suppliers in Metric 8. The research team does not believe this correlation is an accurate representation of JR East's priorities, and this correlation should be considered when JR East chooses a final strategy vector for the NEC market.

### *Uncertainty*

One of the primary advantages of the CLIOSjre Process over other frameworks is that it addresses uncertainty both within each metric grade and for the overall grade. The research team identified two types of uncertainty for our analysis:

1. Uncertainty about the present, and

## 2. Uncertainty about the future.

We discuss each type of uncertainty below.

### **Uncertainty about the Present**

For each CLIOSjre metric, there is some uncertainty in the metric grade. This uncertainty results from our inability to accurately measure the present. For example, Metric 6. Net Societal Benefit relies on two key quantities to estimate the public benefit of each CLIOSjre bundle: the value of time and the value of a statistical life. Our analysis relies on these quantities to convert time saved and lives saved into a monetary value. However, there remains much disagreement in the literature over the value of these two quantities. This disagreement among informed professionals makes leads to an uncertainty about the present. If the true value of these two quantities is different from the values we use in our analysis, the metric grades for Metric 6. Net Societal Benefit may be incorrect. From here onward, we refer to this type of uncertainty as *measurement error*.

To estimate the measurement error for each CLIOSjre metric, the research team performed a sensitivity analysis for each metric. Although the form of this sensitivity analysis is different for each metric, the objective is the same: to identify the range of metric grades that a reasonable analyst would find for each bundle. These sensitivity analyses vary the assumptions for each metric but hold the analysis methodology constant. We cannot guarantee that the *true* metric grade lies within the measurement error for each metric, but we can be confident that the measurement error identifies the range of metric grades that a reasonable analyst would find *given the information we have today*.

### **Uncertainty about the Future**

Although the research team has identified the measurement error for each metric, the true metric grade for a particular metric may lie outside the measurement error for that metric. The measurement error only captures our uncertainty about the present; our larger uncertainties about the future are not captured in the measurement error. Future events (such as a natural disaster or a market collapse) or future technologies (such as telecommuting or autonomous vehicles) may fundamentally shift any of the metric grades. However, it is impossible for the research team to estimate this uncertainty in a robust fashion for each metric. Instead, we have addressed this uncertainty in Metric 5. Flexibility.

Metric 5. Flexibility recognizes that the research team cannot predict the future. Instead, Metric 5 examines four possible scenarios for the future. These four scenarios are illustrative of the different ways the future might play out. Metric 5 then examines the flexibility for JR East presented by each CLIOSjre bundle for these four scenarios. Although this metric analysis does not directly estimate our uncertainty with the future, this analysis examines the flexibility of each

CLIOSjre bundle given that the future is inherently uncertain.

## Summary

No analysis can completely address uncertainty as uncertainty is, by its definition, an inability to know something. However, by breaking uncertainty into two distinct categories – measurement error, and uncertainty about the future – the CLIOSjre Process allows JR East to grasp the types of uncertainty relevant to our analysis. Our expectation is that these two categories will help JR East understand uncertainty in the context of the CLIOSjre Process.

## 6.3 Metric Analysis Using the CLIOSjre Process: Financial Characteristics

The R/HSR Group evaluated all seven NEC CLIOSjre bundles using the CLIOSjre Process. Although the final conclusions of this analysis may change as we receive feedback from JR East and refine our understanding of the market, this document represents a robust proof-of-concept of the CLIOSjre Process applied to the Northeast Corridor of the United States. This section of the thesis summarizes the results of our analysis and our full analysis of the CLIOSjre Process applied to the NEC is in the Appendix.

Our CLIOSjre Process analysis is divided into three sections based on our earlier categorization of the CLIOSjre metrics. This first section details the metrics which evaluate the financial characteristics of the CLIOSjre bundles: Metric 1 and Metric 2.

### *Metric 1. Expansion Potential*<sup>43</sup>

By becoming involved in the planning, construction, or operation of high-speed rail service in the Northeast Corridor, JR East will unlock many potential opportunities and encounter many threats. Of particular interest to JR East is the possibility that investing in the NEC market will make JR East more competitive in other HSR markets in the United States and other countries.

In order to estimate the scope and value of these opportunities, we chose to examine JR East's expansion opportunities as an independent metric in the CLIOSjre Process. To avoid double counting any market or business role characteristics, Metric 1. Expansion Potential focuses on external market characteristics that may relate to JR East's expansion potential, while Metric 8. Strengths and Weaknesses focuses on JR East's own characteristics relevant to the market and Metric 5. Flexibility focuses on expansion opportunities within the NEC. In short, the analysis of Metric 1 focuses on the possibility that a particular NEC business role will translate into additional work in other HSR markets. Table 6-3 provides a brief description of Metric 1. Expansion Potential.

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<sup>43</sup> Scott Middleton was the primary author for this CLIOSjre metric. This section is included with his permission.

Table 6-3. Description of Metric 1. Expansion Potential

<b>Metric 1. Expansion Potential</b>		
Evaluation Questions	Does this bundle facilitate future success for JR East in other HSR markets? This metric considers brand exposure as well as cultural similarities, geographic location, and political factors.	
Method of Evaluation	Qualitative Opportunities Analysis, focused on evaluation of long-term expansion potential in international business	
Description of Evaluation	<p>We use a qualitative analysis based, in part, on the “opportunities” portion of traditional SWOT analysis. In this context, we define opportunities as external characteristics of various U.S. HSR markets with the potential to help JR East pursue its strategic goals as an organization.</p> <p>This qualitative analysis will estimate the expansion potential of the market options that open to JR East as a result of investment in a particular CLIOSjre bundle. These are options for further expansion as a result of that investment on the NEC. This evaluation will focus on inter-market options and will account for cultural similarities, geographical location, and political factors. Intra-market expansion is measured in Metric 5. Flexibility.</p>	
Key Elements of the Metric	This metric will consider the financial benefit of expanding into a related market. To determine which markets are made available by investing in this particular CLIOSjre bundle, the analysis will consider how interactions between JR East and the stakeholders in the NEC may help JR East expand into other HSR markets. In addition, the analysis will describe how other HSR markets are related to the NEC and identify markets in which JR East could assume business roles similar to those in each CLIOSjre bundle.	
Metric Spectrum	'F' Outcome	'A' Outcome
	This CLIOSjre bundle offers no expansion potential or reduces expansion potential for JR East	This CLIOSjre bundle offers large expansion potential for JR East

The R/HSR team considered a detailed analysis of threats as well as opportunities in this metric, but decided to exclude threats because many types of threats are addressed in other portions of our analysis. For example, Metric 9 measures threats to JR East’s reputation for excellent service (i.e., a safety incident marring JR East’s brand and impairing future business). Similarly, Metric 3. Competition captures the impact of threats from competitors. Other threats related to JR East’s expansion potential (e.g., natural disasters, climate change, political instability) are discussed in Metric 5. Flexibility and in the scenario analysis portion of the CLIOS Process. As such, this metric focuses primarily on the opportunities available to JR East in other HSR markets and the impact of various CLIOSjre bundles on those opportunities, although threats receive some consideration in our analysis below.

## Expansion Potential Analysis

The first step of our analysis is to identify and characterize the markets that are available to JR East in the United States. The CLIOSjre bundles in the NEC also afford expansion potential to markets around the world (i.e., not just in the United States), but that our analysis considers only U.S. HSR markets for this proof-of-concept case study.

To this end, we identified ten HSR markets in the United States with the most activity and attention given to HSR. These markets vary widely. A market with an HSR project currently under construction (e.g., California HSR) is very different from one with a project in the planning stage (e.g., Texas Central Railroad), which is different still from a market that has no well-defined projects or a market that has stalled altogether (e.g., Keystone HSR). Thus we conduct analysis to gain an understanding of which HSR corridors are *attractive* from JR East's perspective as a private company and a stakeholder in the NEC. In this context, we define "attractive" to mean the following:

1. The market is **sufficiently likely** to develop HSR. The status of the project would allow JR East to get involved in the future of the new market.
2. The proposed project or projects in the market are **sufficiently large** to warrant JR East's attention. The market is feasible for JR East to consider from a new business perspective.
3. The HSR corridor in question **shares meaningful characteristics** (location, political factors, stakeholders involved, etc.) with the NEC. These characteristics would potentially give JR East an advantage in this new market, depending upon JR East's role in the NEC.

A project that scores well in all three of the above areas is considered to be "strongly" attractive to JR East. A project that scores well in two of the three areas above is considered "medium." A project that scores well in 0-1 of the above areas is considered "weakly" attractive. This step of the Qualitative Opportunities Analysis is addressed later in our analysis.

With an understanding of JR East's interest in each market, the second step of our analysis is to consider the relationship between each potential HSR market and the seven CLIOSjre bundles on the NEC. Those bundles that share characteristics with proposed projects (such as incremental HSR, public funding, etc.) offer a greater degree of expansion potential to JR East than those that do not. As such, we identify those CLIOSjre bundles that are *relevant* to proposed projects in other HSR markets. In this context, we define "relevance" to mean:

1. Overlap in the physical design, organizational structure, and funding structure between a given CLIOSjre bundle on the NEC and a given HSR market elsewhere in the U.S.
2. Participation in the NEC in the defined business role would provide opportunities for JR East (i.e., expertise, reputation) that are applicable and transferable to other markets.



For more detail on the analysis for Metric 1, see the Appendix.

### **Expansion Potential Analysis of the Seven CLIOSjre Bundles on the NEC**

During the course of the CLIOS Process application to the Northeast Corridor, the R/HSR Group developed an understanding of the relative attractiveness of opportunities available in the United States. This understanding has made it possible to compare the relevance of the seven NEC CLIOSjre bundles to JR East’s ability to take advantage of the other HSR opportunities in the United States. With this goal in mind, the R/HSR Group has developed a metric spectrum for Metric 1. Expansion Potential (see Table 6-4 below).

*Table 6-4. Grade Spectrum for Metric 1. Expansion Potential*

<b>Representative Outcome</b>	<b>Metric Grade</b>
The CLIOSjre bundle is relevant to multiple “strongly” attractive expansion opportunities.	A
The CLIOSjre bundle is relevant to at least one “strong” expansion opportunities.	B
The CLIOSjre bundle is relevant to primarily “medium” expansion opportunities.	C
The CLIOSjre bundle is relevant to a mix of “medium” and “weak” expansion opportunities.	D
The CLIOSjre bundle is relevant to only “weak” expansion opportunities.	E
The CLIOSjre bundle is relevant to no expansion opportunities.	F

This spectrum, in combination with our analysis of HSR markets in the United States, allows us to assign a grade for each CLIOSjre bundle for Metric 1. Based on this Qualitative Opportunities Analysis, we assign the following grades to each CLIOSjre bundle:

*Table 6-5. Evaluation of the CLIOSjre Bundles using Metric 1. Expansion Potential*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Metric 1 Grade</b>	F	C	B	A	A	A	C

### **Discussion**

One should consider the possibility of measurement error in any attempt to analyze and compare business opportunities. For HSR markets in the United States, it is possible that our analysis overestimates or underestimates the number or attractiveness of expansion opportunities. For example, given the highly politicized nature of HSR projects in the U.S., a project that seems highly likely could rapidly collapse in the future. In the opposite direction, our analysis may have overlooked HSR markets that have not emerged as serious contenders. However, our judgment is

that the ten markets discussed in this metric (detailed in the Appendix) are the most promising from JR East’s perspective, according to publicly available information. The research team believes that unexpected movement in dormant markets is not likely in the near future.

Because our analysis relies on an extensive amount of professional judgement, the research team assumes that the metric grades for this metric could be incorrect by as much as one full letter grade in either direction. This assumption is designed to capture the overestimation/underestimation effects discussed above. However, based on our definition of the metric spectrum for Metric 1, we find it unlikely that an unexpected or overlooked HSR development would affect a single CLIOSjre bundle (relative to the others) by more than a single letter grade (see Table 6-6).

With additional information, it would be useful for future research to estimate the value of JR East’s market options and the effect of the CLIOSjre bundles on those options. Such an analysis would require data on the size of each market considered (including assumptions on the characteristics of future HSR service in that market). There would also be value in a detailed consideration of international HSR markets outside of the United States, but in our opinion that JR East’s experiences with the various NEC CLIOSjre bundles is most relevant to its expansion potential within the United States.

*Table 6-6. Measurement Error for Metric 1. Expansion Potential*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Measurement Error for Metric 1</b>	F – E	D – B	C – A	B – A	B – A	B – A	D – B

### *Metric 2. Expected Profit*

As a for-profit company, JR East has an obligation to its stockholders to deliver a financial return on its investments. The R/HSR Group has developed Metric 2. Expected Profit to address this fiduciary responsibility for JR East in their approach to the Northeast Corridor.

To evaluate each CLIOSjre bundle using Metric 2, the research team has considered several different types of analysis. In a full financial analysis, a business would consider the full cost of an investment, the full benefits of an investment, and track the cash flow of the investment through time. In addition, a thorough financial analysis would usually attempt to estimate the uncertainty of these numbers and identify methods to mitigate the visible risks. However, the existing uncertainty in the development of the NEC HSR market prevents a rigorous analysis of the projected costs and benefits, especially as they pertain to JR East. Although the R/HSR Group performed a financial analysis as part of the CLIOS Process analysis of the Northeast

Corridor, the financial analysis is based on our informed speculation of uncertain future events.<sup>44</sup> This uncertainty reduces the robustness of the analysis for estimating JR East's expected profitability.

In addition, there are two important drawbacks of our CLIOS financial analysis:

1. The CLIOS Process financial analysis could not capture the level of detail needed to accurately differentiate between different JR East business roles. At this stage of the analysis, this level of detail (e.g. the size of the system design and planning contract for the NEC) is simply not available.
2. The CLIOS Process financial analysis could not reliably predict the levels of public funding (from the US or Japanese governments), private funding (from infrastructure investors), or the timelines of these funding sources which determine the interest rates and payment schedules. With this level of uncertainty in allocation of funding, a financial analysis can only serve as a representative demonstration of one possible financial outcome (as it does in the CLIOS Process and in Metric 5. Flexibility); it cannot reliably predict expected profit or cash flows.

Because of these limitations, the R/HSR Group decided to use industry benchmarking to predict the profitability of JR East in the Northeast Corridor. This industry benchmarking allows the research team to estimate the profit that JR East could expect by engaging in the particular business role associated with each CLIOSjre bundle. As the particulars of the NEC HSR market (especially competition and cooperation) are considered in those other CLIOSjre metrics, this expected profit is a global industry average; it does not account for the particulars of the NEC market. By examining the typical profit of international companies acting in various business roles, Metric 2. Expected Profit provides a benchmark for expected profit for JR East in the NEC. This Metric 2 grade is then augmented by considering the other CLIOSjre metrics. An overview of the Metric 2 analysis process is shown in Table 6-7.

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<sup>44</sup> See Metric 5. Flexibility for more discussion about this uncertainty.

Table 6-7. Description of Metric 2. Expected Profit

<b>Metric 2. Expected Profit</b>		
Evaluation Questions	Does this CLIOSjre bundle hold reasonable expectation for profit for JR East and its partners in the short and long term?	
Method of Evaluation	Industry Benchmarking	
Description of Evaluation	Using financial information from publicly traded companies, the research team will identify and determine the financial performance (cash return on investment) of companies involved in comparable industries and business roles (e.g. consulting, rolling stock sale). This analysis will only consider the profit made by these companies and will not include other potential benefits.	
Key Elements of the Metric	This metric will examine the financial returns for JR East and its partners assuming that it performs similarly to other publicly traded companies in the same industry and business role of the CLIOSjre bundle. This analysis will consider JR East's profit only for the most likely development paths of the HSR market (i.e. excluding unforeseen events such as dramatic changes in industry technology or in the global market). This analysis will only consider the return on the investment and not the size of the investment. Our benchmarking will serve as a surrogate for the profitability of the CLIOSjre bundle.	
Metric Spectrum	'F' Outcome	'A' Outcome
	Negative return on investment – this CLIOSjre bundle offers no opportunities for profit to JR East	15% return on investment or above – this CLIOSjre bundle offers substantial opportunities for profit to JR East

To determine JR East's expected profit for each bundle, the research team identified companies with comparable business roles. For each of these comparison companies, the research team estimated each company's cash return on investment (a performance metric commonly used in the evaluation of securities). This estimate approximates annual return on investment a large investor would achieve by purchasing the company outright. We arrive at this estimate by calculating the ratio of a company's earnings before interest, taxes, depreciation, and amortization (EBITDA) to the company's enterprise value (EV).

$$\text{Cash Return On Investment} = \text{EBITDA} / \text{EV}$$

We use the earnings before interest, taxes, depreciation, and amortization to estimate profit as it corrects for differences in local and national taxes as well as accounting standards across countries with respect to depreciation and amortization. The enterprise value is money required to purchase the company outright (the company's market capitalization and liabilities less the company's cash and cash equivalents). If an investor purchases a company (at its enterprise value), in theory, the investor would realize a return on investment in the first year equivalent to the EBITDA. This method is especially useful as it enables us to benchmark the performance of companies with different capital assets. As JR East's business role in the Northeast Corridor will

require the company to expand into new business lines and markets, this performance evaluation benchmarking approach will enable JR East to estimate the expected profit margin on its investment.

One limitation of this approach is that it does not consider the size of the investment. For JR East to consider investing in the NEC market, the investment must be of substantial size to be worthwhile to JR East. A modest return on a large investment may be more valuable to JR East than a large return on a small investment. The impacts of this limitation are addressed in the discussion section for this metric.

In addition, this analysis does not consider the risk associated with the investment. The risk of each CLIOSjre bundle (and flexibility of JR East’s business role to mitigate this risk) is considered separately in Metric 5. Flexibility.

Table 6-8 shows the metric spectrum for Metric 2. Expected Profit. Although zero defines a clear ‘F’ grade for the metric spectrum, there is no theoretical maximum for cash return on investment (ROI) identified in the literature. Indeed, a good return on investment depends on the level of acceptable risk, the current market conditions, and the size of the investment as well as other investments in the company’s portfolio. With current global market conditions weak due to the slowdown in China, and with the Japanese economy in a prolonged recession, lower but safer returns on investment are preferred. We judge that a cash return on investment of greater than 15% is considered a very good investment. Thus, we choose 15% ROI as our ‘A’ representative outcome for the metric spectrum. This 15% ROI also aligns with the international development literature used in Metric 6. Net Societal Benefit. The remainder of spectrum was developed by projecting linearly between these two endpoints. This linear approximation assumes that JR East cares about each percentage increase in return equally – a reasonable assumption for purely financial returns.

*Table 6-8. Grade Spectrum for Metric 2. Expected Profit*

<b>Cash ROI</b>	0%	3%	6%	9%	12%	15%
<b>Metric 2 Grade</b>	F	E	D	C	B	A

For each CLIOSjre bundle, the research team identified a comparable industry and set of at least three domain-specific companies in that industry. For our analysis, we define domain-specific companies as companies whose revenue and costs are derived almost exclusively from that industry (in contrast to conglomerates which operate in a number of distinct industries). The companies were also selected to be large companies with financial data available. We used the Mergent Intellect database of publicly-traded companies to examine the financials of each company and arrive at an ROI estimate for the company. Our ROI for each company was

averaged over the last three years of profitable operation.

As our benchmarking analysis includes only three companies for each industry,<sup>45</sup> the research team defined the benchmark return on investment for each CLIOSjre bundle as the median ROI of the benchmark companies (i.e. the middle of the three). The median of the three companies ensures that our analysis is not skewed by one company of the three with a particularly high or low cash return on investment. This analysis could be improved in the future with a larger sample of representative companies, but three companies suffice for our proof-of-concept.

Table 6-9 summarizes our Industry Benchmarking analysis for the seven CLIOSjre bundles. More detail of this analysis can be found in the Appendix.

*Table 6-9. Evaluation of the CLIOSjre Bundles using Metric 2. Expected Profit*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Metric 2 Grade</b>	F	C	D	E	B	E	E

To estimate the measurement error of this analysis, the research team examined the range of ROI for the three selected companies in each industry. This range indicates the degree of variation amongst comparable companies in the same industry. The range of ROI and associated measurement error is in Table 6-10.

*Table 6-10. Measurement Error for Metric 2. Expected Profit*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Range of ROI (%)</b>	None	4.6-8.6	4.6-7.3	1.6-3.6	6.5-14	1.6-3.6	2.5-6.8
<b>Measurement Error for Metric 2</b>	F	D – C	D	E	D – A	E	E – D

## Discussion

Based on the research team’s benchmarking analysis, none of these CLIOSjre bundles will be particularly profitable for JR East. However, as with the other metric analyses, the metric grades are more useful in comparison to each other than as standalone grades.

CLIOSjre bundle 1.1 offers the worst return on investment for JR East as the company does not participate in the market. In comparison to this bundle, all CLIOSjre bundles are a better choice for JR East from a perspective of profit. CLIOSjre bundles 3.1, 3.2, and 6.1 offer relatively

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<sup>45</sup> The limited number of publicly held companies in each industry restricted our analysis to three benchmark companies for each industry. Future research may supplement this preliminary analysis with financial data from privately-held companies.

modest returns on JR East's investment. These returns are relatively certain (according to this analysis). The remaining three CLIOSjre bundles (1.2, 5.1, and 6.2) offer higher returns on JR East's investment. In particular, bundle 5.1 offers up to a 13.8% return on investment. However, for all three of these bundles, there was significant variation in the performance of companies in the industry. Thus, although it might be possible for JR East to extract a higher return on its investment, this return depends on the structure of the particular opportunity and not just on JR East's business role.

As noted above, this analysis does not consider the size of the investment for each CLIOSjre bundle. This assumption will skew JR East toward smaller, higher-return bundles (e.g. 1.2 or 5.1) rather than larger, lower-return bundles (e.g. 3.1 or 6.2). JR East should be careful to consider this limitation of our analysis when examining the metric grades.

## 6.4 Metric Analysis Using the CLIOSjre Process: Market Characteristics

This second section details the metrics which evaluate the market characteristics of each CLIOSjre bundle: Metrics 3 through 7.

### *Metric 3. Competition*<sup>46</sup>

As competition is a significant factor in JR East's participation in the Northeast Corridor, the research team devoted a CLIOSjre metric to it. This metric evaluates the competition that JR East will face in a particular CLIOSjre bundle. In addition, Metric 3 evaluates how JR East might have a competitive advantage or disadvantage compared to other players in the market. A brief description of Metric 3. Competition is in Table 6-11.

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<sup>46</sup> Dagin Faulkner was the primary author on this CLIOSjre metric. This section is included with his permission.

Table 6-11. Description of Metric 3. Competition

<b>Metric 3. Competition</b>		
Evaluation Questions	What competition from other players does JR East face in this particular NEC CLIOSjre bundle? How might JR East have a competitive advantage or disadvantage compared to other players? Factors would include JR East's technology in comparison with that of competitors, pricing considerations, growth path opportunities, support after implementation, employment of domestic workforce, and geopolitical factors. An additional consideration is whether the market can afford what JR East wants to or is willing to sell.	
Method of Evaluation	CLIOSjre Six Forces Analysis (adapted from Porter Five Forces analysis)	
Description of Evaluation	Making use of CLIOSjre Six Forces analysis, we will analyze JR East's ability to compete in the CLIOSjre bundle. Six Forces analysis focuses on the structure of the business opportunity from the perspective of the firm (JR East) seeking to enter the market (the Northeast Corridor market for high-speed rail).	
Key Elements of the Metric	This metric will examine the structure of competition in the market. In addition, it will examine the structure of the market opportunity relative to the strengths and weaknesses of potential competitors.	
Metric Spectrum	'F' Outcome	'A' Outcome
	JR East will face intense competition (all six forces are strong)	JR East will have wide market power (all six forces are weak)

CLIOSjre Six Forces analysis is based on the classic Porter Five Forces analysis. Porter Five Forces analysis was developed by Professor Michael Porter at the Harvard Business School and is used globally to understand competition within the marketplace. Michael Porter identifies five forces that shape industry competition:

- Threat of new entrants
- Threat of substitutes
- Power of suppliers
- Power of buyers
- Rivalry of existing competitors

Although Porter Five Forces analysis is used for a number of different industries, the research team found that Porter Five Forces analysis is less than optimal for analyzing competition in the NEC. Michael Porter's five forces do not readily translate to the current situation in the NEC market. Instead, the research team has adapted Porter Five Forces analysis into CLIOSjre Six Forces analysis. We freely acknowledge our intellectual debt to Prof. Porter. This reconfiguration adjusts for the idiosyncrasies of the Northeast Corridor market. CLIOSjre Six Forces analysis identifies six competitive forces:



## **1. Market Competitors**

This force captures businesses that are interested in the NEC market regardless of the particular business role that is available. These companies are existing players in the global HSR market (SNCF/Alstom, Deutsche Bahn/Siemens/Bombardier, JR Central/Nippon Sharyo, China Railway, and others) which have an interest in the NEC market regardless of how the market develops. These companies are interested in all potential business roles in the market. Thus, the strength of competition from these companies will be uniformly strong across CLIOSjre bundles except for CLIOSjre bundle 1.1.

## **2. Business Role Competitors**

This force captures businesses that are only interested in one or two business roles in the NEC market. These companies are not generally involved in the global HSR market (like the Market Competitors above), but may be interested in competing for a particular business role. Example competitors (which compete with JR East on a number of different business roles) are AECOM, WSP Global | Parsons Brinkerhoff, Talgo Inc., American Railcar Industries, BNSF, Keolis, and Firstgroup PLC. The strength of this force will depend on the particular business role and the companies that might be interested in competing for that role.

## **3. Market Substitutes**

This force captures the threat of substitution from other transportation modes in the NEC market. This force depends not on JR East's business role, but on the cost of the HSR system. From the public funding perspective, the government is more likely to seek an alternative if the HSR system is more expensive than other options for capacity expansion (e.g. adding highway capacity to the corridor) become comparably more attractive. Thus, this force is stronger for over-all international quality HSR than for incremental HSR.

## **4. Business Role Substitutes**

This force captures the strength of competition from other companies or public organizations to replace this business role for the CLIOSjre bundle with different service or product. For example, external consulting could be replaced by internal planning and engineering by the US DOT; a turnkey HSR system could be replaced by HSR components. Certain business roles (e.g. HSR operations) cannot be replaced by a substitute service.

## **5. Power of Suppliers**

This force is the same as defined in Porter Five Forces analysis (Porter, 2008). However, it is important to note that this force captures suppliers for JR East's particular business role (not for the general HSR market). Suppliers include JR East's human resources department (who provide talented, well-trained staff valued throughout JR East), providers of HSR components (in the case of turnkey HSR), construction companies, land owners (if JR East is building a private

system), and public regulatory agencies (whose good will is invaluable during design and deployment).

## 6. Power of Buyers

This force captures the power of the buyers of the HSR system (those who pay). For all business roles that require public money, this money will come in part from the US Congress via the US DOT. As Congress has no set timeline for the implementation of HSR, no profit motive, and no urgency in general, this force is strong for any bundle where Congress is the buyer. For all business roles where JR East provides a service directly to the public (e.g. CLIOSjre bundles 3.2 and 6.2), the public is the buyer of concern. Although the public is too diffuse to negotiate on their own behalf, the public can use alternative transportation modes to avoid 'paying for' the JR East private HSR system or service.

### Calculating Grades for Metric 3. Competition

The research team has developed a metric spectrum for assigning grades to each bundle for Metric 3. Competition. For a given bundle, the number of strong, medium, or weak forces will determine the grade assigned. It is useful to convert the “weak”, “medium”, and “strong” classifications into an equivalent numeric system to find a metric grade for each CLIOSjre bundle. Best practices from quality function deployment literature suggests the conversion from an ordinal to a cardinal scale utilizing 1-3-9, 1-3-5, or 1-5-9 scales.<sup>47</sup> The research team choose to employ the 1-3-9 conversions because this provides the greatest (Euclidean) distance and hence differentiation between “medium” and “strong” interests. This is a reasonable representation of the disproportionate effect of strong competitive forces.

For our grade calculations, each strong force receives a score of 9, each medium force receives a score of 3, and each weak force receives a score of 1. The arithmetic mean of the six scores is taken to determine the grade of a bundle. Table 6-12 shows the metric spectrum for Metric 3. Competition.

*Table 6-12. Grade Spectrum for Metric 3. Competition*

<b>Mean of the Six Forces</b>	Strong (9)	7	5	Medium (3)	2	Weak (1)
<b>Metric 3 Grade</b>	F	E	D	C	B	A

Based on a detailed CLIOSjre Six Forces analysis (available in the Appendix), we assigned grades to each of the CLIOSjre bundles in Table 6-13.

<sup>47</sup> For more on the appropriate scaling function, see the works of Akao (1998), Franceschini et al. (2007), and Kim et al. (2012).

*Table 6-13. Evaluation of the CLIOSjre Bundles using Metric 3. Competition*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Metric 3 Grade</b>	A	D	E	E	E	D	D

There are two primary sources of error for Metric 3. Competition. First, the forces that the research group chose for CLIOS Six Forces analysis differs from traditional Porter Five Forces analysis. The six forces identified by the research team may not be an accurate representation of the NEC market competition. Further, these six forces – market competition, business role competition, market substitutes, business role substitutes, suppliers, and buyers – are given equal weight in our analysis. If the six forces were not weighed equally, this would result in a different Metric 3 grade for each bundle.

To estimate the magnitude of this measurement error, the research team recalculated the metric grades with four forces instead: general competition, general substitution, buyers, and suppliers. The first two forces of this analysis (general competition and general substitution) were calculated by averaging the current competition and substitution forces, respectively. The result of this reanalysis is shown in Table 6-14.

*Table 6-14. Estimation of Measurement Error for Metric 3 with Only Four Forces*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Metric 3 Grade with Only Four Forces</b>	A	D	F – E	F – E	E – D	E – D	D

An additional source of error for our analysis is the research team’s characterization of the strength of each force. In particular, while the qualitative line differentiating a medium force from a strong force is ambiguous, the effect of a strong force vs. a medium force classification on the final metric grade is significant.

To estimate the magnitude of this measurement error, the research team recalculated the metric grades with each medium force reclassified as a strong force, and then each medium force reclassified as a weak force. The result of this reanalysis is shown in Table 6-15.

*Table 6-15. Estimation of Measurement Error for Metric 3 with No Medium Forces*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Metric 3 Grade with No Medium Forces</b>	A	E – C	E	E	E	E – D	E – D

Based on these two sensitivity analyses, the research team estimated the measurement error for Metric 3. Competition in Table 6-16. This measurement error represents the extreme values from Table 6-13, Table 6-14, and Table 6-15.

*Table 6-16. Measurement Error for Metric 3. Competition*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Measurement Error for Metric 3</b>	A	E – C	F – E	F – E	E – D	E – D	E – D

## **Discussion**

Metric 3 examines the competition in the HSR market. As there are a significant number of qualified companies interested in the NEC market and a great deal of pressure from the market buyers and suppliers, it is unsurprising that the majority of the CLIOSjre bundles receive a grade below C. This result indicates that the NEC is an exceptionally competitive market.

For CLIOSjre bundle 1.1, JR East will experience no competition for the role of ‘no involvement.’ If JR East is risk adverse to competition and weighs this metric very highly, it might suggest that no involvement for JR East in the NEC is the appropriate business role. Of course, when grades on other metrics are considered, bundle 1.1 is far from the best choice.

The Metric 3. Competition grades for the remaining six CLIOSjre bundles are similar. The remaining CLIOSjre bundles received either a D or an E for Metric 3. Bundle 1.2 received a D rather than an E because the bundle is inexpensive for the federal government and there is therefore little market competition for this bundle. Bundles 6.1 and 6.2 receive a D rather than an E because the international quality high-speed rail system reduces the number of qualified competitors for the business role and because the public is more likely to pay for a system with significantly higher quality service than the other existing transportation modes on the corridor. Although these CLIOSjre bundles (1.2, 6.1, and 6.2) receive slightly higher grades than the other bundles (3.1, 3.2, and 5.1), the measurement error for these bundles indicates that the competition differences between the bundles are subtle and are within the range of error of this analysis.

## *Metric 4. Cooperation*<sup>48</sup>

Cooperation is vital to creating more effective solutions to complex challenges. Many in the business world see cooperation at the heart of future business innovation, creativity, and growth in a global economy. Strategic partnerships<sup>49</sup> can help a company accomplish a variety of goals,

<sup>48</sup> Joanna Moody was the primary author of this CLIOSjre metric. This section is included with her permission.

<sup>49</sup> In general, one might consider two types of partnerships – those ‘outside’ JR East’s business role within a

including easier access to new markets, increased sales and marketing in existing markets, improved access to technology, and gains in human and financial capital. Therefore it is important for JR East to consider the possibility of cooperative endeavors as it evaluates its involvement in international high-speed rail markets.

According to business and management literature, there are two basic steps for identifying possible strategic partners.

1. A company, such as JR East, should list its business goals and identify the goals of other stakeholders in the market. By comparing goals, JR East can determine whether the goals of the two organizations are consistent and compatible.
2. A company must identify what they have to gain (or lose) by cooperating and identify the benefits that potential partners could gain through the relationship.

While this regularized structure exists for considering strategic partnerships on a case-by-case or organization-by-organization pairwise basis, to our knowledge there is no evaluation technique that can capture the overall cooperative potential for JR East of assuming a particular business role within a large group of system stakeholders, such as the actors on the Institutional Sphere of the CLIOS Process applied to the NEC.

Therefore, in the CLIOS Process application to the Northeast Corridor, the R/HSR group developed a methodology called Predictive Coalition-Building Analysis (PCBA) to help visualize, describe, and predict how coalitions might form among actors on the Institutional Sphere of the NEC. PCBA has two main phases. First, stakeholders are clustered based on similarity of interests in the HSR system development objectives. For this we developed an Actor-Objective matrix for the NEC. Second, the Mitchell et al. stakeholder typology from business management literature is used to identify which possible clusters of stakeholders (from the first phase) might have an incentive to work together to gain additional saliency.

Table 6-17 provides an overview of our evaluation procedure for Metric 4. Cooperation.

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market and those 'inside' JR East's business role such as bidding partners. Predictive Coalition-Building Analysis does not distinguish between these two types of partnerships.

Table 6-17. Description of Metric 4. Cooperation

Metric 4. Cooperation		
Evaluation Questions	Will JR East be able to find partners among the stakeholders on the CLIOS institutional sphere of the market given their selected business role in a CLIOSjre bundle? Will these partners be motivated to work with JR East to develop the CLIOSjre bundle?	
Method of Evaluation	Predictive Coalition-Building Analysis (PCBA) which makes use of Clustering Analysis <sup>50</sup> and Mitchell, Agel, and Wood's Stakeholder Typology (1997).	
Description of Evaluation	We will apply Predictive Coalition-Building Analysis to understand how JR East, in its CLIOSjre business role, will relate to existing stakeholders in the HSR market. This two-part methodology first identifies which actors on the Institutional Sphere of the HSR market might have similar interests to JR East when it comes to HSR system development. Second, it discusses how motivated the possible coalition parties might be to work together towards their common goals.	
Key Elements of the Metric	This metric will examine the existing stakeholders in the market based on their similarity of interests with JR East and any incentive they may have to form a partnership.	
Metric Spectrum	'F' Outcome	'A' Outcome
	Zero stakeholders have similar interests to JR East	Multiple potential partners are identified with complementary objectives for the HSR development and both JR East and the partner(s) would gain saliency from working together.

The grade spectrum for Metric 4. Cooperation is given in Table 6-18. This spectrum considers both the number of potential partners for JR East and the similarity in their system development interests with those of JR East from the clustering analysis in Phase 1 of PCBA. The spectrum also considers which (if any) of the parties might gain salience – or the ability to influence the future of HSR development in the market – by working together according to the Mitchell et al. typology used in Phase 2. Stakeholders gain salience by sharing stakeholder attributes – power, legitimacy, and urgency – through partnership. The more of the three attributes a stakeholder or coalition possesses, the more salient they become. Stakeholders that possess full salience (or all three attributes) are referred to as *definitive stakeholders*. If an actor or actor group is a definitive stakeholder, it does not necessarily preclude another actor partnering with it. Instead, it implies that the actor who wants to work with a definitive stakeholder or join a fully salient actor group the onus is on the less salient actor to be the one to expend the energy and make compromises in its interests in order to achieve a relationship with only one-sided incentives.

First, it is reasonable to expect that the more possible partners JR East might have within the market, the better it is for cooperation and therefore the higher the grade for Metric 4. Second,

<sup>50</sup> See the works of Anderberg, 1973, and Fraley & Raftery, 1998.

the closer the alignment of interests between JR East and its possible partner(s), the less compromise will be necessary in forming a partnership and hence the higher the grade. Finally, the highest grade for Metric 4. Cooperation is given only when both JR East and its possible partner(s) are motivated to work together since they both could gain salience from the partnership. If the incentive structure is one-sided, we assign the same grade no matter whether it is the potential partner or JR East that is more motivated to work together. A grade of E is assigned when neither side of a potential partnership is motivated to work together, despite similarity of interests. A grade of F is assigned when there are no possible partners.

*Table 6-18. Grade Spectrum for Metric 4. Cooperation*

<b>Representative Outcome</b>	<b>Metric Grade</b>
Multiple potential partners are identified with complementary objectives for the HSR development. Both JR East and the partners would gain saliency from working together or JR East and its partners are already definitive stakeholders.	A
Multiple potential partners are identified with complementary objectives for the HSR development, but the incentive to work together is one-sided.	B
One potential partner is identified with complementary objectives for the HSR development. Both JR East and the partner would gain saliency from working together or both JR East and that partner are already definitive stakeholders.	C
One potential partner is identified with complementary objectives for the HSR development, but the incentive to work together is one-sided.	D
One or more potential partners is identified with complementary objectives for the HSR development, but neither JR East nor the partner would gain saliency by working together.	E
Zero stakeholders have similar interests to JR East.	F

Predictive Coalition-Building Analysis is a two-phase methodology that first performs agglomerative clustering analysis on the stakeholder’s interests in the many HSR system development objectives. This first phase identifies possible coalitions based on to the idea of belief homophily – groups with similar beliefs are likely to work together – from stakeholder and cooperation analysis in public policy literature.<sup>51</sup> The second phase then applies a stakeholder typology from business and management literature to discuss which of the coalitions identified in Phase 1 might benefit (by gaining salience in future system development decisions) from working together (Mitchell et al., 1997). In order to include JR East as a stakeholder in the analysis for the NEC, we must determine JR East’s interests in the system objectives and JR East’s stakeholder typology for each CLIOSjre bundle. To distinguish between the CLIOSjre bundles, we consider JR East’s different business roles.

More detail on the Predictive Coalition-Building Analysis of the seven CLIOSjre bundles can be

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51 For more on belief homophily, see McPherson et al. (2001) and Gerber et al. (2013).

found in the Appendix. Based on this Predictive Coalition-Building Analysis, we assign the following grades to each CLIOSjre bundle for Metric 4. Cooperation:

*Table 6-19. Evaluation of the CLIOSjre Bundles using Metric 4. Cooperation*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Metric 4 Grade</b>	F	B	C	B	C	B	C

In general we find that CLIOSjre bundles 1.1 – which represent incremental HSR development along the NEC and no business role for JR East in the system – has zero potential for cooperation. While bundle 1.2 also represents incremental HSR, JR East has more potential partners when adopting a consulting role. On the other hand, CLIOSjre bundles where JR East is involved in the market only as an operator – either under concession (as in bundle 3.2) or by buying track capacity from a separate infrastructure operator (as in bundle 6.1) – have the highest potential for coalition-building with grades of B. This is in part due to the large number of passenger transportation operators already existing along the corridor, including Amtrak, multiple Commuter Rail Agencies, Urban Public Transportation Organizations, Intercity Bus Operators, and Airlines.

## Discussion

While the grades presented in Table 6-19 represent the most likely case for the CLIOSjre bundles, there is always uncertainty in how, when, and why partnerships might form. In particular, while the inputs for PCBA are based on domain knowledge and the collective professional judgment of the researchers in the R/HSR group, they are still somewhat subjective. Another analyst could characterize a stakeholder’s interest in one or more objectives differently than those used in the clustering analysis in Phase 1. In particular, including a stakeholder’s indirect interests in the system objective can lead to unintuitive pairings. One could also contend that a given stakeholder in the market should or shouldn’t have an attribute, thus changing its typology in Phase 2. While these changes might reflect in a slightly different clustering tree or incentive structure, many of them would be captured within the range of the grade assigned. Larger differences of opinion in these inputs could cause a shift in a single letter grade. We discuss the probable grade range for each CLIOSjre bundle given measurement error in PCBA and then summarize these results in Table 6-20.

*Table 6-20. Measurement Error for Metric 4. Cooperation*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Measurement Error for Metric 4</b>	F	E – B	D – A	B – A	E – C	B – A	D – A



A significant limitation of this analysis method is that it relies on a certain level of stability in the status quo. PCBA extrapolates from existing conditions to describe how partnerships within a system’s stakeholders might develop. While this approach is founded on evidence that many stakeholders and institutions have relatively stable interests and typology attributes, it cannot account for or predict major pattern breaks within the Institutional Sphere such as large-scale political or administrative change.

### *Metric 5. Flexibility*<sup>52</sup>

As a publicly held company with financial obligations to its stakeholders, JR East is concerned with the possible effects, positive and negative, of uncertainty on its financial return. By that same token, JR East is interested in the use of flexibility to limit its losses and maximize its gains. More flexible business roles allow JR East to both mitigate the negative effects of uncertainty (e.g., decreased demand due to a downturn in economic conditions) and capture new opportunities as they emerge (e.g., increased demand for travel by HSR due to congestion on other modes). In the specific case of HSR on the NEC, JR East is interested in ways to build flexibility into the CLIOSjre bundles under consideration.

In of our analysis the research team defines “flexibility” in the CLIOSjre bundles as the right (but not the obligation) for JR East to take some action at a future date – much as a stock option grants its holder the privilege to buy or sell a stock at an agreed-upon price within a certain period.<sup>53</sup> Our primary question in this metric is “Which CLIOSjre bundles offer JR East the ability to take a potential action in the future that will help it adapt to emerging circumstances on the NEC market?”

Metric 5. Flexibility answers this question through a methodology adapted from Real Options Analysis. Real Options Analysis is an analytical approach that draws upon various disciplines to value real options in a dynamic and uncertain business environment. The following section describes our approach and explains how it differs from traditional Real Options Analysis. Table 6-21 describes Metric 5 in detail.

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<sup>52</sup> Scott Middleton was the primary author of this CLIOSjre metric. This section is included with his permission.

<sup>53</sup> This definition is adapted from the real options framework developed De Neufville & Sholtes, 2011.

Table 6-21. Description of Metric 5. Flexibility

Metric 5. Flexibility		
Evaluation Questions	Does this CLIOSjre bundle have sufficient flexibility to reduce JR East’s risks (demand risk, macro risk, country risk, political risk, legal risk, technology risk, etc.) to an acceptable level?	
Method of Evaluation	Qualitative and Quantitative Flexibility Analysis (adapted from Real Options Analysis) focused on evaluation of business risk and flexibility within this HSR market. In this context, we define risk as the product of the consequences of good/bad events and the probability of those events occurring (i.e., uncertainty). While we typically focus on the negative consequences of these events, this metric also considers positive events as they relate to expansion within the NEC.	
Description of Evaluation	Using Flexibility Analysis, we will assign an estimate of the financial returns resulting from the options open to JR East in a particular CLIOSjre bundle. These options represent the flexibility available to JR East as a result of the company’s investment in the NEC.	
Key Elements of the Metric	The metric will examine the progression of this market over time (as contrasted with Metric 1 which looks at other markets). This builds on the future market scenarios (from the CLIOS Process scenario planning analysis) and incorporates flexibility of JR East’s particular business role in the CLIOSjre bundle.	
Metric Spectrum	'F' Outcome	'A' Outcome
	It is not possible to redesign intervention at a controlled cost to avoid major losses	It is possible to redesign intervention at a controlled cost to avoid major losses and/or to achieve higher gains

Finally, it is worth noting that the use of flexibility to optimize financial returns is not JR East’s only concern. JR East is also interested in protecting the environment; improving living, working, and travel conditions; strengthening its human resources, etc. The company’s ability to achieve these goals is also affected by future uncertainty. A major shift in the public attitude toward climate change, for example, could make it much easier or much more difficult for JR East to achieve its environmental goals. However, the purpose of this metric is to estimate, from a financial perspective, the value of JR East’s ability to adapt to unanticipated risks and opportunities. JR East’s ability to achieve other goals in the face of uncertainty is captured in the other nine metrics, particularly in Metric 6. Net Societal Benefit and Metric 7. Net Environmental Impact. The impacts of risk to JR East’s expansion potential and service reputation are also evaluated in other CLIOSjre metrics (Metric 1 and Metric 9 respectively).

### Relationship to Real Options Analysis

Our methodology for Metric 5, termed “Flexibility Analysis”, is adapted from traditional Real Options Analysis. The following subsections explain how we conducted this analysis in a step-by-step fashion. However, we first explain one important regard in which our Flexibility

Analysis differs from Real Options Analysis.

Traditionally, Real Options Analysis considers the upfront cost of a “real option,” such as an escape clause in a contract or additional upfront construction costs that will reduce the cost of a potential future expansion (e.g., a second deck on a new bridge). This cost is compared to the expected value of the option, which is the product of that real option’s value and the probability that it will be needed. In the case of HSR on the NEC, the complexity of the problem and the lack of existing contracts prevents us from applying classic Real Options Analysis. Because there is no upfront cost or “real option” to evaluate in this case, we consider which CLIOSjre bundles have inherent options built in to the associated business role and assign an estimated financial value to these options. An example of an inherent option would be the option to expand from a consulting role to a more involved role, or for the same role on a larger HSR system in the same market. The term “option” is used to refer to these inherent options for the remainder of the Metric 5 discussion.

### **Relationship to CLIOSjre Scenario Analysis**

As part of the CLIOS Process, the R/HSR Group performed a scenario analysis of the 6 bundles of strategic alternatives identified on the NEC. The scenario analysis addresses questions such as: “What if this CLIOS bundle loses support from political and economic leaders in the market?” and “What obstacles could prevent this particular CLIOS bundle from coming to fruition?”

In this analysis we developed four scenarios that present different sets of potential outcomes and analyze their impacts on the 6 CLIOS bundles. These four scenarios provide a starting point for considering the potential risks faced by JR East on the NEC. The financial analysis from the CLIOS Process scenario analysis process is used as input in our analysis of flexibility.<sup>54</sup>

### **Matching Options to CLIOSjre Bundles**

We used our Flexibility Analysis to calculate the approximate value of each option in each CLIOSjre bundle under each of the four scenarios presented in the Year 1 summary report. In order to calculate this value, we first need to define the viable options for each CLIOSjre bundle. For this analysis we have considered three types of options:<sup>55</sup>

- **Option to Delay:** This option allows JR East to hold off on making further investments in a system if it receives information that suggests the financial performance of a CLIOSjre bundle will be lower than expected. According to the four scenarios we have developed, this option is only appealing to JR East under Scenario A, in which political support for HSR coalesces after a period of turmoil and uncertainty. Under the other three

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54 Although the CLIOSjre bundles are distinct from the CLIOS bundles, the results of this analysis flow naturally into the analysis of the flexibility inherent in each of the seven CLIOSjre bundles.

55 These three options were adapted from the work of Damodaran, 2007.

scenarios we are considering, delaying construction of HSR offers no benefit to JR East, as political support will only wane with time.

This option is available to JR East in bundles where the company is involved in the construction, but not the operation of the actual HSR system. This condition applies to CLIOSjre bundles 1.2, 3.1, 5.1, and 6.2.

- **Option to Abandon:** This option allows JR East to scale down or abandon its investment in the NEC in response to poor performance (e.g., low ridership). This is the most important option for a capital-intensive investment such as HSR because it can lower the risk of financial loss. This option may involve the right to sell off JR East's investment in the NEC for some salvage value. JR East would choose to execute this option if the present value of its future cash flows falls below the liquidation value of its investment. This option is available in all CLIOSjre bundles except for CLIOS bundle 3.2, in which JR East operates HSR on a system owned by another entity as a concessionaire. However, JR East may be required to pay penalties to exercise this option, if doing so violates the agreed-upon terms of a contracting for providing HSR components, construction, or other services.
- **Option to Expand:** This option refers to the possibility of JR East expanding its business role (i.e., from providing consultation to providing HSR components) or the scale of its operations (e.g., from a piecewise HSR system to an all-over international quality HSR system).<sup>56</sup> In this regard, we can see that CLIOSjre bundles 3.1 and 3.2 offer the strongest potential for expansion. If the results of the Boston-New York international-quality HSR segment are positive, these bundles could lead to higher investment in international-quality HSR in other segments of the NEC. Our judgment is that the development of incremental HSR (as in CLIOSjre bundle 1.1 and 1.2) into international-quality HSR may be more difficult than in cases of piecewise HSR.

JR East will use its inherent option to expand if HSR on the NEC is a success (i.e., ridership is high and financial returns are strong) and there is promise of increased profitability. In order to use the option to expand, JR East may need to build production capacity in excess of the expected level of output. This option is available to JR East in all bundles except 6.1 and 6.2 because these bundles represent an all-over international quality system, where JR East will have no opportunity to expand its role.<sup>57</sup>

Based on our evaluation of the options available to JR East (detailed in the Appendix), we define

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<sup>56</sup> The option to expand only refers to expansion potential *within* the NEC market; the possibility of expanding business to other markets is measured in Metric 1. Expansion Potential.

<sup>57</sup> In the case of expansion in CLIOSjre bundles 6.1 and 6.2, the research team did not consider JR East's ability to provide additional service (e.g. more frequent trains) on the international-quality HSR system on the NEC an option to expand, on the grounds that the capacity of the international-quality HSR system in these bundles limits this opportunity for growth.

the metric spectrum for Metric 5. Flexibility as shown in Table 6-22.

*Table 6-22. Grade Spectrum for Metric 5. Flexibility*

<b>Representative Outcome (Expected Value of Options)</b>	<b>Metric Grade</b>
Greater than \$2.0 billion USD	A
Greater than \$1.5 billion USD	B
Greater than \$1.0 billion USD	C
Greater than \$500 million USD	D
Greater than \$0	E
No valuable options are available.	F

More detail on our Qualitative and Quantitative Flexibility Analysis is shown in the Appendix. Table 6-23 summarizes the results of this analysis.

*Table 6-23. Evaluation of the CLIOSjre Bundles using Metric 5. Flexibility*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Expected Value of Options (Billion USD)</b>	\$0	\$1.97	\$1.25	\$0.43	\$1.60	\$1.15	\$0.69
<b>Metric 5 Grade</b>	F	B	C	E	B	C	D

## **Discussion**

Our Flexibility Analysis has several possible sources of measurement error. The first source of measurement error is the probability assigned to each of the scenarios (as well as the base case). To address test these assumptions, the R/HSR team performed a sensitivity analysis on the probability weight assigned to each scenario. In the initial analysis, the monetary value of each option was multiplied by 0.125 to represent a 1/8th probability of each scenario occurring. In the sensitivity analysis, we adjusted this probability across the scenarios to determine how our assumptions affected the evaluation of the bundles.

By varying these assumptions, we discovered that the final grade of each CLIOSjre bundle does vary according to the probability, but that the rank ordering of bundles remains mostly unaffected. The only exception to this is CLIOSjre bundles 6.2 and 3.2. In our initial analysis, bundle 3.2 scored an E and bundle 6.2 scored a D. By increasing the probability of Scenario B and C, bundle 3.2 scores a D and bundle 6.2 scores an E. This minor exception does not detract

from our confidence in the analysis and the results of our sensitivity analysis are presented in Table 6-24.

Another source of measurement error for this metric is error in the outputs of our financial analysis. This source of error was addressed in our CLIOS Process analysis of the Northeast Corridor, and we determined that this error was small in comparison to other sources of error.

*Table 6-24. Measurement Error for Metric 5. Flexibility*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Range of Expected Value (Billion USD)</b>	\$0	\$1.61-2.33	\$0.94-1.55	\$0.33-0.53	\$1.52-1.62	\$1.06-1.25	\$0.35-1.04
<b>Measurement Error for Metric 5</b>	F	B – A	D – B	E – D	B	C	E – C

### *Metric 6. Net Societal Benefit*

To understand the public value of a new high-speed rail system, the R/HSR Group set about to quantify and compare the benefits and costs of each CLIOSjre bundle. Benefit-cost analysis is the standard method for this type of analysis, but the method has several drawbacks. Most fundamentally, benefit-cost analysis requires that all benefits and costs are converted into monetary values for comparison. Converting some impacts (e.g. injuries, fatalities, and environmental degradation) into monetary values is quite difficult and still debated in the literature. Despite these drawbacks, the R/HSR Group decided that benefit-cost analysis was the most robust method for measuring the public benefits of each CLIOSjre bundle. Table 6-25 describes Metric 6 in detail.

Table 6-25. Description of Metric 6. Net Societal Benefit

Metric 6. Net Societal Benefit		
Evaluation Questions	Does this CLIOSjre bundle make sense for the public when one contrasts costs of developing the system with a) revenue and b) other benefits to society that may occur? Does the CLIOSjre bundle improve the living, working, and travel conditions of the regional population? Will the long-term benefits of the HSR project (e.g. improved travel times, better access to the region, more employment opportunities, economic growth) outweigh the costs accrued during construction (e.g. cost of constructing the system, displacement of residents, construction impacts) and other impacts during operations?	
Method of Evaluation	Benefit-Cost Analysis	
Description of Evaluation	The R/HSR Group will perform benefit-cost analysis (from the perspective of the public) to determine the social benefit of the CLIOSjre bundle. This benefit-cost analysis will include reduced environmental footprint, increased safety, equitable economic development, and other social benefits. Bundles will be graded on their internal rate of return (IRR).	
Key Elements of the Metric	This metric will examine the quantifiable net benefit of this particular CLIOSjre bundle. These benefits include benefits to the regional economy as well as quantified social benefits (avoided fatalities, avoided CO2 emissions). This metric will not include qualitative environmental benefits (ecosystem preservation, impact on biodiversity, etc.) since this is captured by Metric 7. Net Environmental Impact. The key concept is that even with political support, a CLIOSjre bundle that does not create appreciable value for system stakeholders may not go forward.	
Metric Spectrum	'F' Outcome	'A' Outcome
	Negative IRR, or the bundle does not fall within the acceptable investment range	15% IRR <sup>58</sup> or higher

As part of the CLIOS Process, the research team performed a benefit-cost analysis for all six CLIOS bundles.<sup>59</sup> Although the CLIOSjre bundles are different from the CLIOS bundles, their public benefit and public costs are very similar. In other words, although JR East has a different business role for CLIOSjre bundle 1.1 and CLIOSjre bundle 1.2, the public benefit of CLIOSjre bundles 1.1 and 1.2 is almost identical to the benefit of CLIOS bundle 1, and the public cost of CLIOSjre bundles 1.1 and 1.2 is almost identical to the public cost of CLIOS bundle 1. From a benefit standpoint, the CLIOS bundles and associated CLIOSjre bundles are very similar because the impacts of the HSR system on the region's people, economy, and environment are primarily dependent on the physical and operational form of the system rather than the specific business role of JR East in the development. From a cost perspective, the higher price of a JR East system

58 For an academic precedent for this approach, see the works of Belli, et al., 1998.

59 It is important to note that fare revenues are not considered in our benefit-cost analysis. As fare revenue is an internal transfer within the US economy, the fares themselves do not produce any economic value or public benefit.

(compared with its competitors) is assumed to be small in comparison to the overall cost of the HSR project. Thus, the research team applied the result of the benefit-cost analysis for CLIOS bundle 1 to CLIOSjre bundles 1.1 and 1.2 as well. The same is true for CLIOS bundles 3, 5, and 6 that correspond to CLIOSjre bundles 3.1, 3.2, 5.1, 6.1, and 6.2 respectively. The full mapping of the CLIOS bundles to the CLIOSjre bundles is shown in Table 6-27.

There is one possible exception to this assumption. JR East’s participation in the market may result in a safer rail system. Depending on JR East’s business role, this safety improvement may be minor or significant. For example, although JR East’s rolling stock and infrastructure has an impeccable safety record, this safety record may only translate to the NEC if JR East is the operator of the HSR system. As this may be a significant assumption in our benefit-cost analysis, we examine this assumption below.

According to the research team’s benefit-cost analysis, avoided accidents and injuries are the most significant benefit of a new high-speed rail system. The existing intercity rail system in the United States already has less than one third the injury rate of the US National Highway System on a per passenger-mile basis. HSR systems around the globe are nearly two orders of magnitude safer than the United States’ highway system (see Table 6-26). This suggests that a significant number of deaths will be prevented and injuries avoided by upgrading the current US intercity rail system to a high-speed rail system and taking more cars off the road.

*Table 6-26. Nationwide Average Injury Rates per Passenger-Mile<sup>60</sup>*

<b>Mode/System</b>	US Highway System	Amtrak System	SNCF System
<b>Injury Rate (per 100 million pass-miles)</b>	5.26	1.54	0.06

These statistics also suggest that there will be a significant increase in safety from the existing rail to any new HSR system. Although the Japanese system is safer than other HSR systems around the world, this additional value is small in comparison to the value of installing any HSR system in the Northeast Corridor. From an economic standpoint, the additional safety benefit from a JR East high-speed rail system is small. Based on this understanding, the research team concluded that the internal rate of return of a given CLIOSjre bundle depends predominantly on the system configuration rather than on the specific equipment provider or system operator. We assume the public benefit of a CLIOSjre bundle is independent of JR East’s role.

<sup>60</sup> This table is based on numbers from SNCF, the US Federal Railway Administration, the US Bureau of Transportation Statistics, and the US National Highway Traffic Safety Administration. Injuries are reported by different agencies with different reporting requirements, and these numbers represent nationwide averages for the United States and France. Thus, they are only useful for illustrative comparison; the injury rates on the TGV system and the Acela system are likely lower than these averages and the injury rate on the National Highway system is likely higher.



*Table 6-27. Mapping of the CLIOS Bundles to the CLIOSjre Bundles*

<b>CLIOS Bundle</b>	1	1	3	3	5	6	6
<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2

The CLIOS Process benefit-cost analysis takes into account a wide variety of public benefits (e.g. reduced carbon dioxide emissions, reduced injuries and fatalities, travel time savings). However, one important benefit is absent from our analysis: agglomeration benefits. Agglomeration – the increase in economic efficiency due to the larger labor and job market provided by new transportation infrastructure – remains a debated subject in the literature. Although there is some indication that transportation infrastructure creates economic mega-regions, it remains difficult to estimate the macroscopic impact of new infrastructure on the economy. Although agglomeration benefits are likely one of the primary benefits of a new HSR system in the Northeast Corridor, the research team decided that these benefits remain too ill defined to include them in our analysis. This should be considered when reviewing the Metric 6 grades for each CLIOSjre bundle.

The R/HSR Group developed the spectrum for Metric 6. Net Societal Benefit by examining the literature for Benefit-Cost Analysis for comparable international projects. We found that a 15% IRR represents an outstanding infrastructure project while projects with a negative IRR are usually considered ineffective and non-implementable. These two reference points define the endpoints of our metric spectrum. The remaining letter grades were defined by linearly extrapolating between these endpoints.

*Table 6-28. Grade Spectrum for Metric 6. Net Societal Benefit*

<b>Representative Outcome (IRR)</b>	Negative	0%	3.75%	7.5%	11.25%	15% or greater
<b>Metric 6 Grade</b>	F	E	D	C	B	A

To assign a letter grade for each CLIOSjre bundle, the research team first calculated the public benefit IRR for each CLIOS bundle using the CLIOS Process benefit-cost analysis. The R/HSR Group used Table 6-27 to map the IRR from the CLIOS bundles to each of the seven CLIOSjre bundles. The group then compared the rate of return with the Metric 6 spectrum in Table 6-28 to determine the metric grade for each bundle. The calculated IRR for each bundle was rounded to the nearest IRR in Table 6-28, and then the bundle was assigned a grade. Table 6-29 displays the evaluation result for each CLIOSjre bundle.

The research team validated our results by performing a sensitivity analysis on the assumptions in the benefit-cost analysis. The costs of the new HSR system are relatively well supported, so

our analysis focused on the potential variability of the projected benefits. Two assumptions in particular need more scrutiny: the value of time of travelers on the system, and the statistical value of a life. By varying these two assumptions by a factor of two,<sup>61</sup> we discovered that the final grade of the CLIOSjre bundles does vary by one letter grade in each direction. These results are reflected in the Range of Metric Grade column of Table 6-29 below.

*Table 6-29. Evaluation of the CLIOSjre Bundles using Metric 6. Net Societal Benefit*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Net Societal Benefit (IRR)</b>	Negative	Negative	5.77%	5.77%	7.44%	7.44%	7.44%
<b>Metric 6 Grade</b>	F	F	C	C	C	C	C
<b>Range of Benefit (IRR)</b>	Negative	Negative	3.75-9.47%	3.75-9.47%	4.23-11.88%	4.23-11.88%	4.23-11.88%
<b>Measurement Error for Metric 6</b>	F	F	D – B	D – B	D – B	D – B	D – B

## Discussion

Metric 6. Net Societal Benefit provides a useful measure of the public importance of high-speed rail on the NEC. Although some will argue that new and improved high-speed rail on the NEC is of national importance, the rate of return for the project (between negative and 7.44%) is not very high in comparison other infrastructure projects worldwide. The CLIOSjre bundles with the highest rate of return (5.1, 6.1, and 6.2) receive only a grade of ‘C’. At first examination, one might conclude that none of these CLIOSjre bundles are particularly good public investments. We argue there two important caveats to this observation:

1. In more developed nations, infrastructure projects often have a much lower rate of return than in developing nations. The improvement of existing infrastructure does not generate as much economic development as the creation of entirely new infrastructure. Furthermore, the cost of construction and maintenance in more densely developed areas, like the metropolitan regions along the NEC, are more costly than in regions with fewer demands on land. Thus, it is somewhat misleading to compare the IRR of these CLIOSjre bundles to the IRR of similar rail projects in developing nations. In this context, a Metric 6 grade of ‘C’ is reasonable.
2. For the Northeast Corridor, it is argued that the United States must select one of the

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<sup>61</sup> Although the value of these two quantities remains a subject of debate the literature and defies typical quantitative analysis, we decided that a factor of two variation captures our measurement error. See the works of De Blaeij et al. (2002) and Noland et al. (2002) for more on this subject.

CLIOSjre bundles presented here or risk collapse of the entire NEC rail corridor. Although the best bundles receive only a ‘C’, in comparison to no investment in the NEC, these bundles are a far better investment than not investing at all.

With those two important caveats, we observe that CLIOSjre bundles 1.1 and 1.2 receive a failing grade. Although they do result in some benefits to the public up front, they result in a downward spiral of deteriorating service on the HSR system in the NEC due to gridlocked rail capacity and continually under-maintained infrastructure. Although the R/HSR Group will retain these two bundles for further analysis, it seems likely that we will eventually discard them because they fail to realize significant public benefits.

CLIOSjre bundles 3.1, 3.2, 5.1, 6.1, and 6.2 all receive a Metric 6 grade of ‘C’. Although the bundles have slightly different rates of return, the difference between the public benefits of the bundles is too small for any of them to stand out. Thus, according to Metric 6. Net Societal Benefit, these bundles are relatively interchangeable. It will be through further analysis of other metrics that we will be able to distinguish these CLIOSjre bundles.

The significant measurement error in our analysis suggests that the public benefit of all seven CLIOSjre bundles is difficult to quantify. Our public benefit estimation relies on the value of two quantities that have not been well defined in the literature: the value of time and the value of a life. However, it is worth noting that the public benefit of CLIOSjre bundles 3.1, 3.2, 5.1, 6.1, and 6.2 remain significantly positive even with these two large sources of error. Although we cannot be certain how much benefit these bundles will deliver, we can be certain that they achieve some level of public benefits, as an important point when one considers the ultimate viability of these bundles.

It is important to consider one final caveat on our benefit-cost analysis when comparing the metric grades: we were unable to quantify all sources of public benefit. In particular, we found no literature that allowed us to definitively quantify the agglomeration benefit of a new high-speed rail system. High-speed rail spurs development on the local and the regional level, and the denser development patterns have been correlated with greater economic development.<sup>62</sup> The research team chose to be conservative and not consider the agglomeration benefits of a new HSR system. As a result, it is likely that the public benefit of all seven CLIOSjre bundles is higher than we have calculated here. Moreover, it is likely that the bundles with more significant investment (3.1, 3.2, 5.1, 6.1, and 6.2) would have a larger agglomeration benefit.

### *Metric 7. Net Environmental Impact*

As a social infrastructure company, JR East is conscious of its impacts on the local and regional environment. The company makes significant technology investments to mitigate the environmental footprint of its rail systems, reduce the energy consumption of its trainsets, and

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<sup>62</sup> See the works of Chatman & Noland (2014) and Chen et al. (2014) for more on this subject.

dampen the noise and vibration of its HSR systems. During our February 2015 meetings in Japan, JR East requested that Metric 7. Net Environmental Impact be added to the CLIOSjre metrics to ensure that each CLIOSjre bundle's impact on local environmental conditions is explicitly estimated and included in the analysis. It is important to note that this analysis only addresses local environmental impacts and not global environmental impacts. Global environmental impacts (e.g. local air pollution, greenhouse gas emissions) are addressed in M6. Net Societal Benefits.

In the United States, environmental impacts are measured using a process known as an Environmental Impact Analysis.<sup>63</sup> This process is mandated by the National Environmental Policy Act of 1970 for all projects receiving federal funding or authorization. Environmental Impact Analysis details the impacts of the project on land uses, natural resources (including parkland and waterways), and minority and low-income communities disproportionately affected by environmental degradation (environmental justice communities). As JR East is particularly interested in these qualitative environmental impacts, the R/HSR Group made the judgement that Environmental Impact Analysis is an appropriate method of analysis for Metric 7.

Once Environmental Impact Analysis is complete, federal agencies are required to implement mitigation for the environmental impacts of the project. However, agencies are not required to mitigate all of the environmental impacts. If mitigation is too expensive (not prudent) or too difficult (not feasible), the project may still go forward. Thus, for our Environmental Impact Analysis for Metric 7, bundles with a poor metric grade may create a significant number of environmental impacts, but they would still be legal options for the market stakeholders to pursue. If market stakeholders choose a CLIOSjre bundle with a poor grade for Metric 7, JR East may decide that involvement in the bundle would result in unacceptable environmental impacts and JR East might not become involved in the NEC market.

The details of Metric 7. Net Environmental Impact are shown in Table 6-30.

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63 For more information, see the Federal Highway Administration's Environmental Review Toolkit (2016).

Table 6-30. Description of Metric 7. Net Environmental Impact

Metric 7. Net Environmental Impact		
Evaluation Questions	Does this CLIOSjre bundle protect and improve the natural environment of the region that is developing the high-speed rail project? Will the long-term local benefits of the HSR project (e.g. lower environmental footprint, dense development, consolidated travel patterns) outweigh the short-term local costs (e.g. construction noise and pollution, negative ecosystem impact)?	
Method of Evaluation	Environmental Impact Analysis	
Description of Evaluation	Drawing from established United States regulations (including the National Environmental Protection Act, Clean Water Act, and Clean Air Act), we will identify and describe the environmental impacts of each CLIOSjre bundle. This analysis will consider potential immediate and long-term impacts as well as possible mitigation, but it will focus exclusively on local, not global, environmental impacts. Global environmental impacts (e.g. air pollution, greenhouse gas emissions) are addressed in M6. Net Societal Benefit.	
Key Elements of the Metric	The metric will examine both qualitative and quantitative short-term environmental impacts (e.g. land converted from other uses, environmental resource loss, displacement of environmental justice communities) as well as the distribution and duration of those impacts. Both construction impacts and the impacts of the system during operation are considered.	
Metric Spectrum	'F' Outcome	'A' Outcome
	There are no feasible or prudent alternatives to mitigate negative impacts to existing natural resources and environmental justice communities.	There will be a no negative impacts to existing natural resources and environmental justice communities.

The environmental impacts of new high-speed rail service in the Northeast Corridor are largely due to the acquisition of new right-of-way. During system construction, new rail right-of-way on the NEC will require substantial conversion of land from other uses and will displace existing residents and disturb natural resources. Once the system is complete, the residents along the corridor may experience higher levels of noise (due to the increased frequency and speed of the trains) and exposure to localized pollution (including machine oils from the trains and electromagnetic interference from the power systems). From the perspective of the NEC stakeholders, these adverse environmental impacts are a barrier to successful implementation of new rail service in the NEC. From the perspective of JR East, these adverse impacts are an opportunity for JR East to showcase the advanced environmental capabilities of their high-speed rail system and differentiate itself from the competition.

In November 2015, the NEC Future Commission completed a Draft Environmental Impact Statement (Draft EIS) that performs a high-level Environmental Impact Analysis for new high-speed rail service in the Northeast Corridor. The NEC Future report compares three Action

Alternatives against a No-action Alternative. While named “no-action,” this No-action Alternative does assume that the Northeast Corridor is brought to a state of good repair. This is a significant improvement over existing operating conditions and hence not really “no action.” Although the three Action Alternatives considered by NEC Future do not align perfectly with the R/HSR Group’s six CLIOS bundles or seven CLIOSjre bundles, the NEC Future Draft EIS provides a great deal of information on environmental impacts in the Northeast Corridor. The R/HSR Group used this Draft EIS to inform our analysis of Metric 7.

For our analysis of the environmental impacts of each CLIOSjre bundle, the research team used the NEC Future No-action Alternative as our point of comparison. The NEC Future No-action Alternative is very similar to our NEC CLIOS Process base case. Thus, the No-action Alternative is a good point of reference. In our analysis, all environmental impacts are compared against the impacts of the No-action Alternative; CLIOSjre bundles which result in environmental impacts that are significantly more than the No-action Alternative must consider appropriate mitigation.

The R/HSR Group draws from the text of the National Environmental Policy Act to define a spectrum for Metric 7. In the federal legislation, there are three important ideas that we use to build the metric spectrum:<sup>64</sup>

- **No Significant Impact:** In federal Environmental Impact Analysis, projects begin by publishing an Environmental Assessment (a high-level observation of the project’s potential to impact the environment). This initial assessment may find that the project will have “no significant impact” on the environment, in which case the project is exempt from further environmental review. Small projects or projects that include in-place upgrades to an existing transportation facility often qualify for a finding of “no significant impact”. We have used this idea to define the ‘A’ metric grade for Metric 7.
- **Feasible alternatives:** If a project does not qualify for a finding of “no significant impact”, the appropriate federal agency must perform a detailed Environmental Impact Analysis and produce an Environmental Impact Statement (e.g. the NEC Future Draft EIS). As part of this detailed analysis, the federal agency will identify all potential environmental impacts of the project. In addition, the federal agency will identify feasible alternatives for the project that accomplish the project goals without causing adverse environmental impacts. These feasible alternatives are considered without regard to the cost or appropriateness of implementing the environmental mitigation. For example, a feasible alternative to reduce noise and vibration on the NEC would be to tunnel the full HSR system from Boston to Washington DC. Although this alternative is likely cost-prohibitive (and therefore not prudent), this alternative would minimize the noise and

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<sup>64</sup> Unfortunately, the word ‘alternative’ is used for several different things in the context of environmental impact analysis. For this report, the three NEC Future Alternative development plans for the NEC will always be capitalized; the local environmental mitigation alternatives will always be in lower case.

vibration impacts of the new HSR system.

- **Prudent alternatives:** In addition to considering feasible alternatives, the federal agency must consider prudent alternatives to mitigate the negative environmental impacts. Although these alternatives may be more expensive than the most simple alternative identified by the federal agency, these alternatives are reasonable considering the project timeline and budget constraints. For example, to mitigate the noise and vibration impacts of a new HSR system, a prudent alternative would be to invest in trainsets that are designed to reduce noise and vibration. Although implementing this mitigation may be more expensive than using traditional trainsets, the additional cost of this alternative would likely be less than the benefit received by local communities.

The R/HSR Group used these three ideas from the federal process to define the spectrum for Metric 7. In the definition of the spectrum, we assume that a few prudent alternatives are more valuable than many feasible but not prudent alternatives. Table 6-31 displays the full spectrum definition for Metric 7. Net Environmental Impact.

*Table 6-31. Grade Spectrum for Metric 7. Net Environmental Impact*

Representative Outcome	Metric Grade
The CLIOSjre bundle will have no significant impact on the environment.	A
There are many feasible alternatives and many prudent alternatives to mitigate the environmental impacts.	B
There are many feasible alternatives and few prudent alternatives to mitigate the environmental impacts.	C
There are many feasible alternatives and no prudent alternatives to mitigate the environmental impacts.	D
There are few feasible alternatives and no prudent alternatives to mitigate the environmental impacts.	E
There are no feasible alternatives to mitigate the environmental impacts.	F

The NEC Future report identifies eight categories of environmental impacts that are “key impacts.” These eight key impacts are important to the federal government as each one is explicitly identified in a federal law or an executive order that mandates that these impacts be addressed. For our analysis of new service on the NEC, the R/HSR group has grouped these eight key impacts from the NEC future report into three classes:

- **Land Use Impacts:** these impacts involve the acquisition of new land for public use and the conversion of land from other, non-transportation land uses.
- **Resource Impacts:** these impacts involve construction on and around existing parkland,

waterways, and ecological resources and operating impacts to these resources once the HSR system is complete.

- **Environmental Justice Impacts:** these impacts involve displacement of low-income and minority communities and negative local conditions (e.g. noise, vibration, pollution) that impact these same communities. Although some of these impacts are also captured in ‘Land Use Impacts,’ federal law mandates that impacts to low-income and minority communities be given special consideration.

Throughout our analysis, we compare the impacts in these three categories against the impacts of the NEC Future No-action Alternative. It is important to note that the majority of land use, resource, and environmental justice impacts of the No-action Alternative are land, resources, and communities *already affected* by the Northeast Corridor. Although state of good repair improvements to the corridor create impacts in all three categories, these impacts are small in comparison to the existing impacts from the Northeast Corridor in its current state.

For our analysis, the R/HSR Group has compiled a summary of the environmental impacts according to the NEC Future Draft EIS. To interpret the NEC Future results, the R/HSR Group mapped the three NEC Future Alternatives to our seven CLIOSjre bundles as shown in Table 6-32. This mapping of NEC Future Alternatives to the seven CLIOSjre bundles is not perfect. In particular, NEC Future Alternative 2 does not involve as much new track as CLIOSjre bundles 3.1 and 3.2. We address this assumption in the discussion section at the end of our analysis.

*Table 6-32. Mapping from the NEC Future Alternatives to the CLIOSjre Bundles*

<b>NEC Future Alternative</b>	1	1	2	2	3	3	3
<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2

The full details of our Environmental Impact Analysis are shown in the Appendix. Based on this Environmental Impact Analysis, we assign the following grades to each CLIOSjre bundle:

*Table 6-33. Evaluation of the CLIOSjre Bundles using Metric 7. Net Environmental Impact*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Metric 7 Grade</b>	C	B	C	D	D	E	C

As this metric analysis is based on an extensive Environmental Impact Analysis completed by the Federal Railroad Administration for the Northeast Corridor, we believe that the measurement error stemming from the NEC Future Draft EIS is very small. However, there are other sources



of measurement error in our analysis.

As noted in the introduction to this metric, CLIOSjre bundles 3.1 and 3.2 do not perfectly match NEC Future Alternative 2. CLIOSjre bundles 3.1 and 3.2 require comparatively more new land acquisition and construction than Alternative 2. Thus, it is likely that CLIOSjre bundles 3.1 and 3.2 should receive slightly lower grades than our analysis indicates here. This fact is reflected in Table 6-34 below.

For the remaining CLIOSjre bundles, the research team believes that we have accurately mapped the NEC Future analysis to the CLIOSjre bundles. While there are limitations of any Environmental Impact Analysis (and the research team discusses several such limitations above), the depth of analysis provided by the NEC Future report allows the R/HSR Group to be very confident in the results of this analysis. We believe throughout that we have represented the influence of JR East’s expertise and technology accurately. Our final estimate for measurement error is represented in Table 6-34 below.

*Table 6-34. Measurement Error for Metric 7. Net Environmental Impact*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Measurement Error for Metric 7</b>	C	B	D – C	E – D	D	E	C

## **Discussion**

As mentioned before, this analysis only addresses local environmental impacts and not global environmental impacts (global impacts are addressed in Metric 6. Net Societal Benefit). In this context, it is unsurprising to find that CLIOSjre bundles with smaller modifications to the existing high-speed rail systems create fewer local environmental impacts. Meanwhile, bundles which result in significant upgrades to the existing system create significant land, resource, and community impacts. It is also important to note that CLIOSjre bundles which make use of JR East’s advanced noise, vibration, and tunneling technologies receive higher grades than CLIOSjre bundles which do not. In particular, CLIOSjre bundle 1.2 (incremental, Amtrak-led, public high-speed rail with JR East as a consultant) receives the highest grade for Metric 7 as it takes advantage of these two characteristics – small changes to the existing high-speed rail system and good utilization of JR East’s expertise. At the other extreme, CLIOSjre bundle 6.1 (international quality HSR with competing operators and JR East as one of the competitors) has neither of these characteristics – the bundle requires significant upgrades to the existing HSR system and does not take advantage of JR East’s expertise and technology.

JR East’s role in the CLIOSjre bundle has a significant impact on the number of feasible and prudent mitigation alternatives. Indeed, the only difference between the E of bundle 6.1 and the

C of bundle 6.2 is that JR East will provide much better mitigation as the owner of a private infrastructure system rather than the operator of a private HSR service. The importance of JR East's business role in the environmental impact of the CLIOSjre bundle is an important takeaway from Metric 7, and should be considered when JR East chooses its approach to the NEC market.

## 6.5 Metric Analysis Using the CLIOSjre Process: JR East's Characteristics

This third and final section details the metrics which evaluate JR East's characteristics with respect to each CLIOSjre bundle: Metrics 8, 9 and 10.

### *Metric 8. Strengths and Weaknesses*

As one of many competitors for the planning, construction, and operation of high-speed rail service in the Northeast Corridor, JR East will be able to make use of its strengths to gain an advantage over the competition. By participating in the market, JR East will also be exposed to situations that emphasize its weaknesses. In order to address these effects, the R/HSR Group examines JR East's strengths and weaknesses as an independent metric in the CLIOSjre Process. To avoid double counting JR East's strengths and weaknesses in multiple CLIOSjre metrics (in particular Metric 3. Competition), the analysis of Metric 8. Strengths and Weaknesses focuses on the characteristics of JR East and how they relate to the market. In particular, this analysis focuses on the business role of the particular CLIOSjre bundle and how it relates to JR East's current abilities and experience. A description of Metric 8. Strengths and Weaknesses is below in Table 6-35.

Table 6-35. Description of Metric 8. Strengths and Weaknesses

Metric 8. Strengths and Weaknesses		
Evaluation Questions	How does this CLIOSjre bundle align with JR East's strengths and avoid JR East's weaknesses in HSR system deployment? How will this CLIOSjre bundle align with the strengths of the subsidiary companies of JR East (e.g. Japan Transport Engineering Company's manufacturing expertise)? Will this CLIOSjre bundle build upon JR East's existing business lines (transportation, lifestyle business, IC card, rolling stock, etc.)?	
Method of Evaluation	Strengths and Weaknesses Analysis	
Description of Evaluation	The research team will consider JR East's fundamental strengths and weaknesses and how they align with each CLIOSjre bundle. This analysis will focus on the qualitative characteristics of JR East not captured in the CLIOSjre Six Forces analysis of Metric 3. Competition.	
Key Elements of the Metric	The metric examines how well JR East's strengths and weaknesses align with the market and JR East's business role. The analysis will focus on the structure of the market and the planned HSR system together with JR East's business role.	
Metric Spectrum	'F' Outcome	'A' Outcome
	The CLIOSjre bundle aligns with most of JR East's weaknesses and no strengths.	The CLIOSjre bundle aligns with most of JR East's strengths and no weaknesses.

To evaluate JR East's strengths and weaknesses, the R/HSR Group will perform a partial SWOT (Strengths, Weaknesses, Opportunities, and Threats) Analysis on each CLIOSjre bundle. SWOT analysis is a structured planning method to evaluate a business venture. For our analysis, the research team will only examine the strengths and weaknesses portion of SWOT analysis; thus, we have named our analysis Strengths and Weaknesses Analysis. The opportunities and threats portion of the full SWOT analysis is considered separately in Metric 1. Expansion Potential.

There are several limitations of full SWOT analysis that are relevant to our Strengths and Weaknesses Analysis:

- SWOT analysis is not designed to rank order or choose between CLIOSjre bundles. Rather, SWOT analysis is designed to help stakeholders think through the relevant issues facing a particular bundle. For our Strengths and Weaknesses Analysis, the R/HSR Group has worked to adapt this comparative analysis into a metric grade (and therefore, an implicit ranking of each bundle).
- As SWOT analysis is sometimes considered an alternative to Porter Five Forces analysis, the R/HSR Group was careful to avoid overlap between our Strengths and Weaknesses Analysis and CLIOSjre Six Forces analysis. In particular, our Strengths and Weaknesses Analysis does not consider the role of any particular stakeholders involved in the

CLIOSjre bundle. In addition, our analysis avoids examination of the role of suppliers and customers of JR East’s business and instead focuses on JR East’s characteristics and how they relate to the CLIOSjre bundle. Despite these efforts, there remains some overlap between Metric 8. Strengths and Weaknesses (which uses Strengths and Weaknesses Analysis) and Metric 3. Competition (which uses CLIOSjre Six Forces analysis). This overlap should be considered when selecting a strategy vector to weigh the metric grades into an overall grade of each bundle.

- SWOT analysis does not differentiate between issues by magnitude. Thus, a SWOT analysis may imply a false equivalence between strengths, weaknesses, opportunities, and threats of different magnitude (for example, a small strength may be falsely equated with a large weakness). For our Strengths and Weaknesses Analysis, the research team was not able to overcome this weakness. We examine the implications of this weakness of the analysis during the discussion section of this metric analysis and consider it in the measurement error of this metric.

With these limitations in mind, the R/HSR Group has developed a metric spectrum for Metric 8. Strengths and Weaknesses (see Table 6-36).

*Table 6-36. Grade Spectrum for Metric 8. Strengths and Weaknesses*

<b>Representative Outcome</b>	<b>Metric Grade</b>
The CLIOSjre bundle aligns with most of JR East’s strengths and no weaknesses.	A
The CLIOSjre bundle aligns with most of JR East’s strengths and few weaknesses.	B
This CLIOSjre bundle aligns with some of JR East’s strengths and few weaknesses.	C
This CLIOSjre bundle aligns with few of JR East’s strengths and some weaknesses.	D
This CLIOSjre bundle aligns with few of JR East’s strengths and most weaknesses.	E
The CLIOSjre bundle aligns with most of JR East’s weaknesses and no strengths.	F

Using input from the CLIOS Process, the R/HSR Group performed a Strengths and Weaknesses Analysis on all seven CLIOSjre bundles. As a world class passenger railroad, JR East has a great deal of expertise in a number of areas. However, an extensive evaluation that includes all of the company’s strengths and weaknesses would be prohibitively time-consuming. Instead, the research team has focused on the strengths and weaknesses of JR East that make it stand out from other competitors or are particularly relevant to international HSR development. During the R/HSR Group’s application of the CLIOSjre Process to the Northeast Corridor, the research team identified a list of JR East’s key strengths and weaknesses. These key strengths and weaknesses are below:

## **Strengths**

- Weather impact mitigation technology (e.g. snow barriers, wind screens)
- Earthquake protection technology
- Environmental footprint mitigation technology (e.g. long nose lead car, bogie covers, pantograph noise reduction, cogeneration systems)
- Operations safety technology (e.g. ATACS control system, level crossing obstacle detection)
- Operations efficiency technology (e.g. automatic train coupling)
- Operating procedures (e.g. employee training, 12-min terminal station turnaround, depot storage of trains)
- Operating experience and safety record
- Advanced payment system technology (e.g. IC Card)
- Station real estate development experience

## **Weaknesses**

- Limited experience with multi-operator system
- Limited experience with mixed right-of-way
- Limited experience with mixed-speed traffic
- Limited experience with vertically separated rail infrastructure

This is not an exhaustive list of JR East's strengths and weaknesses. In particular, JR East's recruitment, training, and retention methods are an additional strength of the company not listed here. JR East's human resource practices are not included in this analysis because this strength is given separate treatment in Metric 10. Human Resource Development. Our omission of this strength (and potentially other strengths and weaknesses) is addressed further in the discussion section of this metric.

Although JR East's strengths and weaknesses are present in all seven CLIOSjre bundles, their importance varies depending on the HSR development plan for the bundle and JR East's business role for the bundle. In addition, the importance of each strength and weakness will depend on the particular HSR market of interest. To understand the relevance of these strengths and weaknesses to each CLIOSjre bundle in the Northeast Corridor, we examine the application of each strength and weakness to each CLIOSjre bundle. Based on this Strengths and Weaknesses Analysis (detailed in the Appendix), we assign the following grades to each CLIOSjre bundle:

*Table 6-37. Evaluation of the CLIOSjre Bundles using Metric 8. Strengths and Weaknesses*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Metric 8 Grade</b>	D	E	A	C	C	C	B

There are a number of sources of measurement error in this analysis. First, and perhaps most importantly, the research team has identified and classified JR East’s strengths and weaknesses into nine strengths and four weaknesses. This list of strengths and weaknesses may not be complete. Our definition of JR East’s strengths and weaknesses has an impact on the grade of each CLIOSjre bundle. For some bundles, this impact is greater than others. Bundles which sit near the boundary between two letter grades may in fact deserve the neighboring grade. For example, a bundle that aligns with JR East’s four operating strengths could receive a grade of C. If instead these four operating strengths were classified as one strength (e.g. operating expertise and technology), the same bundle would receive a grade of D. Of the seven CLIOSjre bundles, bundles 5.1 and 6.1 lie at the threshold between C and D. The possible measurement error due to the classification of strengths and weaknesses is noted in Table 6-38.

In addition, our analysis did not rigorously account for the relative importance of each strength and weakness. This limitation is particularly applicable for CLIOSjre bundle 5.1; although the bundle only aligns with two of JR East’s strengths, these strengths are particularly relevant for the business role of the bundle. We account for this issue with CLIOSjre bundle 5.1 in the measurement error for bundle 5.1 (see Table 6-38).

Finally, one of JR East’s primary strengths and two of JR East’s weaknesses were not addressed by this analysis: JR East’s systematic approach to HSR infrastructure design, the high price of JR East’s full Shinkansen system, and JR East’s limited experience with international development. JR East’s systematic approach and high price were not included in our preliminary Brand Impact Analysis; the research team will address this strength and weakness in our final proof-of-concept application of the CLIOSjre Process to the NEC.

We address JR East’s limited experience with international development in the measurement error of this metric. Of the seven CLIOSjre bundles, only bundle 1.1 does not expose JR East to this weakness as JR East would not participate in the market. The research team decided that addressing JR East’s limited international experience in our Strengths and Weaknesses Analysis would distract from more bundle-specific strengths and weaknesses. However, this omission indicated that bundle 1.1 should receive a higher grade than is indicated by our analysis. This possible measurement error is also shown in Table 6-38.

Based on these limitations of our analysis, the research team identifies the measurement error for Metric 8. Strengths and Weaknesses below:

Table 6-38. Measurement Error for Metric 8. Strengths and Weaknesses

CLIOSjre Bundle	1.1	1.2	3.1	3.2	5.1	6.1	6.2
Measurement Error for Metric 8	D – C	E	A	C	D – C	D – C	B

## Discussion

Metric 8. Strengths and Weaknesses captures JR East’s desire to utilize the company’s strengths and avoid the company’s weaknesses. Thus, it is unsurprising that CLIOSjre bundles 3.1 and 6.2 receive the highest grades. These two bundles involve JR East selling or privately funding a turnkey HSR system – one of the stated long-term goals of the company for the Northeast corridor. A turnkey system takes advantage of most or all of JR East’s strengths and tends to avoid JR East’s key weaknesses. Thus, bundles 3.1 and 6.2 are the best from this perspective.

Most of the other CLIOSjre bundles receive average grades for Metric 8; this indicates that they all align with both JR East’s strengths and weaknesses. Only CLIOSjre bundle 1.2 receives a poor grade for Metric 8. As a planning, engineering, and operations consultant in CLIOSjre bundle 1.2, JR East is likely unable to take full advantage of the company’s many strengths. In addition, because bundle 1.2 is incremental HSR, JR East must face several of its key weaknesses (notably mixed right-of-way and mixed-speed traffic).

One of JR East’s core strengths was not considered in this analysis: JR East’s employee hiring, training, and retention policies. These human resource strengths are a particular advantage to JR East when the business role for the CLIOSjre bundle requires long-term operating support. The human resource strengths of JR East are considered separately in Metric 10. Human Resource Development. Thus, to avoid double-counting, this strength was not considered in our Strengths and Weaknesses Analysis.

## *Metric 9. Reputation for Excellent Service*

As one of the premier high-speed rail companies in the world, JR East is very proud of its well-deserved reputation within Japan and across the globe. JR East has tied its company brand to the internationally recognized Shinkansen system and the system’s key performance characteristics: safety, speed, and reliability. JR East’s staff are a key element of this reputation; they are known to be exceptionally efficient, professional, and responsive to customer needs.

Although the Shinkansen’s reputation is unique globally, all the JR companies have a right to the Shinkansen trademark and associated reputation. JR East has worked to further distinguish its Shinkansen system from other Japanese Shinkansen systems with energy efficiency and environmental mitigation technology. These technologies include a long nose lead car, bogie

covers, and pantograph designs that reduce noise inside and outside the train, and electricity cogeneration systems that improve JR East's energy efficiency and reduce its climate footprint. Although JR East does not yet have name recognition on par with 'Shinkansen,' the company is working to extend the reach of its unique brand.

With a strong reputation globally, JR East is rightfully concerned that a misstep in its expansion into international markets, particularly the well-known Northeast Corridor, could hurt its global reputation. Thus, the R/HSR Group has established a metric of the CLIOSjre Process to capture how HSR development along the Northeast Corridor and JR East's business role within that development might impact JR East's reputation.

The estimation of brand value is an ongoing subject of research in the marketing and business community. Some researchers suggest that brand value should be estimated via the price difference between branded companies and unbranded companies in the same industry. This method presumes that strong brands are not required to compete on price with less well-branded companies; companies with a strong brand can extract a higher price from their customers. Other researchers suggest that financial goodwill (i.e. company value above existing assets) is a better proxy for brand value. Goodwill represents the market value of the company that cannot be attributed to any other asset. Still others suggest that brand surveys (administered directly to the population of interest) are more useful for evaluation of brand value. These surveys ask customers to directly compare two or more brands and describe their feelings for each. These surveys can be useful to understanding a corporate brand even though they do not usually generate a quantitative estimate of value.<sup>65</sup>

Although all of these methods could be applied to JR East's involvement in the Northeast corridor, the research team decided that they were not effective for our purposes for three reasons:

1. These models of brand value are not designed to estimate the additional value of a new business endeavor. The models are primarily designed to validate or estimate the value of a company's existing brand, especially during acquisition by another company. These models would need to be significantly adapted to work in the context of JR East's role in the Northeast Corridor.
2. In order to estimate the additional future brand value that JR East would gain by becoming involved in the NEC, the research team would be required to make substantial assumptions about JR East's marketing in the NEC, the quality of service of the new HSR system, and the impact these factors would have on public perception. We believe it would be very difficult to develop these brand value prediction models with the necessary confidence to utilize them.

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65 For an overview of these survey approaches, see Kamakura & Russell, 1993.



3. Although JR East seeks to expand the reach of its reputation, since the company already enjoys a renowned reputation for excellent service, the company is most concerned about potential losses of reputation in the NEC rather than gains. In this sense, they are risk-averse. In addition, the brand value gained by participating in the NEC market is addressed separately in Metric 1. Expansion Potential. For Metric 9. Reputation for Excellent Service, the research team decided it would be most useful to consider the potential negative impacts to JR East’s brand in the NEC rather than speculative benefits.

With these limitations of existing brand valuation methods in mind, the R/HSR Group has developed Brand Impact Analysis to address potential impacts to JR East’s brand.<sup>2</sup> We discuss it in detail in Table 6-39 below.

*Table 6-39. Description of Metric 9. Reputation for Excellent Service*

<b>Metric 9. Reputation for Excellent Service</b>		
Evaluation Questions	Does this CLIOSjre bundle meet JR East’s standards for safety, speed, and reliability? Will this CLIOSjre bundle improve safety, speed, and reliability over the existing transportation system? How does this CLIOSjre bundle align with JR East’s international reputation for excellent service? Does the CLIOSjre bundle protect JR East’s international brand?	
Method of Evaluation	Brand Impact Analysis	
Description of Evaluation	The research team will examine the ways in which the CLIOSjre bundle may impact JR East’s existing reputation. The team will estimate how well the HSR system will perform in comparison to JR East’s standards, and the team will predict how JR East’s business role in the CLIOSjre bundle will impact JR East’s reputation for excellent service. Given the potential impacts to JR East’s brand, the research team will also identify potential mitigation alternatives to reduce or eliminate the impact to JR East’s brand.	
Key Elements of the Metric	This metric will examine the proposed structure of the HSR system (vertically integrated/separated, single/multi-operator, etc.) as defined by the CLIOS bundle and JR East’s business role. We will consider how well the HSR system will be able to match JR East’s standards for reliability, speed, and safety.	
Metric Spectrum	'F' Outcome	'A' Outcome
	There are no feasible alternatives to mitigate the impacts to JR East’s reputation for excellent service.	The CLIOSjre bundle will have no significant negative impact on JR East’s reputation for excellent service.

As discussed above, the research team developed Brand Impact Analysis to evaluate each CLIOSjre bundle’s impacts to JR East’s reputation and potential mitigation alternatives for these impacts. This methodology is similar in structure to Environmental Impact Analysis. For a review of Environmental Impact Analysis, see Metric 7. Net Environmental Impact.

To evaluate impacts to JR East's brand, the R/HSR Group has developed its own evaluation of each CLIOSjre bundle. Our discussion of each bundle focuses on the risks to the various aspects of JR East's brand. In addition, we discuss potential mitigation strategies and their application to the brand impacts. For example, in a bundle where new HSR service in the NEC could be unreliable and JR East risks negative impacts to its reputation for reliable service, JR East could provide refunds to dissatisfied customers. This may be a prudent short-run mitigation alternative, but in the long run it is neither prudent nor feasible as it could make the HSR service unprofitable.

For the purposes of this analysis, we do not include impacts to JR East's brand that are inherent to HSR system development (e.g. displacement of existing residents, resistance from local jurisdictions) as these impacts are captured separately in Metric 7. Net Environmental Impact. Instead, we focus on brand impacts that are due to the institutional structure of the bundle and JR East's role.

For Brand Impact Analysis, there are three important ideas that we use to build the metric spectrum (again inspired by our work in Metric 7. Net Environmental Impact):

- **No Significant Impact:** For our analysis of impacts to JR East's brand, we consider small risks (reputation issues that may be resolved within a month) to qualify for a finding of "no significant impact." Drawing from our earlier example of unreliable service, a one hour service disruption that is mitigated with refunds to customers would not be considered a significant service disruption for the NEC. A service disruption on this scale would be classified as "no significant impact." This idea defines the 'A' metric grade for Metric 9.
- **Feasible Alternatives:** For our analysis of impacts to JR East's brand, most brand risks will not qualify for a finding of "no significant impact." For these significant impacts, the research team will identify feasible mitigation alternatives. These feasible alternatives are considered without regard to the cost. For example, poor service could be ameliorated by fare cuts to placate customers who have experienced poor service. These fare cuts would not eliminate the damage to JR East's brand, but they would reduce the animosity toward the company.
- **Prudent Alternatives:** For our Brand Impact Analysis, we will also address whether the feasible mitigation alternatives are prudent from the standpoint of JR East. Drawing again from our unreliable service example, fare cuts may be a feasible alternative to mitigate impacts to JR East's brand, but they are likely not a prudent alternative. Long-term fare reductions would reduce JR East's revenue, could undermine profitability of the service, and lead to worsening of the already unreliable service. Although JR East could pursue CLIOSjre bundles that have no prudent mitigation alternatives, JR East must be willing to

accept the risk of damage to its reputation.

The R/HSR Group used these three ideas to define the spectrum for Metric 9. Reputation for Excellent Service. In the definition of the spectrum, we assert that a few prudent alternatives are more valuable than many feasible but not prudent alternatives. Table 6-40 displays the full spectrum definition for Metric 9.

*Table 6-40. Grade Spectrum for Metric 9. Reputation for Excellent Service*

Representative Outcome	Metric Grade
The CLIOSjre bundle will have no significant impact on JR East’s reputation for excellent service.	A
There are many feasible alternatives and many prudent alternatives to mitigate the impacts to JR East’s reputation for excellent service.	B
There are many feasible alternatives and few prudent alternatives to mitigate the impacts to JR East’s reputation for excellent service.	C
There are many feasible alternatives and no prudent alternatives to mitigate the impacts to JR East’s reputation for excellent service.	D
There are few feasible alternatives and no prudent alternatives to mitigate the impacts to JR East’s reputation for excellent service.	E
There are no feasible (nor prudent) alternatives to mitigate the impacts to JR East’s reputation for excellent service.	F

The R/HSR Group has identified five key elements of JR East’s reputation. These key elements are drawn from the JR East Group Management Vision V: Ever Onward. The impacts to JR East’s reputation have been analyzed according to these five elements:

- Speed:** At its most fundamental level, the JR East high-speed rail system allows passengers to traverse great distances in a short amount of time. The speed of the Japanese Shinkansen system is a primary characteristic that is known around the world. For our analysis, we consider JR East’s reputation for speed to be determined by the scheduled travel time of HSR service; a reputation for regular delivery of fast service falls under the heading ‘reliability.’
- Safety:** The safety of the Japanese Shinkansen system (and JR East’s system in particular) is paralleled by only a few other HSR systems in the world. JR East’s view of safety as an emergent property of infrastructure and operations fosters a total quality management approach to safety and an impeccable safety record. The company boasts zero passenger fatalities since the system was created, and JR East is working to reduce deaths and injuries from other causes, such as accidental falls and suicide, with new boarding doors on station platforms. For our analysis, we will examine the operating

conditions of the HSR service and the expected crash rate for these conditions.

- **Reliability:** As with safety, JR East takes pride in the reliability of its integrated infrastructure and operations system. The on-time performance of JR East’s rail system is such that the company will issue delay certificates to passengers if the train is as little as five minutes late. For our analysis, we will examine both the operating conditions and organizational structure of the HSR service to predict the reliability of the system.
- **Hospitality:** All JR East personnel – from cleaning staff to operations management – are held to very high standards of professionalism and expertise. During his speech to the MIT ILP Conference in November 2015, JR East Vice Chairman Masaki Ogata called these high standards ‘omotenashi.’ In particular, he emphasized the “moment of truth” when a customer interacts with a JR East employee and forms an opinion about the company. These high standards of performance are present in all aspects of JR East’s culture, but they are especially relevant for JR East’s station attendants and operations personnel. JR East’s standards for omotenashi translate to reputation for exceptional hospitality. For our analysis, we will consider the role of JR East in the bundle (i.e. whether any JR East staff will interact with customers) and the ability of JR East to control the customer experience.
- **Environment:** JR East has made significant investments in technology to mitigate the environmental footprint and energy consumption of its HSR system. Within Japan, JR East is recognized as a leader in this field. For our analysis, we will examine JR East’s ability to control the environmental performance of the system.

Full detail on our Brand Impact Analysis of the seven CLIOSjre bundles is available in the Appendix. Based on this Brand Impact Analysis, we assign the following grades to each CLIOSjre bundle:

*Table 6-41. Evaluation of the CLIOSjre Bundles using Metric 9. Reputation for Excellent Service*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Metric 9 Grade</b>	A	B	C	B	D	B	A

There are two prominent sources of measurement error in this Brand Impact Analysis. First, the research team’s identification of the key elements of JR East’s brand may be incorrect. Other elements of JR East’s brand (e.g. high-frequency service) may be more important than one of the elements that we have addressed (e.g. speed). Although this is a possible source of error in our analysis, the research team believes its impact is small. In our analysis, we address five key elements of JR East’s brand; adding or subtracting one element would not substantively change our conclusion. The research team does not believe this is a significant source of measurement

error.

Second, our characterization of the brand risks and mitigation alternatives may be incorrect. As this characterization is based on a qualitative review of the risks and alternatives available to JR East, it is possible that the research team has omitted key brand risks or mitigation alternatives. In addition, we made assumptions about the relative importance of the key elements of JR East’s brand. These omissions and assumptions would substantively impact the conclusions of our analysis. The research team has worked to address these sources of error on a bundle-by-bundle basis, and our conclusions are reflected in Table 6-42 below.

*Table 6-42. Measurement Error for Metric 9. Reputation for Excellent Service*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Measurement Error for Metric 9</b>	A	B	D – C	B	D	B	B – A

## **Discussion**

Brand Impact Analysis examines the risk of each bundle to JR East’s existing reputation for excellent service. This metric captures JR East’s risk-adverse approach to its brand. Thus, CLIOSjre bundles perform best according to Metric 9 when they avoid risk (rather than embracing opportunity). In this context, it is unsurprising the CLIOSjre bundle 1.1 performs the best according Metric 9. For bundle 1.1, JR East does not become involved in the NEC HSR market. There are no risks to JR East’s brand, so bundle 1.1 receives a perfect grade of A. However, it is important to note that bundle 1.1 also offers JR East no opportunities to expand the reach of its brand into the United States.

The remaining six CLIOSjre bundles perform relatively well according to Metric 9. Only one bundle (5.1) received a grade below a C. This indicates that although most bundles put JR East’s reputation at risk, for all of the bundles, there are prudent alternatives to mitigate the risk to JR East’s reputation. By entering the market strategically (e.g. as a subsidiary or as a private operator after the infrastructure is complete), JR East can mitigate the risks to its reputation and still capture the other benefits of each CLIOSjre bundle. These strategic mitigation alternatives are highlighted in the analysis of each bundle in the Appendix.

## *Metric 10. Human Resource Development*

The expertise and professionalism of JR East’s employees is essential to the company’s success. At the management level, JR East employees ensure proper maintenance of the JR East rail system and plan strategic investments to keep the system in good condition. At the service level, JR East employees ensure the proper day-to-day operations of the company and directly interact

with customers.

In his presentation during the MIT Industrial Liaison Program conference in November 2015, JR East Vice Chairman Masaki Ogata stressed the importance of the interaction between JR East's employees and the customer. As an integrated technology and service industry, the customer perception of JR East is formed only in the "moment of truth" when rail service is simultaneously provided and consumed. The professionalism and hospitality (*omotenashi*) of this one employee may determine how satisfied a customer is with JR East and its quality of service. As a result, JR East works to ensure that their employees at every level of the company are capable and professional. For JR East, it is of utmost importance to attract, properly train, and retain committed and highly capable employees at all levels of the organization.

This need to attract, train, and retain employees is especially important for JR East as it expands into international markets. The company will hire employees in new HSR markets. JR East will also need to send existing JR East employees to train those new employees, convey the company's expertise, and ensure that the new HSR system delivers service that meets JR East's standards. In order to hire enough people in these new HSR markets, JR East may have to adapt its existing hiring and retention practices to the local labor market. For example, in the United States, employment contracts are typically much shorter than they are in Japan. To ensure that JR East is still able to attract, train, and retain highly capable employees in international HSR markets, it is necessary to consider the impact of each new market on JR East's human resources.

To understand JR East's human resources in the context of the Northeast Corridor of the United States, the R/HSR Group created Metric 10. Human Resource Development. There is no existing consensus in the literature on the proper way to measure human capital. A number of existing methods have been developed that estimate the value of existing human capital within a company (Petty & Guthrie, 2000). However, none of these methods are designed to estimate the growth of human capital as the result of a new business enterprise. Therefore, the research team has developed its own methodology to evaluate the potential human resource development of a new business endeavor.

The qualitative approach developed by R/HSR considers the number of new employees who may be attracted by a project, whether these employees will be internal to JR East and its subsidiary companies or hired from the country of the HSR market, and whether JR East will be able to train and retain these new employees to add to the long-term institutional knowledge and expertise of the company. Table 6-43 explains this method of analysis and how we apply it for Metric 10.

Table 6-43. Description of Metric 10. Human Resource Development

<b>Metric 10. Human Resource Development</b>		
Evaluation Questions	Does this CLIOSjre bundle offer current JR East employees the opportunity to gain experience overseas? Does the CLIOSjre bundle offer JR East the opportunity to hire and train new employees from the country?	
Method of Evaluation	Attract, Train, and Retain (ATR) Analysis	
Description of Evaluation	The R/HSR Group will examine and describe the human resource characteristics of the CLIOSjre bundle. In particular, the team will focus on the bundle’s ability to attract, train, and retain highly capable employees to JR East. This evaluation will consider the impacts to 1) employees currently working for JR East, 2) future hires from Japan, 3) and future hires from the international HSR market (e.g. the United States). The CLIOSjre bundle will then be evaluated on quality and quantity of the employment opportunities that it creates. Based on this evaluation, the research team will assign a metric grade to the CLIOSjre bundle.	
Key Elements of the Metric	The metric will examine the business role of JR East for the particular CLIOSjre bundle and the opportunities the business role presents for human resource development. This metric will not address how human resource development could enable expansion into other HSR markets; this is addressed separately in Metric 1. Expansion Potential.	
Metric Spectrum	'F' Outcome	'A' Outcome
	The CLIOSjre bundle does not offer JR East any opportunities to attract, train, or retain highly capable employees.	The CLIOSjre bundle offers JR East significant opportunities to attract, train, and retain highly capable employees.

Using this method of analysis, there is some overlap between Metric 10 and the other CLIOSjre metrics. In particular, the development of JR East’s human resources will help JR East expand into other HSR markets. Thus, a CLIOSjre bundle that performs well on Metric 10. Human Resource Development will likely also perform well on Metric 1. Expansion Potential. Although this overlap breaks the strict independence requirement of the metric evaluation process, the R/HSR Group believes that this overlap is a proper representation of JR East’s stated goals for new international business. Human resource development is a company goal independent of the company’s goal to expand internationally. Thus, a human resource development metric is needed.

As discussed in Table 6-43, the research team identified three key characteristics of effective human resource development:

1. Attracting new talent
2. Training new and existing employees, and
3. Retaining these employees so that the company builds its institutional knowledge.

Using these three primary characteristics, the research team built a representative metric

spectrum (shown in Table 6-44). This spectrum assumes that JR East would rather accomplish all three tasks well (attraction, training, and retention) than have a large number of employees but be unable to perform all three key functions of human resource development. For example, if a CLIOSjre bundle allows JR East the opportunity to attract, train, and retain 100 highly capable employees, this bundle will receive a higher grade than a bundle which allows JR East the opportunity to attract and train 150 highly capable employees but which doesn't give JR East an opportunity to retain most of them as part of its long-term<sup>66</sup> workforce.

*Table 6-44. Grade Spectrum for Metric 10. Human Resource Development*

<b>Representative Outcome</b>	<b>Metric Grade</b>
The CLIOSjre bundle offers JR East significant opportunities to attract, train, and retain many highly capable employees.	A
The CLIOSjre bundle offers JR East opportunities to attract train and retain a few highly capable employees.	B
The CLIOSjre bundle offers JR East significant opportunities to attract and train many highly capable employees, but they will not remain with the company long-term.	C
The CLIOSjre bundle offers JR East opportunities to attract and train a few highly capable employees, but the new employees will not remain with the company long-term.	D
While current employees may gain some experience, the CLIOSjre bundle does not offer JR East any opportunities to attract, train, or retain new, highly capable employees.	E
The CLIOSjre bundle does not provide any opportunities for existing employees nor does it offer JR East any opportunities to attract, train, or retain new, highly capable employees	F

Using these three elements of effective human resource development as a framework for analysis, the research team performed a Human Resource Analysis of the seven CLIOSjre bundles. The details of this analysis are available in the Appendix, and the results of our analysis are summarized in Table 6-45 below.

*Table 6-45. Evaluation of the CLIOSjre Bundles using Metric 10. Human Resource Development*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Metric 10 Grade</b>	F	D	C	A	D	B	A

The Attract, Train, and Retain Analysis of the seven NEC CLIOSjre bundles is based on the

<sup>66</sup> For our analysis, we consider long-term employees to be employees that work for JR East long enough to apply their experience gained in the Northeast Corridor to another HSR market. For the CLIOSjre bundles where JR East operates an ongoing HSR service on the NEC, long-term employees are employees that remain with the company for ten years or more.



professional judgement of the research team. As a result the precise grade assigned to each bundle is subject to debate. In particular, the distinction between ‘many’ and ‘few’ employees in the representative outcomes for Metric 10 is somewhat unclear. This distinction marks the dividing line between grades A and B and grades C and D. As this distinction is unclear, an informed analyst could find the opposite grade of these pairings from the one the research team selected. This possible measurement error is reflected in Table 6-46.

Aside from this source of error, the research team believes our analysis is a reasonable representation of the Human Resource Development potential of each CLIOSjre bundles. We believe there are no other significant sources of measurement error for this metric.

*Table 6-46. Measurement Error for Metric 10. Human Resource Development*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Measurement Error for Metric 10</b>	F	D – C	D – C	B – A	D – C	B – A	B – A

## **Discussion**

Metric 10. Human Resource Development examines each CLIOSjre bundle according to its ability to grow the human resources of JR East. This includes opportunities to grow the experience of existing JR East employees as well as attract, train, and retain new employees to the company. The CLIOSjre bundles perform relatively well according to this metric: only one bundle received an F and the majority of the bundles receive a C or better. CLIOSjre bundle 1.1 received an F because it offers JR East no opportunities to grow the expertise of its exiting employees and no opportunities to hire new employees. The remaining six CLIOSjre bundles offer JR East a number of opportunities to grow and improve its human resources.

Of the six CLIOSjre bundles that received an acceptable grade for Metric 10, bundles 3.2 and 6.2 receive the highest grade. These bundles offer JR East a significant opportunity to grow its long-term workforce and grow the institutional knowledge of the company. These bundles receive a high grade because JR East will be involved in long-term operations and maintenance of the NEC HSR system. In addition, CLIOSjre bundle 6.2 offers JR East the opportunity to grow its short-term workforce to design and construct the HSR system. Although bundle 6.1 also offers JR East the opportunity to grow its long-term workforce, as JR East will not be involved in the maintenance of the infrastructure, the operations staff will be relatively modest. The other three bundles (1.2, 3.1, and 5.1) offer JR East the opportunity to grow its short-term workforce for design and/or construction of the HSR system, but it is unlikely that these employees will remain with the company in the long term.

## 6.6 Concluding Remarks

The analysis above details our first case study application of the CLIOSjre Process. This proof-of-concept application of the CLIOSjre Process to the Northeast Corridor was fruitful for both JR East and the R/HSR Group. This application provided us with the opportunity to test the CLIOSjre Process on a real world decision facing the East Japan Railway Company. Although JR East has not yet used the outputs of the CLIOSjre Process to make an investment decision, the company has indicated that our results have been useful to them as they consider their investment alternatives.

An astute reader will notice that the CLIOSjre Process is not yet complete: we have not selected a strategy vector to determine the overall grade for each CLIOSjre bundle. We expect JR East to select a final strategy vector in the coming research year which will allow us to complete this proof-of-concept application. In the meantime, the research team has developed a set of seven example strategy vectors in place of this final strategy vector; these example vectors are visible in Figure 5-3. Each of these example strategy vectors represent an approach that JR East might take in the Northeast Corridor.

For example, strategy vector 2, Maximize Profit, places the most emphasis on Metric 2. Expected Profit with lesser emphasis on Metric 1. Expansion Potential and Metric 8. Strengths and Weaknesses. By emphasizing these metrics, this strategy vector emphasizes an approach to the market which is heavily focused on profit potential.

Our expectation is that these example strategy vectors will help JR East develop its own strategy for the market which reflects the priorities of the company.

### *Lessons from this Case Study*

In this proof-of-concept application, we found that the CLIOSjre Process could easily adapt to a wide variety of input. In addition to the input from the CLIOS Process, the CLIOSjre Process accepted input from the NEC Future Environmental Impact Statement and a number of other perspective-specific analyses (e.g. Industry Benchmarking, Predictive Coalition-Building Analysis, ATR Analysis). Both qualitative and quantitative analyses were used to develop the results of the CLIOSjre process, and the CLIOSjre process addressed uncertainty equally well across all ten CLIOSjre metrics. The ability to make use of this varied input is a primary strength of the CLIOSjre Process; it allows us to consider a number of different (and sometimes competing) perspectives.

As JR East has not yet selected a strategy vector for final analysis, we cannot comment on the effectiveness of the linear weighting method. However, by examining the example assessment sheets (Figure 5-2 and Figure 5-3), we find that the metric and overall grades for each bundle are easy to identify and understand. In theory, this presentation will allow JR East to make effective

use of the results of the CLIOSjre Process.

Based on these observations and on our conversations with JR Eat about the CLIOSjre Process, we hypothesize that the CLIOSjre Process will be a useful tool for understanding the decision facing JR East. We surmise that other private and public decision-makers will find that the CLIOSjre Process, when appropriately tailored, is useful for understanding other transportation investment decisions as well.

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In the following chapter, Chapter 7, we review our insights from this case study and identify areas of possible future research.

## 7 Conclusions and Further Research

In this thesis, we developed a multicriteria, multistakeholder decision aid which addresses uncertainty: the CLIOSjre Process. The CLIOSjre Process satisfies the four objectives from the literature identified in Chapter 2, and the CLIOSjre Process applies the lessons from current practice identified in Chapter 3. In Chapter 4, we developed a preliminary decision aid which informed our development of the CLIOSjre Process. In Chapter 5, we described the CLIOSjre Process in detail, and in Chapter 6 we applied the CLIOSjre Process to a case study of the Northeast Corridor of the United States. In our case study, we found that the CLIOSjre Process was a useful tool for understanding the decision facing JR East for choosing among investment opportunities. Based on this result, we surmise that other private and public decision-makers will find that the CLIOSjre Process, when appropriately tailored, is useful for understanding other transportation investment decisions as well.

The CLIOSjre Process is a useful tool because it provides a deeper and more robust understanding of a decision than traditional perspective-specific analysis. Three features of the CLIOSjre Process set it apart from traditional analysis. First, the CLIOSjre Process takes into consideration all of the objectives of the decision-maker even when these objectives are in conflict with one another. Second, the CLIOSjre Process is designed to facilitate negotiation between multiple stakeholders involved in a particular investment decision. Finally, the CLIOSjre Process identifies and addresses the two primary sources of uncertainty in analysis: measurement error and real-world uncertainty. Although traditional perspective-specific analysis tools are occasionally adapted to include one or two of these features, the CLIOSjre Process (and other multicriteria, multistakeholder decision aids which address uncertainty) are uniquely able to address these issues.

### 7.1 The CLIOSjre Process

Our decision aid, the CLIOSjre Process, is designed to help decision-makers compare multiple alternatives and make an informed transportation investment decision. The process examines the decision from multiple perspectives where each of these perspectives represents a single priority of the decision-maker. By considering each priority separately, the CLIOSjre Process provides a detailed understanding of each alternative. The CLIOSjre Process also uses a linear weighting scheme to combine the CLIOSjre metric evaluations into a single overall grade for each alternative. This overall grade for each alternative provides the decision-maker with an actionable ranking of the alternatives. Thus, the CLIOSjre Process provides a detailed and holistic understanding of the decision facing the decision-maker.

Transportation investment decisions often involve multiple stakeholders, and the CLIOS Process accounts for this as well. The multiple metrics of the CLIOSjre Process help the decision-

maker(s) consider the priorities of other stakeholders who have some authority in the investment decision. By presenting the analysis of the alternatives from multiple perspectives, the CLIOSjre Process facilitates negotiation among stakeholders in an investment decision; even if these stakeholders have competing objectives for a transportation investment, the transparency of CLIOSjre Process is designed to help the stakeholders understand other perspectives and find common ground.

In addition to addressing the concerns of multiple stakeholders, the CLIOSjre Process formally identifies and addresses uncertainty in the analysis. Uncertainty in long-term transportation investments is a significant source of risk. Thus, by working to understand this uncertainty, the CLIOSjre Process enables stakeholders to put their trust in the outcomes of the analysis.

Despite these advantages, the CLIOSjre Process is not perfect for all situations. In the next sections, we identify the limitations of the CLIOSjre Process and posit future research to improve the utility of the CLIOSjre Process.

## 7.2 Limitations of the CLIOSjre Processes

### *Combination of Independent Metrics*

In the CLIOSjre Process, we combine the independent CLIOSjre metrics into a single overall measure of the value of each alternative (in the CLIOSjre Process, we call this the Overall Grade). This overall measure of value allows the decision-maker(s) to easily understand and compare the results for each alternative. However, the combination of these independent metrics is theoretically unsatisfying. To quote Roy on the subject of a combining independent metrics (*Multiple Criteria Decision Analysis*, 2005, p. 41),

*“In most cases, there is no obvious and acceptable arithmetic rule which can keep account of these heterogeneous scales by substituting a single scale based on a common unit for each of them ...*

*[Using a single overall scale], in many decision making contexts, might:*

- lead to wrongly neglecting certain aspects of realism;*
- facilitate the setting up of equivalencies, the fictitious nature of which remains invisible;*
- tend to present features of one particular value system as objective.”*

As Roy implies, the use of a single overall scale can obscure the inherent complexity of the trade-off between alternatives. By obscuring this complexity, we make the results easier for the decision-maker to understand, but we also risk inadvertently misleading the decision-maker by

setting up false equivalencies. In an effort to communicate the complexity of the trade-off to the decision-maker, the CLIOSjre Process provides the decision maker with the individual metric grades as well as the overall grade for each alternative. However, it remains unclear whether real decision-makers will make proper use of all of the available information (i.e. the metric grades and the overall grade) or simply gravitate to the most accessible information (i.e. the overall grade).

### *Linear Weighting Scheme*

As discussed in Chapter 2, the linear weighting scheme that we use in the CLIOSjre Process is not as accurate as other methods of aggregating multiple criteria. Denis Bouyssou provides an accessible example of the linear preference assumption breaking down (*Multiple Criteria Decision Analysis*, 2005, p. 116):

*“Consider for instance an individual expressing preferences for the quantity of the two goods he consumes. ... a fairly rational person, consuming pants and jackets, may indeed prefer [3 pants and no jacket] to [no pants and 3 jackets] but at the same time prefer [3 pants and three jackets ] to [six pants and no jackets]. This implies that these preferences cannot be explained by a [linear weighting scheme].”*

By assuming a linear weighting scheme for the CLIOSjre Process, we restrict its ability to represent more complex preferences. Thus, although the linear weighting scheme is intuitive and easy to understand, this linear weighting scheme reduces the accuracy of the CLIOSjre Process in representing the decision-makers preferences.

### *Negotiating with Fundamental Disagreement*

Although the CLIOSjre Process aids the stakeholder negotiation process, this negotiation is not guaranteed to yield a group decision. Each stakeholder has their own definition of value for the system, and these value differences can result in stalemate when logic would otherwise dictate that there is room for agreement. Sussman et al. refer to these value differences as Evaluative Complexity (2009):

*“Evaluative Complexity reflects the multi-stakeholder environment in which CLIOS systems exist ... . Simply put, what may be good performance to one stakeholder, may not be good performance to another stakeholder. Even if one could make good predictions about the behavior of the CLIOS System when strategic alternatives are implemented, evaluative complexity means it is still difficult to make a decision about what to do.”*

A disagreement on fundamental values can make it difficult to agree upon a common set of metrics to evaluate the system and the relative importance of those metrics. Thus, for decisions

where the stakeholders disagree on fundamental values, the CLIOSjre Process will provide little help to the negotiation.

### *Communication of Results*

As discussed in Chapter 5, the output of the CLIOSjre Process is a series of assessment sheets. These assessment sheets present the results of the CLIOSjre analysis in a succinct and standardized format. Each assessment sheet contains a wide variety of information which provides the decision-maker with a deep and detailed understanding of the investment decision. For these assessment sheets, there is a trade-off between content and legibility. If too little information is displayed on the assessment, the sheet is not particularly useful. The opposite situation is equally undesirable: too much information on the assessment sheet would make it difficult to identify the key bits of information and may frustrate the decision-maker. The research team iterated through multiple versions of these assessment sheets to determine a reasonable amount of information.

In addition to defining an appropriate level of information, the research team worked to format the assessment sheets for maximum legibility. Well-formatted assessments allow the decision-maker to quickly identify and understand the information relevant to the decision. Poorly-formatted assessments would make it difficult for the decision-maker to locate the relevant information. Although there are many heuristics that suggest how to format of technical information (Tufte, 2006), there are few well-defined standards for formatting this type of result. Although the research team tested several designs of the assessment sheet, we can make no guarantee that the final form of the assessment sheet (shown in Figure 5-2 and Figure 5-3) is an optimal display of the results of our analysis. Depending on how these CLIOSjre assessment sheets are used in practice, the formatting of these assessments may be adequate or in need of further refinement.

### *Time Constraints*

The CLIOSjre Process provides a robust understanding of a decision. However, to arrive at this understanding, it is necessary to perform an extensive analysis of the decision using the CLIOSjre Process. This analysis often requires a significant time to research the decision, gather information, perform the analysis, and summarize the results of the analysis for the decision-maker(s). For projects with a long planning horizon (several years or more), this time for analysis is well spent. However, for projects with a shorter planning horizon, the delay caused by a thorough CLIOSjre Process analysis may outweigh the insight gained.

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With this understanding of the limitations of the CLIOSjre Process, we turn now to future research which would refine or extend the CLIOSjre Process and improve its usefulness.

## 7.3 Future Research

Although the CLIOSjre Process is ready to be applied to problems in both the public and private sector, there are a number of interesting extensions that would improve the accuracy of the process, increase the range of applications, or make the process more useful for decision-makers. We identify several interesting areas for further research below.

### *Combination of Multiple Metrics*

For the CLIOSjre Process, we selected a linear weighting scheme to combine the independent CLIOSjre metrics into an overall grade for each alternative. This scheme has several advantages:

- The linear weighting scheme is transparent and thus easier to understand than other methods of combining metric grades.
- The linear weighting scheme is flexible and can quickly adjust to new input from the decision-maker.
- The linear weighting scheme is easy to implement for someone who is new to the CLIOSjre Process.

These advantages of a linear weighting scheme are not insignificant. However, as discussed in the previous section, the linear weighting scheme cannot always accurately represent the decision-maker's preferences. There are many other methods for combining independent metrics identified in the literature (e.g. outranking methods, utility models, non-classical approaches). It is possible that one or more of these other methods is equally transparent, flexible, and usable while also more accurate in its representation of the decision-maker's preferences. Although the linear weighting scheme was of sufficient accuracy for our JR East case study, we acknowledge that there are likely alternative approaches to this problem. Further research may identify methods to combine the CLIOSjre metrics which retain the benefits of a linear weighting scheme while also delivering a more accurate representation of the decision-maker's preferences.

### *Cognitive Bias*

As elucidated in the work of Tversky and Kahneman, humans are imprecise creatures (1974). They found that humans have a significant number of implicit biases which affect decision making. For example, humans are known to place more importance on items which appear higher in a list. This bias directly impacts the accuracy of the CLIOSjre Process as the metrics and metric grades are listed in a particular order. As it is currently implemented, the order of CLIOSjre metrics is not based on the priority of the metrics. Thus, a decision-maker examining a CLIOSjre assessment sheet may be inappropriately directed toward the top two or three metrics and led to implicitly believe that the rest are less important.

Behavioral decision analysis is a nascent and rapidly-developing field of study which seeks to



leverage behavioral psychology to understand and avoid this type of implicit bias. A primary goal of behavioral decision analysis is to structure the presentation of a decision so that it the physiology of human decision-making enables and encourages more objective decision making. Future research in this field may identify acceptable solutions to the problem of implicit bias and improve the usefulness of the CLIOSjre Process.<sup>67</sup>

### *Soliciting Preference from Decision-Makers*

The CLIOS Process is designed to have the decision-maker to chose the weights that combine the individual CLIOSjre metrics. Although directly eliciting these weights from the decision-maker is transparent, it may not be the most effective way to determine the decision-maker's preferences. Figueira, Mousseau, and Roy elaborate on this point below (*Multiple Criteria Decision Analysis*, 2005, p. 182):

*“In direct elicitation procedures [decision-makers] provide information directly on the values of the [linear weights for combining the metrics]. A major drawback of such techniques is that it is difficult to understand the precise meaning of the assertions of the [decision-makers].”*

In other words, although the weights are transparent, they are not easy for the decision-maker to translate into terms that mean something to the decision-maker. Thus, the decision maker may be able to assign relative importance, but the particular values of the weights are relatively arbitrary. Figueira et al. then describe an alternative approach:

*“Indirect elicitation techniques do not require [the decision-makers] to provide [the numerical weights for the linear weighting scheme. Instead,] these techniques [proceed] indirectly by posing questions whose answers can be interpreted through the aggregation procedure. ... [Thus, indirect] elicitation techniques make it possible to determine the vector of the ... coefficients from [these] pairwise comparisons ....”*

These indirect solicitation techniques determine the weights through a series of questions framed in terms that mean something to the decision-maker. For example, a direct solicitation technique might ask the decision maker to chose the relative weight of the metrics Expected Profit and Net Societal Benefit. Choosing the relative importance of these two metrics would likely be difficult for the decision-maker. By contrast, an indirect solicitation technique could ask the decision-maker to chose between a series of fictional alternatives where each alternative has progressively more Net Societal Benefit and less Expected Profit. The decision-maker's choice would indirectly imply the relative value of these two metrics and the appropriate weights.

Although the CLIOSjre Process is designed for a direct solicitation of weights, the process is

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<sup>67</sup> An interesting first application of psychology in multicriteria decision aids is described *Multiple Criteria Decision Analysis*, 2005, pages 634-643.

compatible with an indirect solicitation process. Further research could determine if an indirect solicitation technique is a more effective method for soliciting preferences for the CLIOSjre Process.

### *New Sources of Data*

Perhaps the greatest strength of the CLIOSjre Process is that it is able to systematically combine a variety of analyses into a single unified understanding of a decision. As technology enables a more detailed understanding of the world, the CLIOSjre Process (and other multicriteria, multistakeholder decision aids) will help analysts fold these new sources of data into our existing analyses and decision-making processes.

The remarkable detail of these data sources will make them harder to integrate with our traditional analysis processes than the high-level data that we currently in use. However, the detail of these data sources promises a more robust analysis which better models reality. Further, as many of these new data sources are automatically collected, new analysis tools can produce results faster than traditional methods. Overall, these new data sources will produce a stronger understanding of the decisions facing public and private decision makers.

These new sources of data and new analysis processes will likely provide new ways of evaluating the existing CLIOSjre metrics. For example, new data from cell phone carriers (which can estimate travel demand, see Toole et al., 2014) could provide an alternate estimate of the public benefits of a new rail system. Since neither estimate of public benefit will be perfect, the CLIOSjre Process might include both measures of public benefits in the analysis: one metric using the traditional Census analysis and a second metric using cell phone records. Further research will resolve the appropriate methods for integrating these new sources of data into the CLIOSjre Process and our decision-making processes. Regardless of the particulars of integration, these new sources of data promise a more detailed understanding of our transportation investment decisions.

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We thank the reader for their attention throughout this thesis. We hope that the analysis provided herein proved useful and that this thesis provided the reader with a better understanding of the application, challenges, and opportunities of multicriteria, multistakeholder decision aids. We believe that applying these tools to problems in transportation planning will yield better results for both decision-makers and the public.

## 8 Appendix

The R/HSR Group evaluated all seven NEC CLIOSjre bundles using the CLIOSjre Process. This Appendix presents the details of this analysis. For an introduction to each CLIOSjre Metric and a discussion of our results, see Chapter 6.

### 8.1 Metric Analysis Using the CLIOSjre Process: Financial Characteristics

#### *Metric 1. Expansion Potential*<sup>68</sup>

[Continued from Chapter 6]

#### **Overview of U.S. HSR Markets**

The tables in the following section offer a summary of 10 key HSR markets in the United States. This selection is partly based on FRA's 2009 HSR Strategic Plan, Vision for High-Speed Rail in America, which identified ten HSR corridors expected to achieve 90 mph in the coming years.<sup>1</sup> This list was modified based on events in the years since 2009, including the development of private HSR projects and rejection of certain HSR projects by various state and local politicians. Table 8-1 provides an overview of the HSR markets examined in the following section.

Table 8-1 also offers a qualitative determination of the attractiveness of the market to JR East ("strong," "medium," and "weak"). As noted above, the determination of attractiveness is based upon factors such as scale, likelihood of completion, and similarity to the NEC. The subsequent tables provide a more detailed discussion of each market in support of our determinations of attractiveness and relevance, beginning with California HSR.

Table 8-1 presents which of the seven NEC CLIOSjre bundles are most relevant to the HSR market in question (as defined in the previous section). The table also presents the relative attractiveness of each market.

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<sup>68</sup> Scott Middleton was the original author of this section. Included with his permission.

Table 8-1. Overview of US HSR Markets and their Relevance to the NEC

HSR Market/Project Name	Attractiveness to JR East	Relevant CLIOSjre Bundles
California HSR	Strong	Bundle 3.2, Bundle 5.1, Bundle 6.1
Colorado HSR	Weak	Bundle 1.2, Bundle 5.1, Bundle 6.1, Bundle 6.2
Empire Corridor ( <i>New York State</i> )	Weak	Bundle 1.2, Bundle 3.1, Bundle 3.2
Florida/Brightline	Strong	Bundle 3.1, Bundle 6.1
Illinois HSR/Chicago Hub	Medium	Bundle 1.2, Bundle 3.1, Bundle 3.2, Bundle 5.1, Bundle 6.1, Bundle 6.2
Keystone Corridor ( <i>Pennsylvania</i> )	Weak	Bundle 1.2, Bundle 3.1, Bundle 3.2
Pacific Northwest ( <i>Oregon, Washington, British Columbia</i> )	Weak	Bundle 1.2, Bundle 3.1, Bundle 3.2
Southeast Corridor ( <i>Washington, DC to Atlanta, GA</i> )	Medium	Bundle 1.2, Bundle 3.1, Bundle 3.2, Bundle 5.1, Bundle 6.1, Bundle 6.2
Southwest/Xpress West ( <i>L.A. – Las Vegas</i> )	Strong	Bundle 3.1, Bundle 5.1, Bundle 6.1
Texas HSR/Texas Central Railway	Strong	Bundle 3.1, Bundle 5.1, Bundle 6.1

## Detailed Summary of US HSR Markets

The following ten tables present detailed information on the ten HSR markets identified for further study.

Table 8-2. Summary of California HSR

HSR Market: California HSR
<b>Project/Market Background</b>
<p>An 800-mile system has been proposed from Los Angeles to San Francisco (Phase 1), with extensions to Sacramento and San Diego (Phase 2). Ultimately, the project proposes to reduce ground travel time between Los Angeles and San Francisco to less than 3 hours. The project includes improvements to existing passenger rail service. Phase 1 is expected to be complete by 2029, with limited high-speed rail service scheduled to begin in 2022. Construction started in January 2015.</p> <p>The project will be constructed and operated by the California High Speed Rail Authority – a state agency. The project is estimated to cost \$68 billion, with just \$10 billion in state bond funding committed as of January 2016. This funding is intended to cover the initial construction from Bakersfield to Madera, CA and represents a mix of federal, state, local, and private sources.</p>
<b>Stakeholders in Common with the NEC</b>

<b>HSR Market: California HSR</b>
Congress, USEPA, Department of Commerce, Department of Energy, USDOT, Amtrak, Bus Operators, Trucking Industry, Airline Industry, Suppliers, Private Consortia, Labor Unions, Banking Industry, Insurance Industry, Political Activists/Lobbyists, Media, Freight Customers
<b>Attractiveness to JR East: Strong</b>
<p>Unlike HSR in the NEC, California HSR will not be redundant with existing Amtrak passenger service. However, because of the “greenfield” nature of this project (particularly in the Central Valley), it may offer experience in line with all-over international quality HSR.</p> <p>Given the scale of the project, it is certainly large enough to warrant JR East’s attention. Additionally, California HSR appears to be among the most likely markets in the U.S. to implement HSR. Because the project is underway, JR East’s business roles may be limited (providing a turnkey system is not possible, for example). However, for those business roles where involvement is possible, this project is strongly relevant to JR East.</p>
<b>Relevant NEC CLIOSjre Bundles (with Business Role)</b>
<ul style="list-style-type: none"> <li>• Bundle 3.2 (Operate a System Under Concession)</li> <li>• Bundle 5.1 (Provide HSR Components)</li> <li>• Bundle 6.1 (Operate a System By Buying Track Capacity)</li> </ul> <p>Note that CLIOSjre bundles 3.1 and 6.2 are excluded from this list because the business roles “turnkey system provider” and “construct/operate a private system” are incompatible with this market because of the initial steps already taken in California. Bundles 5.1 and 6.1 are most relevant due to the HSR system configuration under development.</p>

*Table 8-3. Summary of Colorado/Southwest HSR*

<b>HSR Market: Colorado/Southwest HSR</b>
<b>Project/Market Background</b>
This market has generated some interest in high-speed service between Pueblo, CO to Fort Collins, CO, via Denver. A multi-jurisdictional government body known as the Rocky Mountain Rail Authority conducted an 18-month feasibility study in 2010 and determined that the construction costs (approximately \$30 billion) would be prohibitively high. As such, the project is currently on hold/terminated. This feasibility study was related to a previous push from various Southwestern states (Colorado, New Mexico, and Texas) to seek federal designation of a high-speed rail corridor in the Southwest. However, this effort is largely dormant as of January 2016.
<b>Stakeholders in Common with the NEC</b>
Congress, USEPA, Department of Commerce, Department of Energy, USDOT, Amtrak, Trucking Industry, Airline Industry, Suppliers, Private Consortia, Labor Unions, Banking Industry, Insurance Industry, Political Activists/Lobbyists, Media, Intercity Travelers, Commuters, Freight Customers
<b>Attractiveness to JR East: Weak</b>
Because this project is ill-defined and unlikely to come to fruition in the short-term, it has only weak attraction to JR East. This corridor does not share many characteristics with the NEC, which further limits its attractiveness. In fact, it demonstrates starkly different population densities and topography, both of which make this area a challenging HSR market for any company.
<b>Relevant NEC CLIOSjre Bundles (with Business Role)</b>

<b>HSR Market: Colorado/Southwest HSR</b>
<ul style="list-style-type: none"> <li>• Bundle 1.2 (Provide Consultation)</li> <li>• Bundle 5.1 (Provide HSR Components)</li> <li>• Bundle 6.1 (Operate a System by Buying Track Capacity)</li> <li>• Bundle 6.2 (Construct and Operate Private System)</li> </ul>

*Table 8-4. Summary of Empire Corridor HSR*

<b>HSR Market: Empire Corridor (New York State)</b>
<b>Project/Market Background</b>
<p>The Empire Corridor is a FRA-designated high-speed corridor connecting the cities of Buffalo, Albany, and New York, including intermediate destinations in New York State. The project would build upon existing “higher-speed” train service operated by Amtrak in the region. The project has enjoyed intermittent political support from state leaders, in part due to the proposed economic benefit of connecting New York’s post-industrial cities with New York City. The New York State Department of Transportation has taken some steps toward completing this project, including conducting a Tier 1 Environmental Impact Statement (EIS) on HSR service from New York City to Niagara Falls (completed in 2014). After the completion of the EIS, remaining alternatives under consideration include top speeds of 79 to 125 mph. However, it is worth noting that the project remains in its early stages, with little to no guaranteed funding committed to the proposal.</p>
<b>Stakeholders in Common with the NEC</b>
<p>Congress, State Governments (Northeast states), Local/Municipal Governments (Northeast states), USEPA, Department of Commerce, Department of Energy, USDOT, Amtrak, NEC Commission, Commuter Rail Agencies (Northeast states), Urban Public Transportation Organizations (Northeast states), Terminals, I-95 Corridor Coalition, Freight Railroad Companies, Intercity Bus Operators, Trucking Industry, Airline Industry, Suppliers, Private Consortia, Labor Unions, Banking Industry, Insurance Industry, Private Landowners, Abutters, Political Activists/Lobbyists, Media, Intercity Travelers, Commuters, Freight Customers</p>
<b>Attractiveness to JR East: Weak</b>
<p>The Empire Corridor shares many stakeholders and system characteristics with the NEC, so it scores well in that regard. However, the proposals for the corridor are not well defined. Furthermore, the level of attractiveness to JR East is uncertain at best. For that reason, this market is weakly relevant to JR East.</p>
<b>Relevant NEC CLIOSjre Bundles (with Business Role)</b>
<ul style="list-style-type: none"> <li>• Bundle 1.2 (Provide Consultation)</li> <li>• Bundle 3.1 (Provide a Turnkey System)</li> <li>• Bundle 3.2 (Operate a System Under Concession)</li> </ul> <p>Note that CLIOSjre bundles 5.1, 6.1, and 6.2 are excluded because all-over international quality HSR has not been proposed in this market up to now.</p>

*Table 8-5. Summary of Florida HSR*

<b>HSR Market: Florida/Brightline</b>
<b>Project/Market Background</b>

<b>HSR Market: Florida/Brightline</b>
The private company All Aboard Florida has proposed new “Brightline” service from Miami to Orlando, FL via Cocoa Beach. The service would offer express train service at 80-125 mph along the 235 mile route, which will include both existing and new rail. Trains are scheduled to begin service from Miami to West Palm Beach via Fort Lauderdale by 2017. Construction began in May 2015.
<b>Stakeholders in Common with the NEC</b>
Congress, USEPA, Department of Commerce, Department of Energy, USDOT, Amtrak, Trucking Industry, Airline Industry, Suppliers, Private Consortia, Labor Unions, Banking Industry, Insurance Industry, Political Activists/Lobbyists, Media, Intercity Travelers, Commuters, Freight Customers
<b>Attractiveness to JR East: Strong</b>
Because this project has already broken ground, has a defined timeline, is large in scope, and seems relatively likely to succeed, it is highly attractive to JR East. Additionally, work on the NEC may translate well to other HSR projects on the East Coast, due to the political environment and the stakeholders involved.
<b>Relevant NEC CLIOSjre Bundles (with Business Role)</b>
<ul style="list-style-type: none"> <li>• Bundle 3.2 (Operate a System Under Concession)</li> <li>• Bundle 6.1 (Operate a System by Buying Track Capacity)</li> </ul> <p>Florida Brightline service is being constructed by a private company, which excludes several of JR East’s business roles in this project. Furthermore the private contractor All Aboard Florida has already purchased trainsets from Siemens, further limiting JR East’s potential involvement. For these reasons, CLIOSjre bundles 3.1, 5.1, and 6.2 are excluded from this list as their associated business roles are not compatible with this project. CLIOSjre bundle 1.2 is excluded from this list because it involves only incremental HSR improvements.</p>

*Table 8-6. Summary of Illinois HSR and Chicago Hub Network*

<b>HSR Market: Illinois HSR/Chicago Hub</b>
<b>Project/Market Background</b>
<p>This market involves two proposed projects. The first is “Illinois High-Speed Rail.” The project proposes improved service on the 284-mile Chicago to St. Louis corridor.<sup>1</sup> The project involves several upgrades that aim to reduce travel time on the existing Amtrak route by about 20% (roughly one hour). A recent Tier 1 EIS recommended the construction of a second track, but the funding for the proposed second track has not been identified.</p> <p>The Chicago Hub Network is a series of proposed high-speed and higher-speed rail lines in the Midwest designated in FRA’s high-speed network. For many years, multiple proposals have circulated, including service connecting several large cities with Chicago as the central hub, including Cincinnati, Cleveland, Detroit, Indianapolis, Kansas City, Louisville, Milwaukee, Minneapolis/St. Paul, and St. Louis. Various Midwestern state governments received federal funding 2009 under ARRA. However, the governors of Ohio and Wisconsin rejected the federal funding, dealing a high-profile political blow to HSR in the Midwest. Nonetheless, the proposed network has generated considerable interest, including from the French rail company SNCF, which has studied the area and identified several feasible routes. Other upgrades to higher-speed rail have also made progress in recent years, particularly on Amtrak’s Wolverine service in Michigan, where trains now reach speeds up to 110 mph.</p>
<b>Stakeholders in Common with the NEC</b>
Congress, USEPA, Department of Commerce, Department of Energy, USDOT, Amtrak, Trucking Industry, Airline Industry, Suppliers, Private Consortia, Labor Unions, Banking Industry, Insurance Industry, Political

<b>HSR Market: Illinois HSR/Chicago Hub</b>
Activists/Lobbyists, Media, Intercity Travelers, Commuters, Freight Customers
<b>Attractiveness to JR East: Medium</b>
These projects, particularly the Chicago Hub Network, would involve many billions of dollars of investment in America’s busiest rail hub and the surrounding region. Such a project would likely draw upon knowledge and experience from HSR in the NEC because of similarities in the age, density, and congestion of the regional transportation network. However, these projects are politically unstable, have made only incremental progress since 2010, and seem unlikely to move forward in the near-term. As such, this market achieves a score of “medium” attractiveness for JR East.
<b>Relevant NEC CLIOSjre Bundles (with Business Role)</b>
Because this project is not well-defined, all CLIOSjre bundles are equally relevant for this market, with the exception of bundle 1.1, which offers no expansion potential.

*Table 8-7. Summary of Keystone Corridor HSR*

<b>HSR Market: Keystone Corridor (Pennsylvania)</b>
<b>Project/Market Background</b>
The Keystone Corridor – a 350-mile rail link between Philadelphia and Pittsburgh, PA – has been an FRA-designated high-speed corridor for nearly two decades. The project would involve upgrades to existing Amtrak service connecting Pittsburgh, Harrisburg, Philadelphia, and New York City, as well as upgrades to commuter rail service near Philadelphia. Amtrak made several improvements to service in the 2000s that resulted in track speeds of up to 110 mph and a reduced 90-minute travel time between Philadelphia and Harrisburg. In 2011, the FRA provided Pennsylvania a \$750,000 High-Speed Intercity Passenger Rail Program grant to study high-speed electrified service from Harrisburg to Pittsburgh. The grant supported the Keystone West High Speed Rail Study, completed in 2015. However the future of the project remains uncertain and no agencies have emerged in a leading role for this project.
<b>Stakeholders in Common with the NEC</b>
Congress, State Governments (Northeast states), Local/Municipal Governments (Northeast states), USEPA, Department of Commerce, Department of Energy, USDOT, Amtrak, NEC Commission, Commuter Rail Agencies (Northeast states), Urban Public Transportation Organizations (Northeast states), Terminals, I-95 Corridor Coalition, Freight Railroad Companies, Intercity Bus Operators, Trucking Industry, Airline Industry, Suppliers, Private Consortia, Labor Unions, Banking Industry, Insurance Industry, Private Landowners, Abutters, Political Activists/Lobbyists, Media, Intercity Travelers, Commuters, Freight Customers
<b>Attractiveness to JR East: Weak</b>
Due to the physical connectivity between the NEC and the Keystone Corridor, there are many close connections between the two markets, including several overlapping stakeholders. However, this project’s future is uncertain; it has produced no major funding; and it does not appear to be a large-scale endeavor. As such, this project is weakly attractive to JR East.
<b>Relevant NEC CLIOSjre Bundles (with Business Role)</b>
<ul style="list-style-type: none"> <li>• Bundle 1.2 (Provide Consultation)</li> <li>• Bundle 3.1 (Provide a Turnkey System)</li> </ul>



<b>HSR Market: Keystone Corridor (Pennsylvania)</b>
<ul style="list-style-type: none"> <li>• Bundle 3.2 (Operate a System under Concession)</li> </ul> <p>Note that CLIOSjre bundles 5.1, 6.1, and 6.2 are excluded because they involve the construction of HSR along new alignment, which has not been proposed in this market up to now.</p>

*Table 8-8. Summary of Pacific Northwest HSR*

<b>HSR Market: Pacific Northwest (Oregon, Washington, British Columbia)</b>
<b>Project/Market Background</b>
<p>The 460-mile corridor between Eugene, OR to Vancouver, BC (including Seattle, WA and Portland, OR) has been an FRA-designated HSR corridor since the 1990s. Proposals to connect these cities at speeds of 90-125 mph by expanding and improving Amtrak’s existing Cascade service have circulated for many years without making much progress.</p> <p>Cascadia High Speed Rail, LLC – a private for-profit company – has developed a conceptual plan for the HSR corridor within rights-of-way owned by freight railroads and the Washington State DOT, but has not secured any funding for the project. Since 2009, WSDOT has been using \$800 million ARRA funding to complete a series of enhancement projects that will result in modest travel time improvements in the corridor. These projects are anticipated to be complete by 2017.</p>
<b>Stakeholders in Common with the NEC</b>
Congress, USEPA, Department of Commerce, Department of Energy, USDOT, Amtrak, Trucking Industry, Airline Industry, Suppliers, Private Consortia, Labor Unions, Banking Industry, Insurance Industry, Political Activists/Lobbyists, Media, Freight Customers
<b>Attractiveness to JR East: Weak</b>
<p>The projects currently underway in Washington State are too narrow in scope to be of much interest to JR East. While the full Cascades HSR corridor is promising from a political and population density perspective, the project is not attracting serious attention or funding. Furthermore, such a project would be starkly different from HSR in the NEC due to differences in geography, the existing rail ownership structure, and the international nature of the project. As such, this market achieves a score of “weak” attractiveness for JR East.</p>
<b>Relevant NEC CLIOSjre Bundles (with Business Role)</b>
<ul style="list-style-type: none"> <li>• Bundle 3.2 (Operate a System Under Concession)</li> <li>• Bundle 6.1 (Operate a System by Buying Track Capacity)</li> </ul> <p>Note that CLIOSjre bundles 3.1, 5.1, and 6.2 are excluded from this list because their associated business roles are not compatible with this project. CLIOSjre bundle 1.2 is excluded from this list because it involves only incremental HSR improvements.</p>

*Table 8-9. Summary of Southeast Corridor HSR*

<b>HSR Market: Southeast Corridor (Washington, DC to Atlanta, GA)</b>
<b>Project/Market Background</b>
<p>The Southeast Corridor is a large, FRA-designated, multistate project that would improve existing passenger services by implementing higher-speed rail connecting Washington, D.C. to Atlanta, GA. The project includes five interrelated sub-projects: Washington to Richmond, VA; Richmond to Hampton Roads, VA (terminated as of</p>

<b>HSR Market: Southeast Corridor (<i>Washington, DC to Atlanta, GA</i>)</b>
<p>January 2016); Richmond to Charlotte, NC; Charlotte to Atlanta. Connections to Jacksonville, FL and Birmingham, AL have also been proposed.</p> <p>As of January 2016, the Washington to Richmond project has received \$55 million in committed as of January 2016 (federal, state, and private sources) with an expected completion date of 2025. The Piedmont Improvement Program (capacity upgrades between Raleigh and Charlotte) has received \$520 million in federal ARRA funding with an expected completion date of 2017. The other projects are in various states of progress, with Tier I EIS studies completed for some segments.</p>
<b>Stakeholders in Common with the NEC</b>
<p>Congress, Local/Municipal Governments (Washington area), USEPA, Department of Commerce, Department of Energy, USDOT, Amtrak, NEC Commission, Commuter Rail Agencies (Washington area), Urban Public Transportation Organizations (Washington area), Terminals, I-95 Corridor Coalition, Freight Railroad Companies, Intercity Bus Operators, Trucking Industry, Airline Industry, Suppliers, Private Consortia, Labor Unions, Banking Industry, Insurance Industry, Political Activists/Lobbyists, Media, Intercity Travelers, Commuters, Freight Customers</p>
<b>Attractiveness to JR East: Medium</b>
<p>Although the proposed projects in this market are scattered in nature, it is large in scope and may be attractive to JR East from a new business perspective. The project is not well defined, but it has also not received the same level of political opposition faced in the Midwest. With the exception of the modest capacity improvements already underway, the market appears to be open to JR East’s involvement. Additionally, work on the NEC may translate well to other HSR projects in the Southeast, due to the stakeholders involved and the physical connectivity through Washington, D.C. As such, this market is of “medium” interest to JR East.</p>
<b>Relevant NEC CLIOSjre Bundles (with Business Role)</b>
<p>Because this project is not well defined, all CLIOSjre bundles are equally relevant for this market, with the exception of bundle 1.1, which offers no expansion potential.</p>

*Table 8-10. Summary of Southwest HSR*

<b>HSR Market: Southwest/Xpress West (<i>Los Angeles to Las Vegas</i>)</b>
<b>Project/Market Background</b>
<p>The proposed Xpress West project would connect the Los Angeles area to Las Vegas, NV with 150 mph service and an 80-minute travel time. The project will be constructed and operated by the private Xpress West company, with involvement from China Railway (CR) International. The project has \$100 million in initial capital. The Final EIS for a 60-mile segment along I-15 has received federal approval and construction could begin in late 2016. Potential extensions have been proposed expanding the service to Arizona, New Mexico, and Colorado.</p>
<b>Stakeholders in Common with the NEC</b>
<p>Congress, USEPA, Department of Commerce, Department of Energy, USDOT, Trucking Industry, Airline Industry, Suppliers, Private Consortia, Labor Unions, Banking Industry, Insurance Industry, Political Activists/Lobbyists, Media, Freight Customers</p>
<b>Attractiveness to JR East: Strong</b>
<p>The scale of the project, the recent progress toward construction, and the involvement of CR certainly warrant JR East’s attention. Because the project is underway and due to competition from other international businesses, JR</p>

<b>HSR Market: Southwest/Xpress West (Los Angeles to Las Vegas)</b>
East’s business roles may be limited. However, for those business roles where involvement is possible, this project is strongly relevant to JR East.
<b>Relevant NEC CLIOSjre Bundles (with Business Role)</b>
<ul style="list-style-type: none"> <li>• Bundle 3.1 (Operate a System under Concession)</li> <li>• Bundle 5.1 (Provide HSR Components)</li> <li>• Bundle 6.1 (Operate a System by Buying Track Capacity)</li> </ul>
Note that CLIOSjre bundle 1.2 is excluded because this project would greatly exceed our definition of “incremental HSR.” Bundle 6.2 is excluded because of the structure of Xpress West precludes JR East’s involvement in that capacity. Bundle 3.2 is excluded because of the organizational structure of the proposed project.

*Table 8-11. Summary of Texas HSR*

<b>HSR Market: Texas</b>
<b>Project/Market Background</b>
<p>Various proposals for Texas HSR have generally succumbed to pressure from project opponents (i.e., the state legislature, the airline industry) and the FRA’s designated South Central Corridor has made little progress.</p> <p>Currently, the most promising development in the Texas HSR market is the proposed Texas Central HSR service from Dallas/Fort Worth to Houston, TX. The project would create a passenger rail link with 80-minute travel times between these cities using technology and major financing from the Central Japan Railway Company (JR Central). The project is being constructed and operated by the private Texas Central Partners. Texas Central Partners have secured \$75 million in private funding for feasibility studies and development planning. Total estimated costs for the project are \$10 billion. The project is currently in the development phase (i.e., fundraising, buying land, seeking public support, and preparing for environmental approvals), with an earliest expected completion date of 2021.</p>
<b>Stakeholders in Common with the NEC</b>
Congress, USEPA, Department of Commerce, Department of Energy, USDOT, Amtrak, Trucking Industry, Airline Industry, Suppliers, Private Consortia, Labor Unions, Banking Industry, Insurance Industry, Political Activists/Lobbyists, Media, Freight Customers
<b>Attractiveness to JR East: Strong</b>
The scale of the project and the recent progress toward construction certainly warrant JR East’s attention. Because the project is underway and due to competition from other international businesses, JR East’s business roles may be limited (JR East will not be hired to construct and operate the system, for example). Additionally, the timeframe of the two projects may mean that HSR in the NEC will lag behind Texas HSR. However, for those business roles where involvement is possible, this project is strongly relevant to JR East.
<b>Relevant NEC CLIOSjre Bundles (with Business Role)</b>
<ul style="list-style-type: none"> <li>• Bundle 3.1 (Provide a Turnkey System)</li> <li>• Bundle 5.1 (Provide HSR Components)</li> <li>• Bundle 6.1 (Operate a System by Buying Track Capacity)</li> </ul>

## HSR Market: Texas

Note that CLIOSjre bundle 1.2 is excluded because this project would greatly exceed our definition of “incremental HSR.” Bundle 6.2 is excluded because of the structure of Texas Central Railway precludes JR East’s involvement in that capacity. JR Central’s involvement in this market would further hinder any effort by JR East to enter the market in this capacity. Bundle 3.2 is excluded because of the organizational structure of the proposed project.

### **Expansion Potential Analysis of the Seven NEC CLIOSjre Bundles**

To explain how we determined which opportunities are relevant to each CLIOSjre bundle, we provide a brief discussion of each bundle, including JR East’s business role, the HSR system configuration, the organizational structure, and the funding structure below.

#### *CLIOSjre Bundle 1.1*

For CLIOSjre bundle 1.1, JR East’s business role is ‘no involvement.’ Because JR East is not involved in the NEC in this bundle, it offers no expansion potential to consider in the United States or abroad.

This situation resembles most closely the representative outcome of grade F, so the research team assigns bundle 1.1 the grade F for Metric 1.

#### *CLIOSjre Bundle 1.2*

For CLIOSjre bundle 1.2, JR East’s business role is to provide planning, engineering, and operations consultation. In comparison to bundle 1.1, this business role greatly enhances JR East’s ability to compete for contracts with government agencies and private firms within the United States. Furthermore, many of the HSR markets in the U.S. are developing incremental HSR system (e.g., Pacific Northwest, Illinois HSR), so JR East’s experiences in this bundle could result in transferable expertise. However, by this same token, JR East’s experiences in this bundle are most relevant to projects that are limited in scale, and thus not particularly attractive to JR East. While the bundle offers many opportunities, these opportunities are all “medium” or “weak” in terms of attractiveness.

Based on this analysis, the CLIOSjre bundle most closely resembles representative outcome C and the research team assigns bundle 1.2 a grade of C for Metric 1.

#### *CLIOSjre Bundle 3.1*

JR East’s business role for CLIOSjre bundle 3.1 is to provide a turnkey system. The HSR system of CLIOSjre bundle 3.1 is single operator with a dedicated track, new alignment, and vertically integrated organizational structure. As such, this bundle is directly relevant to JR East’s ability to expand into many other markets. However, it is worth noting that it would be impossible for JR

East to take this business role in certain “strongly” attractive expansion opportunities, such as California HSR, (which is already under construction).

Based on the above analysis, CLIOSjre bundle 3.1 is relevant to a mix of strong and medium/weak opportunities for expansion in the markets studies and the research team assigns bundle 3.1 a grade of B for Metric 1.

### *CLIOSjre Bundle 3.2*

For CLIOSjre bundle 3.2, JR East’s business role is to operate a system under concession. As an operator of a system owned and constructed by someone else, JR East will be forced to work with whatever infrastructure and rolling stock choices were made by the system owner. This organizational structure poses a threat to this opportunity for expansion. Specifically, JR East’s business role would increase risk to the company’s reputation because JR East will have less control over the construction of the system, which could lead to safety incidents that would impair the company’s expansion potential (as captured in Metric 9. Service Reputation). However, the organizational structure and business role of this bundle make it directly relevant to several strongly attractive opportunities, including those being built by another public or private entity (e.g., California HSR, Florida Brightline). For these reasons, CLIOSjre bundle 3.2 has characteristics that match representative outcome A (it is relevant to multiple strongly attractive expansion opportunities).

The research team assigns bundle 3.2 a grade of A for Metric 1.

### *CLIOSjre Bundle 5.1*

JR East’s business role in CLIOSjre bundle 5.1 is to provide HSR components. In comparison to many other bundles this business role greatly enhances JR East’s ability to compete for bids from government agencies and private firms within the United States. As a company with very advanced rolling stock technology and many generations of technology to draw from, JR East will be very competitive for a bid for rolling stock in markets throughout the United States, including both incremental HSR projects and international-quality HSR projects. However, it is worth noting that JR East will face the threat of competition from other international players seeking to fill this role (i.e., JR Central, CR, Alstom), as captured in Metric 3. Competition. However, for Metric 1, bundle 5.1 is relevant to multiple strongly attractive expansion opportunities.

The bundle most closely resembles representative outcome A, so the research team assigns the bundle a grade of A for Metric 1.

### *CLIOSjre Bundle 6.1*

For CLIOSjre bundle 6.1, JR East’s business role will be to operate a system by purchasing track

capacity from a separate infrastructure manager. As a private operator on a separately owned infrastructure system, JR East will need to work within the constraints of the provided HSR infrastructure. Due to this organizational structure, this CLIOSjre bundle is relevant to several of the strongly attractive HSR markets currently being developed by public or private actors (e.g., California HSR, Florida Brightline, Texas Central Railway). This is because the business role in bundle 6.1 will offer JR East transferable knowledge about operating a system by purchasing capacity that may help JR East find a business role for attractive HSR markets in the future. However, it is worth noting that this bundle's organizational structure (i.e., vertically separated with multiple competing operators) exposes JR East to the threat of direct competition from operators on the same infrastructure (captured in Metric 3).

Despite the threat of direct competition, CLIOSjre bundle 6.1 most closely resembles representative outcome A and the research team assigns bundle 6.1 a grade of A for Metric 1.

### *CLIOSjre Bundle 6.2*

JR East's business role for CLIOSjre bundle 6.2 is to construct and operate a private HSR system owned by JR East. This business role affords JR East a great deal of control over the development of infrastructure and operating standards, which could aid JR East's ability to market itself in other promising HSR markets. However, this business role is incompatible with most of the HSR markets currently under development in the United States, with the exception of ill-defined markets, which we have defined as less attractive opportunities for JR East. As such, this bundle is most relevant to weak/medium markets.

Furthermore, the level of control that comes with this business role implies a greater degree of risk for JR East as a constructor/operator. In the context of expansion to other markets, this risk in the NEC is a threat to the company's ability to expand to other markets in the United States and elsewhere. The fact that this large-scale business role would limit JR East's ability to invest in other markets is an additional threat to the company's expansion potential. Based on this analysis, CLIOSjre bundle 6.2 most closely resembles representative outcome C.

The research group assigns bundle 6.2 a grade of C for Metric 1.

### *Metric 2. Expected Profit*

[Continued from Chapter 6]

### **Benchmarking for All Seven CLIOSjre Bundles**

Below we discuss the mapping of each CLIOSjre bundle to an industry. Table 8-12 summarizes the results of this analysis including the identified industry for the bundle, the selected benchmark companies, and the benchmark return on investment.

### *CLIOSjre Bundle 1.1*

For CLIOSjre bundle 1.1, JR East will not participate in the NEC market. Thus, JR East will not make any investments and will receive no return on its investment.

### *CLIOSjre Bundle 1.2*

For CLIOSjre bundle 1.2, JR East will provide planning, engineering, and operations consulting. In this role, JR East will only make a minimal capital investment. The majority of the costs for JR East will be salaries for its employees. In this role, JR East is most similar to engineering services companies. From this industry, the research team selected AECOM, Fluor Corporation, and Jacobs Engineering as comparable companies for which financial data is available.

### *CLIOSjre Bundle 3.1*

For CLIOSjre bundle 3.1, JR East will provide a turnkey system for the NEC. Although this business role will require JR East to perform a number of different roles, the majority of costs and revenue in this business role will be for infrastructure construction. The research group identified China Railway Construction Company, Hochtief AG, and KBR Incorporated as large, publically held companies that perform similar types of heavy and civil engineering construction.

### *CLIOSjre Bundle 3.2*

For CLIOSjre bundle 3.2, JR East will operate the HSR system under concession. Although there are a number of companies that provide rail operating services throughout the world, the research team was unable to find any companies which are both public and not a conglomerate. For example, Keolis – which operates the Boston commuter rail system as well as many rail services in France – is primarily a rail operator but it is not publically held. Given this limitation, the research team used mixed-mode transit systems as a reasonable approximation for this business role. The research team selected Nagoya Railroad Company, Odakyu Electric Railway, and Firstgroup PLC as comparable companies for which financial data is available.

### *CLIOSjre Bundle 5.1*

For CLIOSjre bundle 5.1, JR East will provide HSR components to the NEC. In this role, JR East will be most similar to rail rolling stock manufacturers. The research team selected American Railcar Industries, Nippon Sharyo, and Freightcar America Incorporated as comparable companies for which data is available.

### *CLIOSjre Bundle 6.1*

For CLIOSjre bundle 6.1, JR East will operate a private HSR system on infrastructure owned by a separate infrastructure manager. As with CLIOSjre bundle 3.2, there are a number of companies which provide rail operating services but none of them are both public and not a

conglomerate. Given this limitation, the research team used mixed-mode transit systems as a reasonable substitute industry. The research team selected Nagoya Railroad Company, Odakyu Electric Railway, and Firstgroup PLC as comparable companies for which financial data is available.

### *CLIOSjre Bundle 6.2*

For CLIOSjre bundle 6.2, JR East will construct and operate a private HSR system in the Northeast Corridor. This business role is most similar to JR East’s existing business. Thus, it makes sense to use JR East as one of the benchmark companies. To provide additional companies for comparison, the research team identified long haul railroads as the appropriate industry for comparison. The other two companies selected for comparison are JR Central and the Taiwan High Speed Rail Corporation. The Taiwan High Speed Rail Corporation is classified as a Commuter Railroad, but its financials are very similar to those of JR East and JR Central.

*Table 8-12. Cash Return on Investment Benchmark for the Seven CLIOSjre Bundles*

<b>CLIOSjre Bundle</b>	1.1	1.2	3.1	3.2	5.1	6.1	6.2
<b>Business Role</b>	None	Consulting	Turnkey System	Concession Operator	HSR Components	Private Operator	Private HSR System
<b>Industry</b>	None	Engineering Services	Heavy and Civil Engineering Construction	Mixed Mode Transit Systems	Railroad Rolling Stock Manufact.	Mixed Mode Transit Systems	Line Haul Railroads
<b>NAICS<sup>69</sup> Code</b>	N/A	541330	237990	485111	336510	485111	482111
<b>Selected Companies</b>	None	AECOM, Fluor Corp., Jacobs Engineering	China Railway Const. Co., Hochtief AG, KBR Inc.	Nagoya Railroad Co., Odakyu Electric Railway, Firstgroup PLC	American Railcar Indust., Nippon Sharyo, Freightcar America Inc.	Nagoya Railroad Co., Odakyu Electric Railway, Firstgroup PLC	JR East, JR Central, Taiwan HSR
<b>Median ROI</b>	0%	8.17%	5.18%	3.05%	10.54%	3.05%	3.83%

<sup>69</sup> North American Industry Classification System



## 8.2 Metric Analysis Using the CLIOSjre Process: Market Characteristics

### *Metric 3. Competition*<sup>70</sup>

[Continued from Chapter 6]

#### **CLIOSjre Six Forces Analysis of the Seven CLIOSjre Bundles**

##### *CLIOSjre Bundle 1.1*

In CLIOSjre bundle 1.1, JR East is not involved in the Northeast Corridor market for high-speed rail. JR East therefore faces no competition from market competitors nor business role competitors. As the federal government will not pay JR East for any services, JR East is not concerned about any incentive for the government to invest in a different mode. The force of market substitutes is therefore weak. In addition, as JR East not involved in the bundle, JR East is unaffected by business role substitutes. Similarly, JR East's noninvolvement means that the forces of suppliers and buyers are also weak.

##### **Summary**

For CLIOSjre bundle 1.1, Market Competitors, Business Role Competitors, Market Substitutes, Business Role Substitutes, the Power of Suppliers, and the Power of Buyers are all weak forces as JR East is not involved in the NEC for this bundle.

Thus, the research team assigns bundle 1.1 the grade A.

##### *CLIOSjre Bundle 1.2*

In CLIOSjre bundle 1.2, JR East provides planning, engineering, and operations consulting to Amtrak in the Northeast Corridor.

##### **Market Competitors (Strong)**

JR East will face stiff competition from European and Chinese high-speed rail firms who have experience in providing high-speed rail engineering and operations consulting and are likely interested in the NEC as a potential market for high-speed rail development.

For CLIOSjre bundle 1.2 the force of market competitors is strong.

##### **Business Role Competitors (Medium)**

In CLIOSjre bundle 1.2, JR East will provide planning, engineering, and operations consulting. Although JR East's involvement is limited in CLIOSjre bundle 1.2, other firms, such as the American freight railroad CSX, could choose to enter the high-speed passenger rail market in the

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<sup>70</sup> Dagin Faulkner was the original author of this section. Included with his permission.

NEC. CSX has a long established understanding of rail services in the NEC and therefore could bring knowledge about the corridor to the table that JR East does not have. However, the entry of a freight railroad into the passenger rail market in the NEC (especially since Amtrak does not share track with freight in the NEC), is unlikely.

More likely competitors for this business role are firms like AECOM and WSP Global | Parsons Brinkerhoff that have provided high-speed rail planning, engineering, and operations consulting elsewhere. These consulting firms have a great deal of expertise in large civil engineering projects. Although these firms do not have the detailed expertise on high-speed rail of JR East and other global HSR firms, these large engineering consultants have a detailed knowledge of the market. This local knowledge gives them an advantage over JR East which has no experience executing a project in the United States.

Given that large consulting firms have little experience in HSR consulting but a great deal of experience in the NEC market, the research team characterizes the force of business role competitors as medium for CLIOSjre bundle 1.2.

### **Market Substitutes (Weak)**

The strength of market substitutes is driven by the relative attractiveness of other transportation modes. For CLIOSjre bundle 1.2, the federal government funds incremental improvements to the NEC. As the NEC is already a significant part of the regional transportation system, it is unlikely that the federal government will completely abandon the system in favor of another mode. Further, the consulting contract for bundle 1.2 will be small in comparison to the rail system's capital investments; it is unlikely that the federal government would forgo this critical planning and engineering for the capital investments. As the incremental improvements to the NEC HSR system will not truly threaten the market share of the airline, automobile, or existing passenger rail services in the Northeast Corridor, these organizations will not lobby for money for other modes. Congress is very likely to fund these investments in the rail system.

Therefore, for CLIOSjre bundle 1.2, the force of market substitutes is weak.

### **Business Role Substitutes (Weak)**

For CLIOSjre bundle 1.2, there are very few business role substitutes for planning, engineering, and operations consulting. Indeed, these services are a necessary part of redesigning the NEC HSR system. However, Amtrak or the USDOT could develop the necessary expertise in-house rather than through a consulting arrangement. Neither Amtrak nor the USDOT has experience with high-speed rail development; it would be difficult (and likely expensive) for them to develop this expertise. As this expertise already exists at a reasonable price in global HSR firms and local engineering consultants, it seems likely that the USDOT would rely on consultants rather than developing the expertise internally.

The research team characterizes the force of business role substitutes as weak.

### **Power of Suppliers (Medium)**

For CLIOSjre bundle 1.2, JR East provides planning, engineering, and operations consultation. Suppliers for this business role are primarily JR East's human resources department. Within JR East, there will be competition among business units for the most capable employees. Although the NEC consulting project may be a top priority for the company, other company objectives will compete for manpower. In addition, JR East normally hires new employees upon graduation from university and trains them with the expectation that they will work for JR East until retirement. These hiring and training practices may preclude JR East from quickly acquiring new employees with expertise in the NEC. Potential internal competition and JR East's employment structure may compromise the company's ability to quickly provide consulting services to the NEC.

Based on this analysis, the research team characterizes the power of suppliers as a medium force.

### **Power of Buyers (Strong)**

For CLIOSjre bundle 1.2, the buyer is the US Congress via USDOT. As the key entities within the USDOT that oversee passenger rail development, Amtrak and the FRA have complete control over who wins the consulting contract. Congress has little motivation and no set timeline to advance high-speed rail in the NEC. Congress is unlikely to prioritize the financing of engineering and operations consulting. By extension, Amtrak and the FRA are in a strong negotiating position one they have the money from Congress – they can thoroughly vet the consulting bidders before selecting a winner. This put the Congress (and by extension, Amtrak and the FRA) in a strong negotiating position.

The research team characterizes this force as strong for CLIOSjre bundle 1.2.

### *CLIOSjre Bundle 3.1*

In CLIOSjre bundle 3.1, JR East provides a turnkey high-speed rail system for the NEC.

### **Market Competitors (Strong)**

JR East will face serious competition from China Railway and European high-speed rail firms who have the expertise necessary to build a turnkey system and are interested in the NEC.

As with CLIOSjre bundle 1.2, the force of market competitors is strong.

### **Business Role Competitors (Weak)**

There are few qualified competitors for this business role that are not global market competitors. A state department of transportation may choose to diversify their portfolio of transport expertise by opting to build a piece of the turnkey high-speed rail system through their state. For example,

the Connecticut Department of Transportation might decide to build the segment of the high-speed rail system in Connecticut. This scenario is unlikely because the states lack high-speed rail expertise and the resources to engage in turnkey high-speed rail development.

A more likely business role competitor would be a North American Class 1 railroad such as CSX or BNSF. These Class 1 railroads have a great deal of expertise in infrastructure development and could subcontract to firms with high-speed rail expertise. With these subcontractors, the Class 1 railroads could develop the knowledge base necessary to build a turnkey high-speed rail system in the NEC. Although the freight railroads in the United States operate a few commuter rail systems, freight railroads in the United States have not expressed any interest in moving into the passenger rail market.

As the potential business role competitors are not qualified or not interested in constructing a turnkey high-speed rail system, the research team characterizes the force of business role competitors as weak.

### **Market Substitutes (Strong)**

A turnkey system will be of significant cost to the federal government. Private financing could relieve the government of some of the financial burden, but as USDOT would ultimately own the infrastructure, JR East does not have the opportunity to directly attract private investors. In an attempt to avoid this high price tag, the federal government will likely look to other transportation modes to reduce the cost of new corridor capacity. Although adding sufficient capacity via another transportation mode would likely be much more expensive than a turnkey system, rail only commands a minority of trips in the NEC and lobbying by airline and automobile special interest groups may force the federal government to invest in a different mode instead of the turnkey system.

Based on this understanding the research team characterizes this force as strong for CLIOSjre bundle 3.1.

### **Business Role Substitutes (Strong)**

For CLIOSjre bundle 3.1, one plausible business role substitute for JR East implementing a turnkey high-speed rail system in the NEC is the federal government breaking the contract into components. By breaking up the contract into high-speed rail components, the US government opens the market to a number of other firms with existing experience constructing components of a high-speed rail system. Such a scheme could see one firm constructing a segment of the high-speed rail line (a component) or multiple firms building infrastructure and supplying high-speed rail rolling stock (various components).

In addition, another potential business role substitute is the development of alternative high-speed, fixed route transportation system in the NEC. JR Central is currently working with

Northeast Maglev to bring a superconducting maglev service to the NEC. Simultaneously, SpaceX (led by Elon Musk) has made forays into high-speed rail development through the development of the Hyperloop concept (which is very much in the pre-experimental phase). Should either of these technologies become a viable and attractive option for the NEC, JR East's turnkey system will face competition for federal funding.

Due to these multitude of business role substitutes for JR East's turnkey system, the research team characterizes this force for CLIOSjre bundle 3.1 as strong.

### **Power of Suppliers (Strong)**

For CLIOSjre bundle 3.1, there are a number of suppliers for the turnkey HSR system. JR East will supply the labor necessary to construct a turnkey high-speed rail system in the NEC. Many of these employees will be new hires in the United States. JR East normally hires new employees upon graduation from university and trains these workers with the expectation that they will work for JR East until retirement. Implementing these hiring procedures in the United States would ensure that JR East's expertise and professionalism is cultivated in this new American workforce. However, it is unclear if American employees are interested in this type of long-term employment.

Private and public landowners will supply the land on which the dedicated track in CLIOSjre bundle 3.1 will be built. Their willingness and the price at which they are willing to sell land to the project determines the strength of their negotiating power. Depending on the contract arrangement between JR East and the federal government, the federal government may shoulder the risk and financial burden of these landowner disputes.

In addition, private investors will supply substantial financial capital in CLIOSjre bundle 3.1. Their willingness to finance high-speed rail in the NEC will be tied to their expected return on investment. If any portion of the project compromises their profits, investors will be inclined to increase interest rates, reduce their level of financial support, or withdraw their funds entirely. Public financial support for the project will come from the federal and state governments, two bodies whose institutional gridlock is likely to slow the allocation of critical public funds to high-speed rail. Public agencies have a strong impact on the viability of high-speed rail development in the NEC.

As many suppliers have strong negotiating power over JR East in this business role, the research team characterizes the force of the power of suppliers as strong.

### **Power of Buyers (Strong)**

The buyer in CLIOSjre bundle 3.1 is the federal government. The federal government can choose to forego turnkey high-speed rail altogether or break the turnkey contract into smaller pieces. This ability to break the contract into smaller pieces puts the Federal government in a very strong

negotiating position.

Because the Federal government has a great deal of power in the contract negotiation, the research team classifies the power of buyers as strong.

### *CLIOSjre Bundle 3.2*

In CLIOSjre bundle 3.2, JR East operates high-speed rail in the NEC under a government concession.

#### **Market Competitors (Strong)**

JR East will face stiff competition from China Railway and European high-speed rail firms who have the expertise necessary to operate high-speed rail and are interested in the NEC. Firms like SNCF already provide operations consulting outside their home country and have the wherewithal to operate high-speed rail in the NEC. JR East will face stiff competition from the existing global players.

For CLIOSjre bundle 3.2, the force of market competitors is strong.

#### **Business Role Competitors (Strong)**

Existing passenger rail services in the NEC (e.g. Amtrak, Metro North Railroad, Long Island Railroad) could develop the ability to operate international quality high-speed rail. Class 1 railroads (e.g. CSX, BNSF) are experts in long-distance rail travel and operate some commuter rail systems in the US. These freight companies could also position themselves as viable candidates for an operations concession.

With a large number of qualified organizations interested in the operations concession, the research team characterizes the force of business role competitors as strong for CLIOSjre bundle 3.2.

#### **Market Substitutes (Strong)**

For CLIOSjre bundle 3.2, JR East will rely on fare revenue to pay for the operation of the HSR system. As this bundle is composed of piecewise high-speed rail, the northern half of the system will operate international quality high-speed rail and the southern half of the rail corridor will not perform much better than it does today. For this southern portion of the corridor, the automobile, air, and conventional passenger rail service modal split will likely remain the same. Delays on the southern portion of the route may propagate through the system and reduce the service quality on the northern part of the route. In addition, as high-speed rail service on the northern portion of the corridor will be significantly more expensive than other transportation services, competing modes will remain a significant barrier to JR East's profitability.

The research team characterizes the force of market substitutes as strong.

### **Business Role Substitutes (Weak)**

There are no business role substitutes for high-speed rail operations. For CLIOSjre bundle 3.2, the force of business role substitutes is weak.

### **Power of Suppliers (Strong)**

Labor suppliers are the primary suppliers in CLIOSjre bundle 3.2. JR East can either supply the labor directly or provide training to an American labor force. JR East normally hires new employees upon graduation from university and trains these workers with the expectation that they will work for JR East until retirement. These hiring and training practices can preclude JR East from quickly acquiring new employees with expertise in the NEC. The limitations of JR East's hiring and training practices would make expansion into NEC operations difficult.

The research team characterizes the power of suppliers as strong for CLIOSjre bundle 3.2.

### **Power of Buyers (Strong)**

The buyer in CLIOSjre bundle 3.2 is the federal government. The United States' government has historically provided Amtrak with funds insufficient to meet the full scale of operational and maintenance requirements; this puts the government in a strong position over JR East. In addition, the Federal government can choose to forgo JR East as the system operator and instead require Amtrak to operate its own services.

As a buyer, the federal government is a strong force.

### *CLIOSjre Bundle 5.1*

In CLIOSjre bundle 5.1, JR East sells high-speed rail components to the NEC.

### **Market Competitors (Strong)**

JR East could face stiff competition from the numerous firms who have the expertise necessary to build high-speed rail components and are interested in the NEC. A number of these global firms already provide high-speed rail components to customers in other countries. Alstom, Bombardier, Siemens, and Nippon Sharyo supply high-speed rail rolling stock beyond their home countries. The Canadian firm Bombardier and the French firm Alstom manufactured the Acela trainsets currently in use in the NEC; this gives them an edge for compliance with the Federal Railroad Administration's stringent crash standards. Even though Acela is not international quality high-speed rail, the manufacturers of its rolling stock supply international quality high-speed rail trainsets to other countries. Siemens AG provides high-speed rail rolling stock in China, Russia, and Spain. As well, SNCF has worked with Administrador de Infraestructuras Ferroviarias (ADIF) in Spain to deliver high-speed rail signaling infrastructure. JR East must demonstrate that its delivery of high-speed rail components to another nation is comparable or superior to that of Siemens AG, SNCF, or other firms who have provided high-

speed rail components to other countries.

For CLIOSjre bundle 5.1, the force of market competitors is strong.

### **Business Role Competitors (Strong)**

In addition to the global HSR firms, there are a large number of qualified companies that currently provide rail components and may be interested in the high-speed rail market. In particular, GE Transportation, American Railcar Industries, Freightcar America Inc., and Talgo Inc. currently provide engines and rolling stock in the United States; Ansaldo Signalling and Transportation Systems currently provide signaling infrastructure worldwide. Although these companies do not have the expertise to provide a full turnkey HSR system, these companies will be qualified competitors for particular HSR components of the HSR system.

As there are a large number of qualified competitors for this business role, the research team characterizes the business role competitors as a strong force.

### **Market Substitutes (Strong)**

A new international quality high-speed rail system throughout the NEC would require a great deal of federal funding. Even as individual components, new rolling stock and other HSR components will be very expensive and require financial support from the federal government. As CLIOSjre bundle 5.1 requires a new spine along the full corridor, the cost to the federal government could not be covered by existing USDOT grant programs – this improvements would require a special appropriation. Private financing or soft loans from JR East could relieve the government of some of the immediate financial burden, but the price of the system would cause Congress to look to other transportation modes for a cheaper alternative. Although adding sufficient capacity via another transportation mode would likely be much more expensive than a turnkey system, rail only commands a minority of trips in the NEC and lobbying by the airlines and automobile industries could force the federal government to invest in a different mode instead of the new HSR system.

The research team characterizes this force as strong for CLIOSjre bundle 5.1.

### **Business Role Substitutes (Weak)**

The only business role substitutes for HSR components are a turnkey HSR system. As a turnkey system would require a single system contract and single payment for the system all at once, it is unlikely that market stakeholders (in particular, the federal government) would be interested in a turnkey system once they have settled on a plan for HSR components.

The research team characterizes the force of business role substitutes as weak for CLIOSjre bundle 5.1.

### **Power of Suppliers (Weak)**



Labor unions and raw material producers are the primary suppliers in CLIOSjre bundle 5.1. Buy America provisions mandate that transportation infrastructure projects are built with American products and labor.<sup>1</sup> As high-speed rail development in the NEC falls within the purview of the United States Department of Transportation, JR East will have to comply with Buy America provisions in CLIOSjre bundle 5.1. JR East will need to hire and train an American labor force to assemble HSR components in the US. Although labor unions (especially for skilled trades) have traditionally been very strong in the United States (and in particular, in the northeast and Midwest), political changes in the last several years have substantially reduced the bargaining power of organized labor. As raw materials (e.g. sheet metal) are commodities, it is likely that these suppliers will also have little negotiating power.

Since these two suppliers (labor and raw materials) are in a poor position to negotiate, the research team characterizes the overall force of the power of suppliers as weak.

### **Power of Buyers (Strong)**

The buyer in CLIOSjre bundle 5.1 is the Federal government. With no set timeline for HSR implementation, the Federal government can delay or choose not to purchase high-speed rail components from JR East, thus rendering the Federal government a strong force as a buyer.

The research team therefore characterizes the power of buyers as a strong force for CLIOSjre bundle 5.1.

### *CLIOSjre Bundle 6.1*

In CLIOSjre bundle 6.1, JR East would operate a high-speed rail system by purchasing track capacity from a separate infrastructure manager.

### **Market Competitors (Strong)**

CLIOSjre bundle 6.1 is vertically separated with respect to operators. This structure permits significant competition among those firms with high-speed rail construction and operations expertise. SNCF, operator of the Train à Grande Vitesse (TGV), currently offers consulting services in numerous countries (including Taiwan where they provide operations training consulting). China Railway and XpressWest have formed a partnership that aims to build high-speed rail between Las Vegas and Los Angeles. JR Central is working with Northeast Maglev to bring Maglev service to the NEC. These international HSR competitors have expressed a general interest in the Northeast Corridor, and a private operations bid is no exception.

Thus, the force of market competitors is strong.

### **Business Role Competitors (Medium)**

In CLIOSjre bundle 6.1, one potential business role competitor is Amtrak. As the infrastructure manager, Amtrak could decide to vertically integrate and operate services itself. However,

Amtrak's lack of experience in high-speed rail operations may result in substandard service quality.

Given Amtrak's inexperience with international quality high-speed rail but vested interest in the corridor, the research team characterizes the force of business role competitors as medium.

### **Market Substitutes (Weak)**

The force of market substitutes depends on the cost of the high-speed rail system to the federal government. For CLIOSjre bundle 6.1, JR East would operate high-speed rail service in the NEC; however, the federal government would bear no operations costs. Once the federal government has committed to constructing the new HSR infrastructure, the incremental cost of an operating concession is negligible.

Thus, the force of market substitutes is weak.

### **Business Role Substitutes (Weak)**

There is no business role substitute for high-speed rail operations. For CLIOSjre bundle 6.1, the force of business role substitutes is weak.

### **Power of Suppliers (Strong)**

In CLIOSjre bundle 6.1, JR East will operate a system by purchasing track capacity from a separate infrastructure manager. Although other suppliers (labor, raw materials) will supply key components for this business role, these other suppliers will have very little impact of JR East's profitability in comparison to the infrastructure manager. This infrastructure manager will have exclusive control over JR East's track capacity. As the infrastructure manager will also be the contractor who built the HSR system, they will likely be very knowledgeable about HSR operating costs, expected demand, and profit margins. As a dominant and informed player, the infrastructure manager will be in a strong negotiating position.

Thus we characterize the power of suppliers as a strong force for CLIOSjre bundle 6.1.

### **Power of Buyers (Strong)**

In CLIOSjre bundle 6.1, JR East is reliant on the fare to yield a return on its investment. Potential high-speed rail customers wield significant power once operations begin. If high-speed rail is not regarded as a meaningful alternative to air, road, or existing passenger rail services, and thus does not induce mode shift away from the aforementioned modes, then high-speed rail in the Northeast Corridor will not be successful. In addition, the federal government may regulate fares are a certain level to ensure that the new high-speed rail system is well-used (for political and practical reasons).

The research team characterizes the power of buyers as a strong force in CLIOSjre bundle 6.1 given the strong negotiating position of potential high-speed rail users.

## *CLIOSjre Bundle 6.2*

In CLIOSjre bundle 6.2, JR East would construct and operate a high-speed rail system with infrastructure owned by JR East.

### **Market Competitors (Strong)**

There are a number of existing competitors in the market that already have proficiency in the high-speed rail engineering and operations consulting market who are more familiar with business practices in the NEC. This means that JR East must demonstrate a comparable or superior level of knowledge of the culture in the NEC marketplace for high-speed rail. Other firms have already entered the broader United States market for high-speed rail. For example, JR Central has been working with Texas Central Railway to build high-speed rail in Texas. The performance of JR Central in Texas will inform the scale and preferred scope of future international involvement in HSR development in the United States. The institutional complexity in the NEC differs from that in Texas, but the success of HSR firms in one region of the US will affect the willingness of other firms to enter the market in another region. Another market competitor, China Railway International, has formed a partnership with XpressWest to build high-speed rail between Las Vegas and Southern California.

With a number of other global competitors already involved in the United States, the force of market competitors is strong.

### **Business Role Competitors (Weak)**

There are a number of existing companies in the NEC that might be interested in this business role. For example, AECOM, Parsons, WSP Global | Parsons Brinkerhoff, Steer Davies Gleave, and Siemens AG are all involved in the NEC market and may be interested in partnering to produce a private turnkey system. However in comparison to the global HSR competitors, these companies do not have the financing power or expertise to execute a project of this size. Even if these companies decide to partner with each other in a large joint venture, it is unlikely that they would be able to compete with the resources of JR East.

The research team characterizes this force as weak.

### **Market Substitutes (Strong)**

The federal government is more likely to seek an alternative to full-scale international quality high-speed rail because of the high cost required to implement such a system. One alternative might be marginal upgrades to the existing Acela service. The federal government has historically provided Amtrak with funds insufficient to meet the full scale of operational and maintenance requirements. Given the comparable cost and complexity of this project, the federal government might find it more palatable to fund more modest improvements to the existing rail system than to invest in a completely new service. Even with significant private money from JR

East, it is unlikely that project will be inexpensive for the federal government.

With the long-running tendency of the federal government to underfund improvements to rail projects in the United States, the force of market substitutes is strong.

### **Business Role Substitutes (Medium)**

There are a number of substitutes for high-speed rail in the NEC already underway. JR Central is working with Northeast Maglev to bring superconducting maglev service to the NEC. JR Central can construct and operate such a system, which poses significant competition for JR East. In addition, SpaceX has made forays into high-speed rail development through the Hyperloop concept and technology competition. Should either of these technologies become a viable and attractive option for the NEC, JR East will face competition for federal support and funding. However, in comparison to the NEC high-speed rail systems, both the Maglev and Hyperloop will be significantly more expensive and have lower capacity.

Given these limitations and the uncertainty in deployment of these two technologies, the research team characterizes the force of business role competitors as medium.

### **Power of Suppliers (Strong)**

In the Northeast Corridor, landowners are one group of suppliers. Land use policies and eminent domain laws can override any resistance landowners put up to ceding property for high-speed rail development. However, landowners can garner significant public support in their favor, which has historically blocked transport projects in the NEC. Another group of suppliers includes the firm(s) that will provide labor. JR East will likely supply the engineering labor in this bundle given their expertise. However, construction and operations labor in this bundle would likely be supplied by other private firms with an existing American presence. Although there are many construction firms, few are qualified to work on a project of this size and complexity. In addition, Buy America requirements will compel JR East to purchase American-made materials for construction.

With these significant constraints on the supply chain for bundle 6.2, the research team characterizes the power of suppliers as a strong force.

### **Power of Buyers (Weak)**

For CLIOSjre bundle 6.2, JR East will construct and operate a private system with infrastructure owned by JR East. If high-speed rail is not regarded as a meaningful alternative to air, road, or existing passenger rail services, and thus does not draw passengers away from the aforementioned modes, then international quality high-speed rail in the Northeast Corridor may not be successful.

However, JR East's project will likely include real estate development around the stations. JR

East has a large real estate group that could initiate commercial development in the NEC. This presents business opportunities for JR East and other real estate developers in the corridor. If JR East builds any commercial developments, the company could lease space and develop sources of revenue that do not depend on the HSR demand. Although high-speed rail customers wield some power once operations begin, this alternate source of revenue will buffer JR East against changes in travel patterns or prices.

Given that bundle 6.2 will provide rail service that is vastly superior to anything else currently available on the corridor, and that JR East will be able to make money from real estate, the research team characterizes the power of buyers as a weak force in CLIOSjre bundle 6.2.

#### *Metric 4. Cooperation*<sup>71</sup>

[Continued from Chapter 6]

JR East’s level of interest in each of the objectives in Figure 8-1 is coded according to Table 8-13 below. The strength of JR East’s interest in each objective is evaluated from the viewpoint of JR East in its particular business role. As discussed in the CLIOS Process application of PCBA to the NEC, these numeric codes represent best practice for the clustering approach used in the first phase of the evaluation (Akao, 1998). We choose to employ the 1-3-9 conversions because this provides the greatest (Euclidean) distance and hence differentiation between “medium” and “strong” interests for each actor on the Institutional Sphere.

*Table 8-13. Key for the Numeric Coding of JR East's Interests*

<b>Key for the JR East-Objective Matrix</b>	
0	No interest
1	Weak stakeholder interest
3	Medium stakeholder interest
9	Strong stakeholder interest

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71 Joanna Moody was the original author of this section. Included with her permission.

Figure 8-1. JR East-Objective Matrix for the NEC

#	Objective	JR East Business Role						
		1.1	1.2	3.1	3.2	5.1	6.1	6.2
1+2	Reduce the transportation system user fatality rate and the number of non-fatal accidents and injuries	0	0	9	9	0	9	9
3+4	Increase the physical capacity of the transportation system and ensure its effective utilization	0	0	9	3	0	9	9
5	Reduce the backlog of deferred maintenance for each mode	0	0	0	3	0	1	9
6	Facilitate the interconnection between different transportation modes	0	0	3	1	0	1	3
7	Decrease trip times	0	0	3	1	0	9	3
8	Increase trip time reliability	0	0	0	9	0	9	3
9	Reduce congestion	0	0	0	1	0	3	0
10+11	Reduce fares and provide a comfortable travel experience	0	0	0	1	0	1	0
12	Foster livable communities through place-based policies and investments that increase transportation choices and access to transportation services	0	1	0	0	0	0	9
13	Increase accessibility of labour force participants to firms (jobs); increase accessibility of firms to labour force participants	0	0	0	0	0	0	0
14	Increase the productivity of firms in all sectors	0	0	0	0	0	0	0
15	Promote short- and long-term job creation	0	0	0	0	0	0	0
16	Stimulate real estate development	0	0	0	0	0	0	3
17	Ensure that the net benefits of transportation system improvements are evenly distributed spatially and by socioeconomic class	0	0	0	0	0	0	0
18	Reduce emissions of air pollutants related to the transportation sector	0	0	0	0	0	0	3
19	Reduce energy consumption by the transportation sector	0	0	0	3	0	3	3
20	Minimize the spatial footprint of the transportation sector, particularly in areas of high-environmental sensitivity	0	0	3	0	0	0	3
21	Maximize benefits from public investment in the transportation system	0	0	9	1	0	0	0
22	Maximize profitability for private operators and/or infrastructure managers	0	0	0	3	0	9	9
23	Create an organizational structure that will minimize the time and cost required for project implementation	0	3	9	0	1	0	9
24	Create an organizational structure that will allow the needs of all NEC operators to be considered during transportation investments	0	0	0	9	0	9	0
25	Create a flexible transportation system with a management structure that effectively identifies and mitigates risks	0	9	9	9	1	3	9
26+28	Create a transportation system that can withstand environmental pressures, mitigate the effects of natural disasters, and support efficient evacuation routes.	0	0	9	0	0	0	9
27	Create a transportation system that can mitigate the effects of human disasters	0	0	3	0	0	0	9

In addition to understanding JR East’s interests in the system objectives given each of its seven business roles, it is also important to consider where JR East lies within the stakeholder typology

used for the second phase of PCBA. According to the framework developed by Mitchell, Agel, and Wood, we assign JR East any number of the three stakeholder attributes – power, legitimacy, and urgency – in each of its CLIOSjre business roles (Figure 8-2). This information can be combined with the CLIOS Process typology assignments for each of the other stakeholders on the Institutional Sphere for the NEC to discuss cooperative incentives.

Figure 8-2. Assignment of the Stakeholder Attributes for the NEC

JR East Business Role							
	No involvement	Provide engineering or operations consulting	Provide a turn-key system	Operate a system under concession	Provide HSR component(s) capacity from a separate infrastructure manager	Operate a system by buying track with infrastructure owned by JR East	Construct and operate a private system
Attribute	1.1	1.2	3.1	3.2	5.1	6.1	6.2
Power	X	✓	✓	X	X	X	✓
Legitimacy	X	✓	✓	✓	✓	✓	✓
Urgency	X	X	✓	X	✓	X	✓
Stakeholder Typology	Nonstakeholder (0 0 0)	Dominant (P L 0)	Definitive (P L U)	Discretionary (0 L 0)	Dependent (0 L U)	Discretionary (0 L 0)	Definitive (P L U)

### Predictive Coalition-Building Analysis of the Seven CLIOSjre Bundles

For each of the seven CLIOSjre bundles, we run the first phase of PCBA with an actor-objective matrix including JR East in its business role and all of the actors identified on the CLIOS Institutional Sphere of the NEC. Hierarchical clustering is performed exactly as in the CLIOS Process application of PCBA: using Euclidean distance as the measure of dissimilarity between interest vectors and complete linkage algorithm as the measure of cluster distance.

This produces a dendrogram, or tree diagram, that highlights the stakeholders with the most similar interests to JR East on the NEC. At the right of the diagram we have the finest or most granular level of detail, where the actors are each placed into their own singleton cluster based on their unique interests in the HSR system development. When two branches come together at a node, this indicates that the two actors or actor groups have been clustered together based on their interests in the system objectives. The further to the left this node is located on the diagram, the less similar the interests of the actors in the cluster are. For our analysis, we interpret less similarity among actors as indicative of the need for more compromise on interest or more effort expended in order to work together and form a coalition. Therefore, the higher the level of detail (further left) the node of two actor branches in the dendrogram, the less likely they are to form a coalition based on their interests.

We then consider the stakeholder typologies for those actors in the cluster with JR East to see if JR East and the other like-minded stakeholder(s) have something to gain from working together. That is, does their combined salience improve by sharing stakeholder attributes in the Mitchell, Agel, and Wood typology?

We will now discuss the results of the PCBA for each of the seven CLIOSjre bundles identified for the Northeast Corridor.

### *CLIOSjre Bundle 1.1*

In bundle 1.1, high-speed rail development on the NEC continues incrementally without JR East involvement. Because JR East has no business role, it is not included as a stakeholder or actor on the Institutional Sphere for the NEC. Since JR East has no interest or role in this market, there are no possible partnerships among the stakeholders on the NEC.

Therefore, bundle 1.1 is given a grade of F for Metric 4. Cooperation.

### *CLIOSjre Bundle 1.2*

For CLIOSjre bundle 1.2, JR East takes on the business role of providing engineering or operations consulting on the CLIOS bundle 1 development of incremental HSR on the NEC. Given that its role is only in the conceptual design and construction phases of the project, JR East has limited interests in the many of the full life-cycle objectives of the system.

Performing the first phase of PCBA for CLIOSjre bundle 1, we find that the NEC stakeholders with the most similar interests to those of JR East are the Banking Industry and Insurance Industry. This makes sense given the shorter-term nature of JR East's interests in this business role – the company's main concern as a consultant would likely be in fulfilling the terms of its contract and encouraging the project to be completed on time and on budget. These monetary and construction-phase concerns are echoed by banks and, to a lesser extent, by the insurance industry. The insurance industry differs from the other two stakeholders in the possible coalition because it has some concerns for mitigating longer-term risks that are not shared by the banking industry and JR East in its consulting role.

We next consider the second phase of PCBA. From Figure 8-2, we know that JR East in its role as a consultant is a discretionary stakeholder with a typology of (0 L 0). From the CLIOS Process analysis of the NEC, we have identified that both the Banking Industry and the Insurance Industry are dominant stakeholders with a typology of (P L 0). Therefore, JR East could gain saliency by acquiring the attribute of power through partnership with either or both of the banking and insurance industries. However, because both of these stakeholders already have legitimacy, there is no incentive for partnership for them. While the incentive to form partnerships is one-sided, there are multiple possible partnerships available to JR East in this bundle.



This maps to a letter grade of B on our Metric 4 spectrum for CLIOSjre bundle 1.2.

### *CLIOSjre Bundle 3.1*

For the CLIOSjre bundle 3.1, JR East takes on the business role of providing a turnkey system for a piecewise international-quality HSR development on the NEC. In this role, JR East will be extensively involved in the design and construction phases of the project and therefore has strong interest in these shorter-term objectives. In addition, it might have some interest in operation-related objectives because its reputation and brand may be tied to the infrastructure it is handing over.

In our analysis, we find that the NEC stakeholder with the most similar interests to those of JR East is the U.S. Department of Transportation. This partnership is plausible given JR East and the US DOT's interest in transportation infrastructure, expanding capacity and improving its utilization along the NEC; however we note that this pairing does not appear until much further left in the dendrogram than other partnership nodes, indicating that the interest of this coalition are fairly dissimilar.

In its CLIOSjre bundle 3.1 business role, JR East is a definitive stakeholder with all three stakeholder attributes, (P L U). Therefore, JR East does not need to partner with any other stakeholder on the NEC to gain salience unless it helps JR East in other ways within the market. The stakeholder with the closest interests is the USDOT which is also a definitive stakeholder. Since they have the same stakeholder typology, they may not have an incentive to work together based on gaining saliency through the acquisition of a stakeholder attribute. However, since the number of definitive stakeholders in the system is small and they have the most influence in shaping the development of the system, there is still a significant amount of benefit that can be gained by both parties working together. JR East could gain significant political support by partnering with a federal agency while the US DOT can ensure that the system delivered meets the needs of the country.

Mapping this to the Metric 4 spectrum, we get a letter grade of C for CLIOSjre bundle 3.1.

### *CLIOSjre Bundle 3.2*

For CLIOSjre bundle 3.2, JR East takes on the business role of operating service under concession for a piecewise international-quality HSR development on the NEC with a non-Amtrak single operator. In this case, JR East has no role in the design or construction phases of the project and will simply commence operations on whatever infrastructure is implemented. Therefore, the company's concerns are related to quality and level of service as well as life-cycle properties of the system.

From our results in the first phase of the PCBA, it is clear that the NEC stakeholder with the most similar interests to those of JR East as a concessionaire is Amtrak, followed by Commuter

Rail Agencies and Urban Public Transportation Organizations. The similarity in interest between JR East and Amtrak is logical because JR East would likely adopt Amtrak's existing role as the intercity operator along the international-quality portions of the HSR development along the NEC. While Amtrak is not under concession, its regulation and subsidization by the government may be similar to some of the terms in a lease of operation on an upgraded NEC.

The similarity of interests between JR East and Commuter Rail Agencies and Urban Public Transportation Organizations represent other transportation providers that might be sharing track along some but not all of the alignment or providing important connections for intercity passengers on JR East's HSR service.

In its business role of operating service under concession, JR East is a discretionary stakeholder with typology (0 L 0). On the other hand, Amtrak and Commuter Rail Agencies are each definitive stakeholders with the power, legitimacy, and urgency (P L U) to strongly influence HSR development along the NEC by themselves. Therefore, they have no clear incentive to work with JR East even though JR East could gain power and/or urgency from a partnership. Urban Public Transportation Organizations are dependent stakeholders (0 L U) who also have no incentive to partner with JR East. While the incentive to form partnerships is one-sided, there are multiple possible partnerships available to JR East in this bundle.

Therefore, CLIOSjre bundle 3.2 is given a grade of B for Metric 4. Cooperation.

### *CLIOSjre Bundle 5.1*

For CLIOSjre bundle 5.1, JR East takes a limited role in the development of international quality HSR along the entire length of the NEC. As a supplier of HSR components (such as rolling stock, signaling systems, or micropayment and IC card systems), JR East is again involved more heavily in the design and construction phases of the project rather than the operation once the infrastructure is complete. The company's concerns are related to the timely and budget-conscious completion of any contract work and avoiding component failure of their products.

The results of the first phase of PCBA indicate that The NEC stakeholder with the most similar interests to those of JR East is Suppliers. This is intuitive since JR East is essentially another supplier entering the NEC market in its business role as a provider of HSR components. In its capacity as an HSR component provider, JR East is a dependent stakeholder with a typology of (0 L U). In the CLIOS Process Applied to the NEC, Suppliers were also found to be demanding stakeholders with a typology of (0 L U). Because JR East and other NEC suppliers have the same typology, they do not have an incentive to work together despite having similar interests in the development of the HSR system. In fact many of these suppliers might be direct competitors to JR East for contracts in the HSR market. Therefore, there is little potential for partnership with Suppliers.

Our results also suggest that the Media is a potential partner with JR East in its role as a supplier

of HSR components. These two stakeholders are clustered because they both have only medium or weak interests in a few objectives that are concerned with the outcomes of the system design and planning rather than the details. In its capacity as an HSR component provider, JR East is a dependent stakeholder with a typology of (0 L U) and the Media is a dormant stakeholder with a typology of (P 0 0). JR East could gain power by working with the Media, and the Media could gain both legitimacy and urgency from working with JR East. Therefore, both sides are motivated toward a partnership and the coalition formed would be a definitive stakeholder with full saliency to influence the development of HSR along the NEC. At first glance this may seem like a less intuitive pairing than many of the others in the dendrogram; however it may be indicative of the power of advertising and positive media coverage when JR East is trying to sell its specific brand or product in a market that is new for them.

Because one potential partner is identified with a two-sided incentive to work together, bundle 5.1 is assigned a grade of C for Metric 4. Cooperation.

### *CLIOSjre Bundle 6.1*

In CLIOSjre bundle 6.1, JR East participates in a vertically separated, all-over international quality HSR system that is open to competition. Therefore, it operates HSR service by buying track capacity from a separate infrastructure manager. Because JR East would be involved only after the infrastructure manager and other stakeholders have completed the design and construction of the system, JR East's interests are limited to service-quality and operations-related system objectives that would determine their competitiveness for customers within the intercity passenger rail market. They would also be particularly concerned that the needs of all operators along the corridor be considered in any investment decisions and protected by the corridor management structure.

Performing Predictive-Coalition Building Analysis on JR East's interests in its role as a competing operator on a vertically separated system, we find that there are no NEC stakeholders with interests closely related to JR East, but those that have the most similar interests are Amtrak, Commuter Rail Agencies, Urban Public Transportation Organizations, and the Airline Industry. This grouping is intuitive, since these actors represent the private passenger transportation operators along the corridor other than JR East. The Airline Industry is matched with JR East due to similar concerns, such as reducing congestion and expanding capacity, its interests are likely limited to air transportation and therefore not directly linked to railroad capacity expansion and improvement. Therefore, it is difficult to predict whether the Airline Industry will look on HSR development cooperatively or competitively based on its unique interest in the system objectives.

Considering the incentives to form coalitions, we note that JR East is a discretionary stakeholder (0 L 0) in its role as a competing, private operator on a vertically separated system and therefore could gain saliency by partnering with an actor on the NEC that has either power or urgency.

Any of the stakeholders in this cluster could lend JR East urgency, so JR East has an incentive to partner with any actor in the group. In the other direction, both Amtrak and Commuter Rail Agencies are already definitive stakeholders (P L U) and therefore have no incentive to work with JR East. Similarly, Urban Public Transportation Organizations and the Airline Industry are both dependent stakeholders (0 L U) and would not gain saliency by partnering with JR East because JR East cannot lend them power in its business role. Thus, we find that there are multiple potential partners for JR East, but the incentive to form coalitions is one-sided.

Accordingly, we assign CLIOSjre bundle 6.1 the grade of B for Metric 4. Cooperation.

### *CLIOSjre Bundle 6.2*

We now consider JR East's cooperative potential in its role constructing and operating an all-over international quality HSR system. In this highly engaged role, JR East has strong interest in almost all of the system objectives. Because of its overarching interest in the system infrastructure and operations, JR East's interests on the NEC best align with the U.S. Department of Transportation but there are no other potential partnerships based on similarity of interests. Because JR East is a definitive stakeholder in the market and possesses the rare attribute of power,<sup>1</sup> it is likely that many stakeholders wish to partner with them based on their stakeholder typology. However, because these stakeholders are far-removed in the cluster hierarchy, it suggests that this partnership not only has a one-sided incentive, but would also require a significant compromise of their interests.

Since both JR East and the US DOT are definitive stakeholders in this development path for the system, CLIOSjre bundle 6.2 receives a grade of C for Metric 4. Cooperation.

### *Metric 5. Flexibility<sup>72</sup>*

[Continued from Chapter 6]

Table 8-14 outlines the CLIOSjre bundles to the options that are available for each bundle.

Note that no options are available in bundle 1.1, because this bundle includes no involvement from JR East. Furthermore, note that JR East may only be able to take advantage of options at specific phases of the project (given the knowledge available at that time). In CLIOSjre bundle 6.2, for example, the options to delay and abandon are only available before and during construction, not during the operations phase of the project.

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<sup>72</sup> Scott Middleton was the original author of this section. Included with his permission.

Table 8-14. Options Available for Each CLIOSjre Bundle

CLIOSjre Bundle	Options Available for Each CLIOSjre Bundle		
	Delay	Abandon	Expand
Bundle 1.1	No	No	No
Bundle 1.2	Yes	Yes	Yes
Bundle 3.1	Yes	Yes	Yes
Bundle 3.2	No	No	Yes
Bundle 5.1	Yes	Yes	Yes
Bundle 6.1	No	Yes	Yes
Bundle 6.2	Yes	Yes	No

### Assigning Value to Each Option

With an understanding of the options viable for each bundle, the next step in estimating the approximate value of the each option is to estimate the financial outcome of each CLIOSjre bundle in the base case<sup>1</sup> and each of the scenarios from the scenario analysis. To develop these estimates, we draw from the output of the financial and scenario analysis from our CLIOS Process application to the NEC.

In this report the research team calculated a financial net-present value (NPV) for each CLIOS bundle of strategic alternatives. The NPV allowed us to determine each bundle’s financial performance and compare the financial performance of the various CLIOS bundles. Our financial calculations drew from several important inputs, including the estimated demand for each new service, the estimated fares produced by each new service, and the cost of constructing and operating each new service.

Our financial calculations also relied on a few major assumptions, including the discount rate used to express future earnings and costs in present value and the evaluation horizon for all benefits and costs. Although the choice of the discount rate and evaluation horizon is contested in the literature, the use of a consistent discount rate and evaluation horizon allows us to compare the performance of the different CLIOS bundles to each other.

We also conducted an economic analysis that quantified non-financial benefits of HSR, such as the implications of the service for other modes, for safety, and for the environment. While each CLIOS bundle can have only one economic NPV, the same bundle may have different financial NPVs for different stakeholders. This is because the financial analysis does not measure all the benefits and costs of the projects, but only the ones received and incurred by a particular

stakeholder. In the case of this financial analysis, the NPV measures the benefits received and costs incurred by the system owner. This consideration complicates any attempt to estimate the financial return available to JR East specifically. However, the objective of this metric is to compare the relative financial performance of each CLIOSjre bundle (drawing from our analysis of CLIOS bundles), rather than to interpret each financial NPV on its own.

The financial analysis described above allowed us to conduct a scenario analysis to understand how uncertainty in the real world affects the financial performance of each of the CLIOSjre bundles. In this metric, we use the output of the scenario analysis to identify where flexibility in each bundle may help improve the financial performance of each bundle (as measured in financial NPV) as the market develops. Table 8-15 presents the financial NPV in each of five cases – the four scenarios and the base case.

*Table 8-15. Financial NPV for Each CLIOSjre Bundle (12% discount rate)*

CLIOSjre Bundle	Financial Net Present Value (NPV) in Each Scenario (million USD)				
	Base Case	Scenario A	Scenario B	Scenario C	Scenario D
Bundle 1.1	16,671	11,192	19,434	18,870	14,099
Bundle 1.2	16,671	11,192	19,434	18,870	14,099
Bundle 3.1	4,038	-315	5,986	4,624	4,948
Bundle 3.2	4,038	-315	5,986	4,624	4,948
Bundle 5.1	328	-4,091	1,612	4,643	431
Bundle 6.1	-931	-4,618	229	3,266	-774
Bundle 6.2	-931	-4,618	229	3,266	-744

Before translating the values in Table 8-15 into an estimated value of the viable options in each CLIOSjre bundle, it is worth explaining the meaning of these numbers. First, the numbers above are not intended to be predictions of what will happen, but rather to capture the essence of what we may expect to see under such scenarios. Secondly, CLIOSjre bundles 1.1 and 1.2 present positive NPV under all four scenarios because they have positive cash flows in the first years of operations. However, later the costs of the continuous infrastructure upgrades will be difficult or even impossible to support with the services operated because of capacity limitations imposed by the existing infrastructure. Therefore, the cash flow for CLIOSjre bundles 1.1 and 1.2 is negative for all years after 2030. Third, the financial NPV of CLIOSjre bundles 3.1 and 3.2 also stems from the positive cash flows in the first years of operations. The actual profitability of these bundles will depend on the availability of public grants and bonds. Finally, CLIOSjre bundles 5.1, 6.1, and 6.2 perform best in future years, although the NPV varies considerably with the

differences in funding availability under each scenario.

To use the values in Table 8-15 to assign an approximate value to each of the three options (delay, abandon, expand) for each of the seven CLIOSjre bundles, we consider the following:

1. Does JR East have the ability to apply the option to each scenario, according to the table above? This question is addressed in the previous section.
2. Would JR East want to apply the option to under each scenario? For example, we assume that JR East would only choose to abandon an investment if the financial performance of a CLIOSjre bundle (as measured by NPV) in a scenario is negative or if it is worse than the base case. Similarly, we assume JR East would choose to expand its investment if the outcomes are as good or better than expected.
3. If JR East chooses to apply an option, what is the approximate value of that option to the company? Our method for answering this question is described below.

In our analysis, we define an approximate value for each of the three types of options. First, we define the value of the option to expand as the difference between financial NPV in the base case and financial NPV in each scenario (but only if the NPV increases under the scenario in question).

Second, we define the option to abandon as the difference between financial NPV in the base case and financial NPV in each scenario (but only if the NPV is worse in the scenario in question).

Third, we define the value of the option to delay as one half of the value of the option to abandon (only if financial NPV is worse in the scenario than in the base case, and only for Scenario A, as discussed above). This proportion was chosen to reflect the fact that the option to delay is not as valuable to JR East as the option to abandon, if necessary. Furthermore, we recognize that JR East would not likely choose to exercise both the option to abandon and delay (indeed abandoning a project eliminates the possibility of delaying). However, we consider both of these options valuable because they increase JR East's flexibility.

Finally, with the value of options in place from Step 3 above, we need to assign the probability of each scenario occurring. For the first cut of the Flexibility Analysis, we assigned a probability of one-half (50%) to the base case and a probability of one-eighth (12.5%) to each of the four scenarios, implying that each scenario is equally likely to occur. The robustness of this assumption will be tested later in the sensitivity analysis.

By multiplying the probability of a given scenario occurring by the value of applying a particular option to that scenario, we calculate the expected value of each option. We add together the expected values of all options viable in each scenario for each CLIOSjre bundle to calculate a total expected value of all the options viable for each bundle. While JR East would not and could

not exercise all three options in a given CLIOSjre bundle, this sum reflects an approximate estimate of the value of the flexibility inherent in each CLIOSjre bundle and business role in light of the four scenarios that we have created in our analysis.

To present an example of this calculation, we consider CLIOSjre bundle 3.1. First, we calculate the option to expand, which is available under all scenarios. JR East would choose to apply it in Scenarios B, C, and D, which project a stronger financial performance than the base case. To estimate the approximate value of these options, first we subtract the base case NPV (\$4,038 million) from the financial NPV in each of the three scenarios we are considering. This gives us \$1,948 million for Scenario B, \$586 million for Scenario C, and \$901 million for Scenario D. We multiply each of these differences by the probability of each scenario occurring (12.5%), then sum the three products to get \$431 million – the estimated value of the option to expand. We apply the same method to estimate the approximate value of the options to abandon and delay, then add the three types of options together to get a total estimated value of \$1,247 million.

After completing this calculation for each of the seven CLIOSjre bundles, we compared the result for each bundle to the spectrum in Table 6-22. The R/HSR Group developed the spectrum for Metric 5 based on two observations: an expected value of zero means that there is no valuable flexibility built in to a project (i.e., the project cannot be modified to avoid major losses or unlock potential gains), while an expected value of approximately \$2 billion (i.e., the value of modifying the project to avoid losses or unlock gains) is about the most that can be expected for this project. These two reference points define the endpoints of our metric spectrum below. The remaining letter grades were defined by linearly extrapolating between these endpoints.

### **Results for Metric 5. Flexibility**

Using the results from the Flexibility Analysis, the R/HSR Group compiled a summary of metric grades for each CLIOSjre bundle. By comparing the expected value of the options viable for each CLIOSjre bundle to the spectrum in Table 6-22, we assigned letter grades to the seven CLIOSjre bundles. The following section describes the output for each bundle in greater detail.

#### *CLIOSjre Bundle 1.1*

The options to delay, expand, and abandon are not available under this bundle because JR East has no involvement in CLIOSjre bundle 1.1.

**Summary:** This bundle offers JR East no options and no flexibility.

Based on this analysis, we assign this CLIOSjre bundle a grade of F for Metric 5.

#### *CLIOSjre Bundle 1.2*

The option to delay is available under Scenario A, and JR East would choose to apply it to reduce financial losses. This option is valued at \$342 million. The option to abandon is available



under all scenarios, and JR East would choose to apply it in Scenario A and Scenario D, both of which project a financial performance worse than the base case. This option is valued at \$1,006,000,000. The option to expand is available under all scenarios, because of JR East's business role (consulting) and because of the HSR system in question (incremental HSR). JR East would choose to apply it in Scenario B and Scenario C, which project a stronger financial performance than the base case. The expected value of this option is \$620 million.

**Summary:** The total expected value of the viable options under this bundle is nearly \$2 billion. It should be noted that this bundle offers the greatest degree of flexibility for JR East and the minimum amount of risk due to the business role as an independent contractor and due to the incremental nature of the HSR system.

Based on this analysis, we assign bundle 1.2 a grade of B for Metric 5

### *CLIOSjre Bundle 3.1*

The option to delay is available under Scenario A. JR East would choose to apply it to reduce its losses in that scenario. This option is valued at \$272 million. The option to abandon is available under all scenarios, and JR East would choose to apply it in Scenario A, which is the only scenario that projects a financial performance worse than the base case. This option is valued at \$544 million. The option to expand is available under all scenarios, because JR East's business role does not include HSR operations, and because this bundle represents piecemeal international quality HSR. JR East would choose to apply it in Scenarios B, C, and D, which project a stronger financial performance than the base case. The expected value of this option is \$431 million.

**Summary:** This bundle offers all three options, so summing the expected values we have a total expected value of \$1.25 billion.

Based on this analysis, we assign bundle 3.1 a grade of C for Metric 5.

### *CLIOSjre Bundle 3.2*

The option to delay is not available under this bundle because JR East has an operations role, and obligated by its concession to provide HSR service on the NEC. The option to abandon is not available under this bundle because JR East has an operations role, and obligated by its concession to provide HSR service on the NEC. The option to expand is available under all scenarios; JR East has the potential to expand its business role if the NEC is a success. Similarly, the NEC may expand to include international quality HSR from New York to Boston, which could provide an additional business opportunity for JR East. JR East would choose to apply this option in Scenarios B, C, and D, which project a financial performance stronger than the base case. The expected value of this option is \$431 million.

**Summary:** This bundle offers a strong option to expand, but no options to abandon or delay.

Based on this analysis, we assign bundle 3.2 a grade of E for Metric 5.

### *CLIOSjre Bundle 5.1*

The option to delay is available under Scenario A. JR East would choose to apply it to reduce its losses in that scenario. This option is valued at \$256 million. Because of JR East's business role (provide HSR components), the company could abandon this project at any time. Hence the option to abandon is available under all scenarios, but JR East would choose to apply it only in Scenario A, which projects a financial performance worse than the base case. This option is valued at \$511 million. The option to expand is available under all scenarios, because JR East's business role is only to provide HSR components. JR East would choose to apply this option in Scenarios B, C, and D, which project a stronger financial performance than the base case. The expected value of this option is \$836 million.

**Summary:** CLIOSjre bundle 5.1 offers all three options, with a total expected value of \$1.6 billion.

Based on this analysis, we assign bundle 5.1 a grade of B for Metric 5.

### *CLIOSjre Bundle 6.1*

The option to delay is not available under this bundle because JR East has an operations role, not a construction role. Because of JR East's business role (operate by buying track capacity), the company could abandon this project at any time by simply not using its capacity. Hence the option to abandon is available under all scenarios, but JR East would choose to apply it only in Scenario A, which projects a financial performance worse than the base case. This option is valued at \$461 million. The option to expand is available under all scenarios, because JR East could presumably purchase additional capacity to meet demand if necessary. JR East would choose to apply this option in Scenarios B, C, and D, which project a stronger financial performance than the base case. The expected value of this option is \$689 million.

**Summary:** CLIOSjre bundle 6.1 offers the options to expand and abandon, with a total expected value of \$1.15 billion.

Based on this analysis, we assign bundle 6.1 a grade of C for Metric 5.

### *CLIOSjre Bundle 6.2*

The option to delay is available under Scenario A. JR East would choose to apply it to reduce its losses in that scenario. This option is valued at \$230 million. The option to abandon is available under all scenarios, but only prior to the construction of HSR in the NEC. Once JR East is operating HSR in the NEC it will be difficult to abandon the project. Due to this timeline, JR East would choose to apply this option in Scenario A, which that projects a financial performance worse than the base case. This option is valued at \$461 million. The option to

expand is not available under this bundle because of JR East's extensive involvement in both construction and operation of all-over international-quality HSR on the NEC.

**Summary:** The total expected value of the viable options under CLIOSjre bundle 6.2 is \$691 million. Because bundles 3.2 and 6.2 score the lowest in the Flexibility Analysis (in addition to bundle 1.1, in which JR East has no involvement), we see that building additional flexibility into this bundle would be necessary to reduce the effect of real world uncertainty on the performance of these bundles, allowing JR East to adapt to future situations at a limited cost.

Based on this analysis, we assign bundle 6.2 a grade of D for Metric 5.

### *Metric 6. Net Societal Benefit*

[No additional analysis details.]

### *Metric 7. Net Environmental Impact*

[Continued from Chapter 6]

#### **Summary of Environmental Impacts**

Using the results from the NEC Future Draft EIS, the R/HSR Group compiled a summary of environmental impacts for each CLIOSjre bundle.

#### *CLIOSjre Bundle 1.1*

**Land Use Impacts:** Compared with the existing Northeast Corridor, the construction of CLIOSjre bundle 1.1 would require little new land acquisition or conversion of land use. The NEC Future report estimates that only an additional 400 acres of developed land would be required and 315 acres of undeveloped land in comparison to the NEC Future No-action Alternative. As the NEC Future No-action Alternative impacts 6,475 acres of developed land and 1,490 acres of undeveloped land to bring the existing NEC spine to a state of good repair, this additional land acquisition for CLIOSjre bundle 1.1 is modest.

Although the potential land use impact of CLIOSjre bundle 1.1 is small, it would be somewhat difficult to mitigate this impact. There are many feasible alternatives to this impact (elevation, tunneling, rerouting along existing transportation corridors), but as these alternatives are too expensive to be practical, there are few prudent alternatives.

JR East's business role in this CLIOSjre bundle (no involvement) would not improve the feasibility or prudence of mitigation alternatives for land use impacts in this bundle.

**Resource Impacts:** The construction of CLIOSjre bundle 1.1 would affect only marginally more areas of parkland than the NEC Future No-action Alternative. The effects on this parkland would include noise, vibration, and electromagnetic interference. According to the NEC Future report,

the NEC Future No-action Alternative affects 8,285 acres of parkland while CLIOSjre bundle 1.1 will impact only 660 additional acres. As with parkland, water resources are not significantly affected by the construction of CLIOSjre bundle 1.1 in comparison to the NEC Future No-action Alternative.

A substantial number of ecologically sensitive areas would be affected by the construction of CLIOSjre bundle 1.1 in comparison to the NEC Future No-action Alternative. The NEC Future report estimates that an additional 6,795 acres of sensitive areas would be affected (in comparison to 45,560 acres in the NEC Future No-action Alternative). The federal implementing agency would be required to mitigate these ecological impacts. There are many feasible and prudent alternatives to mitigate these impacts (both through the design of the HSR system and through strategic habitat repair elsewhere along the corridor).

JR East's business role in CLIOSjre bundle 1.1 (no involvement) would not improve the feasibility or prudence of mitigation alternatives for resource impacts in this bundle.

**Environmental Justice Impacts:** Compared with the NEC Future No-action Alternative, the construction of CLIOSjre bundle 1.1 will only marginally affect Environmental Justice populations. The NEC Future report estimates that an additional 22,085 minority individuals and an additional 4,736 low-income individuals will be affected by bundle 1.1 (as compared with 2,381,775 and 722,863 individuals in the NEC Future No-action Alternative, respectively). Environmental Justice communities will be affected proportionately less by the new construction than they have been historically, but they will remain proportionately more affected by the construction than the general population.

There are some feasible and prudent alternatives to mitigate the Environmental Justice impacts of bundle 1.1, but JR East's role in the bundle (no involvement) would not improve the feasibility or prudence of the mitigation alternatives.

**Summary:** CLIOSjre bundle 1.1 will have only modest impacts on land use, modest impacts on natural resources, and negligible impacts on Environmental Justice communities. Further, for this bundle, there are a few feasible and prudent alternatives to mitigate adverse impacts. As JR East is not involved in this CLIOSjre bundle, JR East does not add any feasible or prudent mitigation alternatives.

Based on this analysis, we assign CLIOSjre bundle 1.1 a grade of C for Metric 7.

### *CLIOSjre Bundle 1.2*

**Land Use Impacts:** As with CLIOSjre bundle 1.1, the construction of CLIOSjre bundle 1.2 would require little new land acquisition or conversion of use. The NEC Future report estimates that only an additional 400 acres of developed land would be required and 315 acres of undeveloped land in comparison to the NEC Future No-action Alternative. This additional land

acquisition for CLIOSjre bundle 1.2 is modest.

It would be somewhat difficult to mitigate this land use impact. There are many feasible alternatives to this impact (elevation, tunneling, rerouting along existing transportation corridors), but there are few prudent alternatives. JR East's business role in this CLIOSjre bundle (planning, engineering, and operations consultation) would likely improve the feasibility or prudence of mitigation alternatives for this bundle. Because of JR East's extensive experience with HSR planning and engineering (in particular, tunneling), it is likely that JR East will be able to overcome some of the physical constraints on the construction of a HSR system and identify additional prudent alternatives to reduce land acquisition and conversion.

**Resource Impacts:** As with CLIOSjre bundle 1.1, the construction of CLIOSjre bundle 1.2 will affect only 660 additional acres of parkland in comparison to the NEC Future No-action Alternative. Water resources are not significantly affected by the construction of CLIOSjre bundle 1.2 in comparison to the NEC Future No-action Alternative. Substantially more ecologically sensitive areas would be affected by the construction of CLIOSjre bundle 1.2 than the NEC Future No-action Alternative. The NEC Future report estimates that an additional 6,795 acres of sensitive areas would be affected. The federal implementing agency would be required to mitigate these ecological impacts, but there are many feasible and prudent alternatives to mitigate these impacts (both through the design of the HSR system and through strategic habitat repair elsewhere along the corridor).

As stated by the NEC Future report, mitigation of these land, water, and ecological resource impacts is "most appropriate during the design and construction phases of a project."<sup>2</sup> With extensive experience designing and constructing high-speed rail systems in environmentally sensitive areas, JR East's role as a planning, engineering, and operations consultant in CLIOSjre bundle 1.2 could improve the feasibility and prudence of several mitigation strategies for resource impacts.

**Environmental Justice Impacts:** Compared with the NEC Future No-action Alternative, the construction of CLIOSjre bundle 1.2 will only marginally affect Environmental Justice populations. The NEC Future report estimates that an additional 22,085 minority individuals and an additional 4,736 low-income individuals will be affected by bundle 1.2. Environmental Justice communities will be affected proportionately less by the new construction than they have been historically, but they will remain proportionately more affected by the construction than the general population. There are some feasible and prudent alternatives to mitigate the Environmental Justice impacts of CLIOSjre bundle 1.2 but as JR East does not have experience working with Environmental Justice communities in the United States, JR East's role in the bundle (planning, engineering, and operations consultant) will have no perceptible effect on the feasibility or prudence of the mitigation alternatives.

Summary: CLIOSjre bundle 1.2 will have only modest impacts on land use, modest impacts on

natural resources, and negligible impacts on Environmental Justice communities. Further, for this bundles, there are a few feasible and prudent alternatives to mitigate adverse impacts, and JR East's role in the bundle (planning, engineering, and operations consultant) will increase the number of feasible and prudent alternatives.

Based on this analysis, we assign CLIOSjre bundle 1.2 a grade of B for Metric 7.

### *CLIOSjre Bundle 3.1*

**Land Use Impacts:** As compared with the existing NEC spine, CLIOSjre bundle 3.1 would require substantial land acquisition. The NEC Future report estimates that an additional 2,000 acres of developed land and 1,130 acres of undeveloped land would be acquired or converted as compared with the NEC Future No-action Alternative. These new land use impacts represent nearly a 40% increase in the area of land devoted to the rail corridor in comparison to the NEC Future No-action Alternative. These impacts therefore require appropriate mitigation.

There are many feasible alternatives to mitigate these land use impacts. However, tunneling or elevating the high-speed rail system would be prohibitively expensive (i.e. not prudent). Rerouting the new high-speed rail onto existing transportation corridors would make the travel times prohibitively long. Thus, although there are many feasible alternatives to mitigate these land use impacts, there are no prudent alternatives. Although JR East has extensive experience with tunneling, for JR East's business role in CLIOSjre bundle 3.1, tunneling in the Northeast Corridor will likely remain prohibitively expensive. JR East's business role will not improve the feasibility or prudence of any of the mitigation alternatives.

**Resource Impacts:** The construction of CLIOSjre bundle 3.1 will affect more parkland than the NEC Future No-action Alternative (estimated by the NEC future report to be an additional 3,230 acres). The noise, vibration, and electromagnetic interference impacts on this parkland will degrade the value of these natural resources and recreational areas. As a result, the federal agency implementing the new high-speed rail service will be required to mitigate these parkland impacts.

Regional and local water resources are affected by the construction of CLIOSjre bundle 3.1 in comparison to the NEC Future No-action Alternative. The magnitude of these impacts are typically 20% greater in acreage than the NEC Future No-action Alternative depending on the resource type. The federal implementing agency would be required to mitigate these impacts.

Substantially more ecologically sensitive areas would be affected by the construction of CLIOSjre bundle 3.1 than the NEC Future No-action Alternative. The NEC Future report estimates that an additional 23,745 acres of sensitive areas would be affected (50% more than the NEC Future No-action Alternative). The federal implementing agency would be required to mitigate these ecological impacts, but there are a few feasible and prudent alternatives to mitigate these impacts (both through the design of the HSR system and through strategic habitat

repair elsewhere along the corridor).

Although JR East has experience mitigating resource impacts, JR East's business role in CLIOSjre bundle 3.1 (provide a turnkey system) would likely result in an arm's length transaction that does not improve the feasibility or prudence of any of the mitigation alternatives.

**Environmental Justice Impacts:** Compared with the NEC Future No-action Alternative, the construction of CLIOSjre bundle 3.1 will only somewhat affect Environmental Justice populations. The NEC Future report estimates that an additional 152,055 minority individuals and an additional 42,307 low-income individuals will be affected by the construction of bundle 3.1. Environmental Justice communities will be affected proportionately less by the new construction than they have been historically, but they will remain proportionately more affected by the construction than the general population. There are a few feasible and prudent alternatives to mitigate the Environmental Justice impacts of bundle 3.1, and as JR East's HSR technology is quieter and less obtrusive than typical HSR systems, JR East's role in bundle 3.1 (providing a turnkey system) will increase the number of feasible and prudent mitigation alternatives.

**Summary:** CLIOSjre bundle 3.1 would have substantial land use impacts, substantial resource impacts, and modest Environmental Justice impacts. Although, there are many feasible alternatives to mitigate these impacts, the scope of the impacts make most of the alternatives cost-prohibitive (i.e. they are not prudent). The advanced technology provided by a JR East's role in this bundle (providing a turnkey system) improves the prudence of a few of the alternatives.

Based on this analysis, we assign this bundle a grade of C for Metric 7.

### *CLIOSjre Bundle 3.2*

**Land Use Impacts:** As with CLIOSjre bundle 3.1, CLIOSjre bundle 3.2 would require substantial land acquisition. The NEC Future report estimates that an additional 2,000 acres of developed land and 1,130 acres of undeveloped land would be acquired or converted as compared with the NEC Future No-action Alternative. These new land use impacts represent nearly a 40% increase in the area of land devoted to the rail corridor in comparison to the NEC Future No-action Alternative. These impacts require appropriate mitigation.

There are many feasible alternatives to mitigate these land use impacts. As with CLIOSjre bundle 3.1, there are no prudent alternatives to mitigate these impacts. JR East's business role in CLIOSjre bundle 3.2 (operate a system under concession) will not give JR East decision-making authority over the system during design or planning. As JR East only becomes involved in the system once the system is constructed, JR East will not improve the feasibility or prudence of mitigation alternatives for this bundle.

**Resource Impacts:** As with CLIOSjre bundle 3.1, the construction of CLIOSjre bundle 3.2 will affect more parkland than the NEC Future No-action Alternative (estimated by the NEC Future

report to be an additional 3,230 acres). The noise, vibration, and electromagnetic interference impacts on this parkland will require mitigation.

Regional and local water resources are affected by the construction of CLIOSjre bundle 3.2 in comparison to the NEC Future No-action Alternative. The magnitude of these impacts are typically 20% greater in acreage than the NEC Future No-action Alternative depending on the resource type. The federal implementing agency would be required to mitigate these impacts.

As with CLIOSjre bundle 3.1, substantially more ecologically sensitive areas would be affected by the construction of CLIOSjre bundle 3.2 than the NEC Future No-action Alternative. The NEC Future report estimates that an additional 23,745 acres of sensitive areas would be affected (50% more than the NEC Future No-action Alternative). The federal implementing agency would be required to mitigate these ecological impacts, but there are a few feasible and prudent alternatives to mitigate these impacts (both through the design of the HSR system and through strategic habitat repair elsewhere along the corridor).

Although JR East has experience mitigating resource impacts, JR East's business role in CLIOSjre bundle 3.2 (operate a system under concession) would likely result in an arm's length transaction that does not work with the market stakeholders to improve the feasibility or prudence of any of the mitigation alternatives.

**Environmental Justice Impacts:** Compared with the NEC Future No-action Alternative, the construction of CLIOSjre bundle 3.2 will only affect a modest number of Environmental Justice populations. The NEC Future report estimates that an additional 152,055 minority individuals and an additional 42,307 low-income individuals will be affected by the construction of bundle 3.1. Environmental Justice communities will be affected proportionately less by the new construction than they have been historically, but they will remain proportionately more affected by the construction than the general population. There are a few feasible and prudent alternatives to mitigate the Environmental Justice impacts of bundle 3.2, but as JR East's will not provide any technology to the HSR system, JR East's role in the bundle (operate a system under concession) will not increase the number of feasible or prudent mitigation alternatives.

**Summary:** CLIOSjre bundle 3.1 would have substantial land use impacts, substantial resource impacts, and modest Environmental Justice impacts. Although, there are many feasible alternatives to mitigate these impacts, the scope of the impacts make most of the alternatives cost-prohibitive (i.e. not prudent). As JR East's role in this bundle (operate a system under concession) does not utilize any of JR East's advanced technologies, JR East's role would not improve the feasibility or prudence of the mitigation alternatives.

Based on this analysis, we assign this bundle a grade of D for Metric 7.



### *CLIOSjre Bundle 5.1*

**Land Use Impacts:** Compared to the NEC Future No-action Alternative, CLIOSjre bundle 5.1 would require significant land acquisition and conversion. The NEC Future report estimates between 5,975 and 7,645 additional developed acres and between 1,710 and 2,625 additional undeveloped acres would be acquired or converted as compared with the NEC Future No-action Alternative. These land use impacts are larger than the land use impacts of the NEC Future No-action Alternative and thus require mitigation.

Although there are a few feasible alternatives to mitigate these land use impacts, there are no prudent alternatives. Tunneling, elevating, or rerouting the high-speed rail line is not feasible for the entire route, and all three methods would be cost-prohibitive or lengthen the travel times significantly. JR East's business role in bundle 5.1 (provide rolling stock) would not improve the feasibility or prudence of any of these mitigation alternatives.

**Resource Impacts:** The construction of CLIOSjre bundle 5.1 will affect more parkland than the NEC Future No-Action alternative (estimated by the NEC Future report to be between an additional 1,970 and 5,535 acres). The immense variation in this impact estimation is a result of the multiple routing options for the HSR route from New York City to Boston. The noise, vibration, and electromagnetic interference impacts on this parkland will degrade the value of these natural resources and recreational areas. As a result, the federal agency implementing the new high-speed rail service will be required to mitigate these parkland impacts. However, because multiple routes are under consideration for the northern segment of the HSR route, there market stakeholders could choose a route with fewer parkland impacts. These routes represent a few prudent alternatives to mitigate the environmental impacts to parkland.

Regional and local water resources are more strongly affected by the construction of CLIOSjre bundle 5.1 in comparison to the NEC Future No-action Alternative. The magnitude of these impacts are typically 40% greater in acreage than the NEC Future No-Action alternative depending on the resource type and the selected HSR route. The federal implementing agency would be required to mitigate these impacts, but the multiple route choices present a few prudent alternatives to somewhat reduce the water resource impacts.

In comparison to the NEC Future No-action Alternative, twice as many ecologically sensitive areas would be affected by the construction of CLIOSjre bundle 5.1. The NEC Future report estimates that between an additional 29,390 acres and 50,470 acres of sensitive areas would be affected (in comparison to 45,560 acres in the NEC Future No-action Alternative). The federal implementing agency would be required to mitigate these ecological impacts, and there are no feasible and prudent alternatives to mitigate these impacts because of their scale. Although the different HSR routes result in different levels of ecological impacts, none of the routes result in an acceptable amount of ecological damage.

JR East's business role in CLIOSjre bundle 5.1 (provide rolling stock) would likely result in an arm's length transaction that does not allow JR East to help the market stakeholders improve the feasibility or prudence of any of the mitigation alternatives.

**Environmental Justice Impacts:** The construction of CLIOSjre bundle 5.1 will substantively impact Environmental Justice populations compared with the NEC Future No-action Alternative. The NEC Future report estimates that between an additional 529,817 and 975,909 minority individuals and between an additional 120,901 and 199,542 low-income individuals will be affected by the construction of bundle 5.1. Environmental Justice communities will be affected proportionately less by the new construction than they have been historically, but they will remain proportionately more affected by the construction than the general population. There are feasible alternatives to mitigate the Environmental Justice impacts of bundle 5.1, but not prudent ones (due to the scope of the impacts). As JR East's will provide rolling stock for the HSR system, it would be possible to use JR East's technology to reduce noise and vibration impacts. JR East's role in the bundle will add a few prudent mitigation alternatives.

**Summary:** CLIOSjre bundle 5.1 would have substantial land use impacts, substantial resource impacts, and substantial Environmental Justice impacts. There are few feasible alternatives to mitigate these impacts, and there are barely any prudent mitigation alternatives. JR East's role in the bundle (providing rolling stock) would add a few prudent mitigation alternatives.

This bundle has characteristics of both grade E (few feasible alternatives) and grade C (few prudent alternatives) and we therefore assign it the compromise grade of D for Metric 7.

### *CLIOSjre Bundle 6.1*

**Land Use Impacts:** As with CLIOSjre bundle 5.1, CLIOSjre bundle 6.1 would require significant land acquisition and conversion. The NEC Future report estimates that between 5,975 and 7,645 additional developed acres and between 1,710 and 2,625 additional undeveloped acres would be acquired or converted as compared with the NEC Future No-action Alternative. These land use impacts are larger than the land use impacts of the NEC Future No-action Alternative and thus require mitigation.

Although there are a few feasible alternatives to mitigate these land use impacts, there are no prudent alternatives. Tunneling, elevating, or rerouting the high-speed rail line is not feasible for the entire route, and all three mitigation alternatives would be cost-prohibitive or lengthen the travel times significantly. JR East's business role in bundle 6.1 (operate a system by purchasing capacity) would not improve the feasibility or prudence of any of these mitigation alternatives.

**Resource Impacts:** As with CLIOSjre bundle 5.1, the construction of CLIOSjre bundle 6.1 will affect more parkland than the NEC Future No-action Alternative (estimated by the NEC future report to be between an additional 1,970 and 5,535 acres). The noise, vibration, and electromagnetic interference impacts on this parkland will require mitigation. However, because

multiple routes are under consideration for the northern segment of the HSR route, the market stakeholders could select a route with fewer parkland impacts. These routes represent a few prudent alternatives to mitigate the environmental impacts to parkland.

Regional and local water resources are affected by the construction of CLIOSjre bundle 6.1 in comparison to the NEC Future No-action Alternative. The magnitude of these impacts are typically 40% greater in acreage than the NEC Future No-action Alternative depending on the resource type and the selected HSR route. The federal implementing agency would be required to mitigate these impacts, but the multiple route choices present a few prudent alternatives to somewhat reduce the water resource impacts.

In comparison to the NEC Future No-action Alternative, twice as many ecologically sensitive areas would be affected by the construction of CLIOSjre bundle 5.1. The NEC Future report estimates that between an additional 29,390 acres and 50,470 acres of sensitive areas would be affected. The federal implementing agency would be required to mitigate these ecological impacts, and there are no feasible and prudent alternatives to mitigate these impacts. Although the different HSR routes result in different levels of ecological impacts, none of the routes result in an acceptable amount of ecological damage.

Although JR East has experience mitigating resource impacts, JR East's business role in CLIOSjre bundle 6.1 (operate a system by purchasing capacity) would likely result in an arm's length transaction that does not improve the feasibility or prudence of any of the mitigation alternatives.

**Environmental Justice Impacts:** As with CLIOSjre bundle 5.1, the construction of CLIOSjre bundle 6.1 will substantially impact Environmental Justice populations compared with the NEC Future No-action Alternative. The NEC Future report estimates that between an additional 529,817 and 975,909 minority individuals and between an additional 120,901 and 199,542 low-income individuals will be affected by the construction of bundle 6.1. Environmental Justice communities will be affected proportionately less by the new construction than they have been historically, but they will remain proportionately more affected by the construction than the general population. There are feasible alternatives to mitigate the Environmental Justice impacts of bundle 6.1, but not prudent ones (due to the scope of the impacts). As JR East will only provide a small portion of the technology for the HSR system, JR East's role in the bundle (operate a system by purchasing capacity) will not substantively change the feasibility or prudence of mitigation alternatives.

**Summary:** CLIOSjre bundle 6.1 would have substantial land use impacts, substantial resource impacts, and substantial Environmental Justice impacts. There are few feasible alternatives to mitigate these impacts, and there are barely any prudent mitigation alternatives. JR East's role in the bundle (operate a system by purchasing capacity) would not improve the feasibility or prudence of the mitigation alternatives.

Based on this analysis, we assign this bundle a grade of E for Metric 7.

### *CLIOSjre Bundle 6.2*

**Land Use Impacts:** As with bundles 5.1 and 6.1, CLIOSjre bundle 6.2 would require significant land acquisition and conversion. The NEC Future report estimates that between 5,975 and 7,645 additional developed acres and between 1,710 and 2,625 additional undeveloped acres would be acquired or converted as compared with the NEC Future No-action Alternative. These land use impacts are larger than the land use impacts of the NEC Future No-action Alternative and thus require mitigation.

Although there are a few feasible alternatives to mitigate these land use impacts, there are no prudent alternatives. Tunneling, elevating, or rerouting the high-speed rail line is not feasible for the entire route, and all three mitigation alternatives would be cost-prohibitive or lengthen the travel times significantly. It is possible that JR East's business role in bundle 6.1 (build and operate a private HSR system) would improve the feasibility of these mitigation alternatives. In particular, JR East's extensive tunneling experience would improve the feasibility of that alternative, although it would like remain prohibitively expensive.

**Resource Impacts:** As with CLIOSjre bundle 6.1, the construction of CLIOSjre bundle 6.2 will affect more parkland than the NEC Future No-action Alternative (estimated by the NEC future report to be between an additional 1,970 and 5,535 acres). The noise, vibration, and electromagnetic interference impacts on this parkland will require mitigation these parkland impacts. However, because multiple routes are under consideration for the northern segment of the HSR route, there are a few prudent alternatives to mitigate the environmental impacts to parkland.

Regional and local water resources are affected by the construction of CLIOSjre bundle 6.2 in comparison to the NEC Future No-action Alternative. The magnitude of these impacts are typically 40% greater in acreage than the NEC Future No-action Alternative depending on the resource type and the selected HSR route. The federal implementing agency would be required to mitigate these impacts, but the multiple route choices present a few prudent alternatives to somewhat reduce the water resource impacts.

As with CLIOSjre bundle 6.1, twice as many ecologically sensitive areas would be affected by the construction of CLIOSjre bundle 6.2 as compared to the NEC Future No-action Alternative. The NEC Future report estimates that between an additional 29,390 acres and 50,470 acres of sensitive areas would be affected. The federal implementing agency would be required to mitigate these ecological impacts, and there are no feasible and prudent alternatives to mitigate these impacts. Although the different HSR routes result in different levels of ecological impacts, none of the routes result in an acceptable amount of ecological damage.

With extensive experience designing and constructing high-speed rail systems in

environmentally sensitive areas, JR East's role building a private HSR system for CLIOSjre bundle 6.2 could improve the feasibility and prudence of several mitigation strategies for resource impacts.

**Environmental Justice Impacts:** As with CLIOSjre bundle 6.1, the construction of CLIOSjre bundle 6.2 will substantially impact Environmental Justice populations compared with the no-action alternative. The NEC Future report estimates that between an additional 529,817 and 975,909 minority individuals and between an additional 120,901 and 199,542 low-income individuals will be affected by the construction of bundle 6.2. Environmental Justice communities will be affected proportionately less by the new construction than they have been historically, but they will remain proportionately more affected by the construction than the general population. There are feasible alternatives to mitigate the Environmental Justice impacts of bundle 6.2, but not prudent ones (due to the scope of the impacts). As JR East will construct its own private HSR system using its advanced noise and vibration mitigation technologies, JR East's role in the bundle will add a few feasible and prudent mitigation alternatives.

**Summary:** CLIOSjre bundle 6.2 would have substantial land use impacts, substantial resource impacts, and substantial Environmental Justice impacts. For the system designed by NEC Future, there are few feasible alternatives to mitigate these impacts, and there are barely any prudent mitigation alternatives. However, JR East's role in the bundle (build a private HSR system) improves both the feasibility and prudence of the mitigation alternatives.

Based on this analysis, we assign this bundle a grade of C for Metric 7.

## 8.3 Metric Analysis Using the CLIOSjre Process: JR East's Characteristics

### *Metric 8. Strengths and Weaknesses*

[Continued from Chapter 6]

We examine the application of each strength and weakness to each CLIOSjre bundle below.

#### *CLIOSjre Bundle 1.1*

For CLIOSjre bundle 1.1, JR East's business role is 'no involvement.' Because JR East is not actively involved in this bundle, the bundle will make use of none of JR East's strengths and does not expose JR East to any weaknesses.

This situation resembles most closely the representative outcome of grade D, so the research team assigns bundle 1.1 the grade D for Metric 8.

### *CLIOSjre Bundle 1.2*

For CLIOSjre bundle 1.2, JR East's business role is to provide planning, engineering, and operations consultation. Although this business role does not require JR East to invest significant resources in the Northeast Corridor HSR system, JR East's ability to compete for a contract with the United States federal government will be a direct result of JR East's strengths and weaknesses.

Of the nine strengths of JR East identified by the research team, only three will be utilized by CLIOSjre bundle 1.2. JR East's earthquake protection technology is not likely to be useful in the NEC. Although JR East's environmental footprint mitigation technology, operations safety technology, operations efficiency technology, operating procedures, and advanced payment system technology would be useful for the NEC, it is likely that JR East would not have the opportunity to use these strengths as a consultant. For CLIOSjre bundle 1.2, changes to the NEC system will be incremental and modest – this makes it difficult for JR East to introduce new operating technologies or procedures. For our analysis, the research team assumed that these operating technologies would be impossible to implement as a consultant and will not be used by JR East in bundle 1.2.

Of JR East's many strengths, only JR East's weather impact mitigation technology, operating experience, and station real estate development experience would be used by JR East's role as a consultant in the market. For the incremental and completely public HSR system of CLIOSjre bundle 1.2, it is likely that JR East would have trouble integrating these technological advances with the existing rail system and they would not provide a significant benefit.

Of the four weaknesses of JR East identified by the research team, two will make JR East vulnerable in CLIOSjre bundle 1.2. Although CLIOSjre bundle 1.2 is largely a single operator system with vertically integrated infrastructure, JR East's inexperience with mixed right-of-way and with mixed-speed traffic will be barriers to JR East's involvement in the bundle. Given that most of JR East's advanced technology will not be used by bundle 1.2, it is likely that these barriers would make it difficult for JR East to participate as a consultant.

This analysis finds that CLIOSjre bundle 1.2 might involve three of JR East's nine strengths (depending on JR East's ability to integrate them) while it will definitely involve two of JR East's four weakness.

Based on this analysis, the CLIOSjre bundle most closely resembles representative outcome E and the research team assigns bundle 1.2 a grade of E for Metric 8.

### *CLIOSjre Bundle 3.1*

JR East's business role for CLIOSjre bundle 3.1 is to provide a turnkey system. Unlike bundles 1.1 and 1.2, this role positions JR East well to take advantage of nearly all of its applicable

strengths. Of the nine strengths identified by the R/HSR team, eight of them relate to bundle 3.1. Earthquake protection technology is not useful in the Northeast Corridor, but the remaining eight strengths of JR East would be well utilized in this bundle. As JR East is providing a turnkey system for a vertically integrated system, it is likely that most or all of these technological advantages would be successfully implemented in the new HSR system.

Of the four weaknesses of JR East identified by the research team, none are relevant to this bundle. The HSR system of CLIOSjre bundle 3.1 is single operator with a dedicated track, single-speed traffic, and vertically integrated organizational structure (i.e. the infrastructure owner also operates the trains). While the piecewise nature of the HSR system will require JR East to phase its implementation of new HSR infrastructure and interact with at-grade crossings on the older portions of the system, JR East has gained experience with a phased approach to HSR systems and through-running with the Mini-Shinkansen. The research team does not believe that phasing will pose problems for JR East.

Based on the above analysis, CLIOSjre bundle 3.1 will align with most of JR East's strengths and none of JR East's weaknesses.

The research team assigns CLIOSjre bundle 3.1 the grade A for Metric 8.

### *CLIOSjre Bundle 3.2*

For CLIOSjre bundle 3.2, JR East's business role is to operate a system under concession. As an operator of a system owned and constructed by someone else, JR East needs to work with whatever infrastructure and rolling stock choices were made by the system owner. This bundle is not consistent with JR East's principle that safety and reliability are an emergent system property – something that is a result of successful system integration of many separate components. However, this CLIOSjre bundle offers JR East an opportunity to participate in the NEC market even if the company loses the bid for a turnkey system and does not participate in the construction of the system.

Of the nine JR East strengths identified by the R/HSR Group, this CLIOSjre bundle makes use of only two. Earthquake protection technology is not useful in the Northeast Corridor. Although weather mitigation technology, environmental footprint mitigation technology, operations safety technology, operations efficiency technology, advanced payment systems, and station development experience would be useful in the NEC, JR East will not be able to make use of these strengths as simply an operator of a system built and owned by someone else. Only JR East's operating procedures and operating experience will be useful in this CLIOSjre bundle.

Of the four weaknesses of JR East, none are relevant to this bundle. The HSR system of CLIOSjre bundle 3.2 is single operator with a dedicated track, uniform speed traffic, and vertically integrated organizational structure. While the piecewise nature of the HSR system will require JR East to phase its implementation of new HSR infrastructure, JR East has gained

experience with a phased approach to HSR systems and through-running with the Mini-Shinkansen. The research team does not believe that phasing will pose problems for JR East.

Based on the above analysis, CLIOSjre bundle 3.2 has characteristics that match representative outcome E (it aligns with few of JR East's strengths) and representative outcome A (it aligns with none of JR East's weaknesses).

Thus, the research team assigns bundle 3.2 a compromise grade of C for metric 8.

### *CLIOSjre Bundle 5.1*

JR East's business role in CLIOSjre bundle 5.1 is to provide HSR components. As a company with very advanced rolling stock technology and many generations of technology to draw from, JR East will be very competitive for a bid for rolling stock in the NEC.

CLIOSjre bundle 5.1 uses only two of the nine strengths of JR East identified by the research team. Although weather mitigation technology, operations safety technology, operating procedures, advanced payment technology, station development experience, and JR East's operating experience would be useful for the NEC, only JR East's environmental footprint mitigation technology (including noise and vibration mitigation technology on its trainsets) and operations efficiency technology (including automatic train coupling) will be utilized in the NEC by the sale of rolling stock.

Of the four weaknesses of JR East identified by the research team, two are applicable to CLIOSjre bundle 5.1. Bundle 5.1 will have shared track; this means there will likely be multiple operators and mixed-speed traffic. However, because JR East is only providing rolling stock for this system and is not concerned with operating issues, JR East's inexperience with these operating conditions will likely not be a significant barrier.

Based on this analysis, bundle 5.1 aligns with a few of JR East's strengths and may expose JR East to a few of its weaknesses. Although this analysis is most similar to representative outcome D, the two particular strengths that apply to this bundle (environmental footprint mitigation technology and operations efficiency technology) are very relevant for this business role (sale of rolling stock). In this context, the research team decided to boost the grade for this bundle from D to C.

The research team assigns the bundle a grade of C for Metric 8.

### *CLIOSjre Bundle 6.1*

For CLIOSjre bundle 6.1, JR East's business role will be to operate a system by purchasing track capacity from a separate infrastructure manager. As a private operator on a separately owned infrastructure system, JR East will need to work within the constraints of the provided HSR infrastructure. However, JR East will have close to complete control over its operating



procedures and fare revenues which could provide a unique opportunity.

As JR East will not provide any of the infrastructure for CLIOSjre bundle 6.1, this bundle aligns with five of JR East's nine strengths. Earthquake protection technology would not be particularly useful in the Northeast Corridor, and JR East would not be able to implement it anyway. Although weather mitigation technology, advanced payment technology, and JR East's station development experience would be useful for the NEC, none of these strengths will be used by JR East's operations on infrastructure built and owned by someone else. JR East's environmental footprint mitigation technology, operations efficiency technology, operations safety technology, operating procedures, and extensive operating experience will be utilized in the NEC by JR East's private operations. These five strengths offer JR East an opportunity to demonstrate its operating technology in direct comparison to other HSR technologies on the same supporting infrastructure.

As CLIOSjre bundle 6.1 will have dedicated track with several competing operators, JR East will be subject to two of its four weaknesses. JR East's inexperience with multiple operators and inexperience with vertically separated infrastructure may reduce the effectiveness of JR East's operating procedures and hurt JR East's safety record. As JR East has never operated a system in direct competition with another operator on the same infrastructure, it is difficult to estimate how important these weaknesses will be.

Based on the above analysis, CLIOSjre bundle 6.1 will align with some of JR East's strengths and a few of its weaknesses.

The research team assigns bundle 6.1 a grade of C for Metric 8.

### *CLIOSjre Bundle 6.2*

JR East's business role for CLIOSjre bundle 6.2 is to construct and operate a private HSR system owned by JR East. This strategy involves significant investment risk for JR East, but as a primary stakeholder in the development of the HSR system, JR East will have a great deal of control over the development of infrastructure and operating standards.

For this bundle, JR East will make use of eight of its nine key strengths. Although earthquake protection technology will not be useful in the Northeast Corridor, JR East will be in control of the implementation of its remaining eight strengths. As the infrastructure will be a privately owned new HSR alignment, JR East will have significant negotiating power of the other stakeholders when determining the infrastructure implementation of the HSR system and the technologies used. In addition, because JR East will own the infrastructure, JR East will be able to use all of its operating procedures as a vertically integrated social infrastructure company.

Of the four key weaknesses of JR East as identified by the R/HSR Group, only one is exposed by this CLIOSjre bundle. Other competing operators on JR East's infrastructure may make it more

difficult for JR East to operate at its extreme safety and reliability standards. In addition, the public interest in establishing true competition between the operators will require JR East to open access to its proprietary infrastructure and operating technology (e.g. rolling stock monitoring systems). Once the new HSR infrastructure is constructed, JR East would likely be required to open access to these infrastructure systems to other operators or turn them off altogether (to the detriment of all operators). Although this requirement may make JR East's operations somewhat more complex than they are on a single operator system (as in Japan), the research team does not believe this will be an insurmountable barrier.

Based on this analysis, CLIOSjre bundle 6.2 most closely resembles representative outcome B.

Thus, the research group assigns bundle 6.2 a grade of B for Metric 8.

### *Metric 9. Reputation for Excellent Service*

[Continued from Chapter 6]

#### **Brand Impact Analysis of the Seven CLIOSjre Bundles**

Using these five elements of JR East's reputation as a framework for analysis, the research team performed a Brand Impact Analysis on the seven NEC CLIOSjre bundles. Each CLIOSjre bundle was carefully considered from the perspective of these five key elements of JR East's brand. By examining the system design and organization structure of the bundle, the research team estimated the potential impacts to JR East's brand and identified feasible and prudent mitigation alternatives. The full analysis is below.

#### *CLIOSjre Bundle 1.1*

As JR East is not involved in bundle 1.1, this bundle will pose no risk to JR East's reputation for a fast, safe, and reliable HSR system, JR East's reputation for professional service, nor JR East's reputation as an environmentally conscious and energy efficient operator. JR East's role in this bundle (no involvement) ensures that none of the key elements of JR East's reputation will be at risk. This result most closely resembles the representative outcome "no significant impact."

Therefore the research team has assigned bundle 1.1 the grade A for Metric 9.

#### *CLIOSjre Bundle 1.2*

**Speed:** CLIOSjre bundle 1.2 will be built on the existing NEC alignment using shared track. With this configuration, true international-quality high-speed rail will be impossible. Thus, the system will not perform up to JR East's speed standards for high-speed rail. In particular, the incremental HSR system of bundle 1.2 may reach speeds over 180 mph on short sections of the route, but the system will not maintain consistently high speeds between stations. This arrangement will risk JR East's reputation for exceptionally fast service – a major selling point of

the Shinkansen system.

Although these conditions put JR East's reputation for speed at risk, JR East's role as a consultant will somewhat mitigate this risk. JR East could feasibly require that the company's name (and the Shinkansen brand) not be used in conjunction with the project. This alternative may be prudent given that Amtrak (the system operator) would likely want to apply its own branding to the project. It is likely that JR East's name would be used in some of the newspaper articles about the project, but this branding restriction would prevent JR East's brand from experiencing significant negative press if and when the system does not perform well.

To further distance itself from the operational performance of the NEC, JR East could only provide engineering and planning consultation on the project (not operations consulting). By remaining uninvolved in NEC operations, JR East can reduce its connection with the operating performance of the system.

In addition to these alternatives, JR East could create an American subsidiary company to provide consulting in the NEC. This subsidiary would not carry the JR East or Shinkansen brand, but would still translate the expertise of JR East to the NEC market and give JR East the other benefits of becoming directly involved. Thus, a subsidiary would be another feasible and prudent alternative to mitigate any risks to JR East's reputation for high-speed service. Given these mitigation alternatives, JR East can mitigate any risks to JR East's reputation for speedy HSR service.

**Safety:** As discussed above, bundle 1.2 makes true international-quality high-speed rail impossible in the NEC. Thus, the system will not perform at JR East's standard for high-speed rail. In particular, the new HSR system of bundle 1.2 will not be grade separated and fatalities and injuries along the line will remain high in comparison to international standards. A low safety standard for the infrastructure risks harm to JR East's reputation for exceptionally safe rail service.

As with JR East's reputation for speed, JR East's role as a consultant will mitigate any risk to JR East's reputation for safety. JR East could require that the company's name (and the Shinkansen brand) not be used in conjunction with the project. In addition, JR East could avoid consulting on the operations of the HSR system. Finally, JR East could create a subsidiary company that does not use the JR East brand. Given these mitigation alternatives, JR East can mitigate any risks to JR East's reputation for safe HSR service.

**Reliability:** As discussed above, true international-quality high-speed rail will be impossible for the NEC. The shared track on the NEC HSR system will not perform at JR East's standards for on-time performance and reliability. This arrangement puts JR East's reputation for reliable service at risk.

As with JR East's reputation for speed and safety, JR East's role as a consultant will mitigate any

risk to JR East's reputation for safety. JR East could require that the company's name (and the Shinkansen brand) not be used in conjunction with the project. JR East could avoid consulting on the operations of the HSR system or create a subsidiary company that does not use the JR East brand. Given these mitigation alternatives, JR East will be able mitigate any risks to JR East's reputation for reliable HSR service.

**Hospitality:** As JR East's business role for CLIOSjre bundle 1.2 is to be a consultant, JR East will have no involvement in the operation of the new HSR system. JR East's employees will not interact directly with HSR customers, and JR East's reputation for prompt and professional hospitality will not be at risk.

**Environment:** CLIOSjre bundle 1.2 will be built on the existing NEC alignment using shared track. With this configuration, JR East will not be involved in the construction or design of significant new sections of track, and JR East will not provide any rolling stock for the HSR system. In this role, JR East will not provide any significant technology to the HSR system. Although JR East will not spread its reputation for environmental stewardship and energy efficiency, these aspects of JR East's brand will not be at risk.

**Summary:** Of the five key elements of JR East's brand, only three of them are put at risk in CLIOSjre bundle 1.2. In addition, JR East has an array of mitigation alternatives to mitigate any risks to JR East's reputation.

The research team judged that this result is most similar to representative outcome B, and we therefore assign bundle 1.2 the grade B for Metric 9.

### *CLIOSjre Bundle 3.1*

**Speed:** Unlike CLIOSjre bundles 1.1 and 1.2, CLIOSjre bundle 3.1 offers an opportunity for the NEC to achieve international quality HSR along portions of the route. In particular, bundle 3.1 will bring 180 mph service to the segment of the NEC between Boston and New York. This speed is consistent with JR East's standards in Japan for the northern segment of the route. However, because the southern half of the route will continue to operate at lower speeds, through service from Boston to Washington, D.C., will not operate at international-quality speeds. Although JR East will not have any involvement in the southern segment of the route, it is likely that JR East's reputation for speedy service will be attached to the entire corridor. Thus, JR East's reputation for high-speed service will be at risk.

Although JR East can work to ensure that the northern segment of the route is designed for high-speed service, JR East will not be able to affect speeds on the southern segment of the route. JR East could feasibly request that the JR East trademark (and Shinkansen trademark) not be used in the context of the project, but this is not a prudent mitigation alternative. For NEC system stakeholders, one of the primary selling points of a JR East system would be the brand value, and it would be unreasonable to prevent the NEC stakeholders from using the JR East name. Thus,

there are no prudent alternatives for JR East to mitigate the risk to its reputation for speed.

**Safety:** As discussed above, CLIOSjre bundle 3.1 will bring international quality high-speed rail to the northern segment of the NEC. This new infrastructure will be separated from the existing infrastructure and be dedicated to HSR between Boston and New York. The segment from Boston to New York will eliminate level crossings and freight operations will not be permitted on the new tracks. These upgrades will dramatically improve the safety of the Boston-New York segment and raise them to international standards. However, the existing track from DC to New York will not be raised to these standards. This poses a risk that the southern segment of the route will not be as safe as other high-speed rail systems.

As JR East will provide a turnkey system for CLIOSjre bundle 3.1, JR East's reputation for safety is significantly at risk. Although JR East will provide both infrastructure and rolling stock for this new system, JR East would have no control over the operation and maintenance of the system. Operation by another company would likely result in a higher crash rate than if JR East were operating the system. In addition, level crossings on the southern segment of the system will likely remain less safe than comparable international HSR systems. JR East could feasibly request that the JR East trademark (and Shinkansen trademark) not be used in the context of the project, but as this is one of the selling points of a JR East system, it would be unreasonable to prevent the NEC stakeholders from using the brand. Thus, there are no prudent alternatives for JR East to mitigate the risk to its reputation for safety.

**Reliability:** CLIOSjre bundle 3.1 will bring international quality high-speed rail to the northern segment of the NEC. For the northern segment of the route, the new infrastructure will be separated from the existing infrastructure and be dedicated to HSR. Service on the northern segment from Boston to New York will not be interrupted by freight rail and slower-speed regional service. These upgrades will improve the punctuality of the Boston-New York service. However, the southern segment of the route will not be brought to these higher operating standards.

As JR East will provide a turnkey system for CLIOSjre bundle 3.1, JR East's reputation for reliability is significantly at risk. JR East will have no control over the operation and maintenance of the system. As other operators will not be familiar with JR East's technology, operation by another company will likely result in lower standards for maintenance and lower reliability than if JR East operated the system. As CLIOSjre bundle 3.1 calls for a private operator of the public system, the private operator will likely not have significant incentives to maintain the system at peak performance (known as the principal-agent problem<sup>1</sup>). Further, as the southern portion of the route will still require interoperation with slower-speed regional service, delays and maintenance issues on the southern portion of the route may propagate to service on the northern segment.

JR East could feasibly request that the JR East name (and Shinkansen name) not be used in the

context of the HSR project, but this is not a prudent mitigation alternative. For NEC system stakeholders, one of the primary selling points of a JR East system would be the brand value, and it would be unreasonable to prevent the NEC stakeholders from using the JR East name. Thus, there are no prudent alternatives for JR East to mitigate the risk to its reputation for reliability.

**Hospitality:** As JR East's business role for CLIOSjre bundle 3.1 is to provide a turnkey system, JR East will have no involvement in the operation of the new HSR system. JR East's employees will not interact with the NEC customers, and customers will not directly experience the hospitality of JR East. Although JR East's name may be affiliated with the infrastructure project, JR East will not be affiliated with the operation of the service. JR East's reputation for prompt and professional hospitality will not be at risk.

**Environment:** As JR East will provide a new turnkey system for CLIOSjre bundle 3.1, JR East's reputation for environmental stewardship and energy efficiency is at risk. However, because these elements of JR East's brand are primarily dependent on their implementation and not particularly dependent on the operation of the system, JR East will have control over the new HSR system's environmental performance and therefore can largely control the risk. Although poor maintenance of JR East's rolling stock by another private company may reduce the environmental benefits of JR East's technology (e.g. poor maintenance of the low-noise pantographs, improper lubrication of the trainsets resulting in local pollution), this loss of environmental performance will be small in comparison to value of JR East's technology. Thus, JR East is largely in control of its reputation for environmental stewardship and energy efficiency for CLIOSjre bundle 3.1. There will be many prudent alternatives in the design of the system for JR East to mitigate the risk to the JR East brand.

**Summary:** Of the five key elements of JR East's brand, four (speed, safety, reliability, and environment) will be at risk for CLIOSjre bundle 3.1. For environmental stewardship, there will be many opportunities for JR East to mitigate the impacts to its reputation. However, for speed, safety, and reliability, there will be no prudent alternatives to mitigate these risks. Based on this analysis, the bundle has elements of representative outcome B and representative outcome D. This suggests the compromise grade of C. However, as the majority of the key elements of JR East's brand are at risk, the grade of D may be more appropriate for this bundle. We account for this possibility in the measurement error for this bundle.

The research team assigns bundle 3.1 a grade of C for Metric 9.

### *CLIOSjre Bundle 3.2*

**Speed:** As with CLIOSjre bundle 3.1, CLIOSjre bundle 3.2 offers an opportunity for the NEC to achieve international quality HSR along portions of the route. In particular, bundle 3.2 will bring 180 mph service to the segment of the NEC between Boston and New York. This speed is consistent with JR East's standards in Japan for the northern segment of the route. However,

because the southern half of the route will continue to operate at lower speeds, through service from Boston to Washington, D.C., will not operate at international-quality speeds. JR East's reputation for high-speed service will be at risk.

As an operator of the system under concession, JR East will not have much control over the operating speeds on the system. The operating speeds will be largely determined by the design of the HSR system and the schedules of other operators on the southern section of the corridor. JR East could request that the JR East trademark (and Shinkansen trademark) not be used in the context of operations, but this is not a prudent mitigation alternative. Alternatively, JR East could create a subsidiary for the operation of the NEC HSR system. This operations subsidiary successfully protected the brand of SNCF in winter of 2015; Keolis, a subsidiary of SNCF, was the operator of the MBTA commuter rail during a period of exceptionally poor service. However, the brand associated with the poor service was Keolis. Thus, the reputation of SNCF was somewhat insulated from the poor service.

In addition, because the NEC HSR infrastructure will be designed and partially complete before JR East is invited to bid on the operating concession, JR East could decide not to bid on the concession if the design or technology is insufficient to meet JR East's standards. Thus, there are multiple prudent alternatives for JR East to mitigate the risk to its reputation for speed should the NEC system fail to perform up to JR East's standards. For CLIOSjre bundle 3.2, the risk to JR East's reputation for speed is not substantial.

**Safety:** CLIOSjre bundle 3.2 will bring international quality high-speed rail to the NEC. This new infrastructure will be separated from the existing infrastructure and be dedicated to HSR between Boston and New York. Although the existing track from DC to New York will not be raised to these standards, the segment from Boston to New York will eliminate level crossings and prevent freight from operating on the new tracks. These upgrades will improve the safety of the Boston-New York segment and raise them to international standards.

JR East's role for CLIOSjre bundle 3.2 is to operate a system under concession. As a result, JR East will be forced to work with the infrastructure and rolling stock provided by another company. As the infrastructure and rolling stock may be subpar, JR East's reputation for safety will be at risk. However, because the infrastructure will be designed and partially complete before JR East is invited to bid on the operating concession, JR East could decide not to bid on the concession if the design or technology is insufficient to meet JR East's standards. This contrasts starkly with bundle 3.1 – for bundle 3.1 JR East will likely have to provide the turnkey system before a private operator is chosen. In addition, as an operator of the system, JR East will be able to establish standards of operation that further ensure the safety of the system.

To further protect the company brand from risk, JR East could create a subsidiary for the operation of the NEC HSR system. A subsidiary company would insulate JR East from any accidents or crashes (especially on the southern segment of the corridor where freight trains will

continue to operate). With multiple prudent alternatives for JR East to mitigate the risk to its reputation for safety, JR East's reputation for safety is not an issue for CLIOSjre bundle 3.2

**Reliability:** CLIOSjre bundle 3.2 will bring international quality high-speed rail to the NEC. This new infrastructure will be separated from the existing infrastructure and be dedicated to HSR between Boston and New York. Service on the segment from Boston to New York will not be interrupted by freight rail or slower-speed regional service. These upgrades will improve the punctuality of the Boston-New York service. However, the existing track from DC to New York will not be raised to these operating standards.

JR East's role for CLIOSjre bundle 3.2 is to operate a system under concession. As a result, JR East will need to work with the infrastructure and rolling stock provided by another company. As the infrastructure and rolling stock may be subpar, JR East's reputation for reliable service will be at risk. JR East may be unfamiliar with the manufacturing standards of the rolling stock or the operating procedures designed into the infrastructure. However, because the infrastructure will be designed and partially complete before JR East is invited to bid on the operating concession, JR East could decide not to bid on the concession if the design or technology is insufficient to meet JR East's standards.

To further protect the company brand from risk, JR East could create a subsidiary for the operation of the NEC HSR system. A subsidiary company would insulate JR East from reliability issues. In particular, delays propagating from the conventional southern segment of the corridor would be difficult for JR East to predict or resolve. With a subsidiary company performing the operations, JR East's brand will not be at risk. With multiple prudent alternatives for JR East to mitigate the risk to its reputation for reliability, JR East's reputation for reliability is not threatened for CLIOSjre bundle 3.2

**Hospitality:** As JR East is the primary HSR operator for CLIOSjre bundle 3.2 and does not control the infrastructure or rolling stock, JR East's reputation for prompt and professional hospitality will be at risk. However, JR East will be able to guide its employees' interactions with customers. Although the service in the NEC (especially on the southern segment of the corridor) may not meet JR East's standards for speed, safety, or reliability, JR East will be in control of omotenashi of its employees. As system operator, JR East's employees will have the latitude to change reservations if trains are delayed, provide refunds for poor experiences, and offer replacement services for cancelled trains. Although services may not meet JR East's standards, JR East's employees can mitigate any risk to JR East's reputation for hospitality.

**Environment:** As an operator of the HSR system, JR East will have little-to-no control over the system's environmental performance. JR East will not have a role in the design or construction of the system; the operating speeds, operating voltages, equipment design, and scheduling of trains will largely be determined by the design of the infrastructure. Thus, other than performing good maintenance, JR East will not be able to impact the system's environmental performance.



Therefore, it is unlikely that the environmental performance of the system will reflect on JR East's reputation. JR East's reputation for environmental stewardship and energy efficiency will not be at risk.

**Summary:** Of the five key elements of JR East's reputation, four will be at risk. As JR East is in control of system operations and can create a subsidiary company with different branding, there are many feasible and prudent alternatives to mitigate risks to JR East's reputation for speed, safety, and reliability. In addition, because JR East will be in charge of the operating procedures, the company will be in control of its reputation for hospitality.

As this bundle is most similar to representative outcome B, the research team assigns bundle 3.2 a grade of B for Metric 9.

### *CLIOSjre Bundle 5.1*

**Speed:** As CLIOSjre bundle 5.1 will achieve international quality HSR along the full Northeast Corridor, JR East's reputation for high-speed service will not be at risk. Bundle 5.1 will bring 180 mph service to the full corridor; this speed is consistent with JR East's standards in Japan. Even if flaws in the system design prevent trains from reaching 180 mph, JR East will only provide the rolling stock for the system. JR East will not have any difficulty distancing itself from the NEC if the system does not reach high speeds; any blame directed at JR East will be without merit.

**Safety:** For CLIOSjre bundle 5.1, JR East will provide rolling stock but will not have influence on the construction of the system. As a result, JR East will need to work with the infrastructure provided by another company. As the infrastructure may be subpar, JR East's reputation for safety will be at risk. This new infrastructure will be separated from the existing infrastructure, but the alignment will be shared with other services. The new tracks will eliminate level crossings, but freight rail and slower rail services will be allowed to operate on the new tracks. These upgrades will dramatically improve the safety on the corridor, but the mixed speeds of service will remain a liability. In addition, the high-speed rail service will continue to be operated by Amtrak. These variables are almost certain to cause operational problems and higher injury and fatality rates than comparable international systems.

While there will likely be a few feasible alternatives to mitigate the risks to JR East's brand (e.g. requiring that JR East's name is not used), JR East's brand is a significant reason that the NEC stakeholders would purchase JR East's rolling stock. It would not be prudent for JR East to withhold the use of its brand from the stakeholders of the NEC. The research team believes there would be no prudent alternatives for JR East to mitigate the risks to its reputation for safety.

**Reliability:** For CLIOSjre bundle 5.1, JR East will provide rolling stock for infrastructure provided by another company. As the infrastructure may be subpar, JR East's reputation for reliability will be at risk. This new infrastructure will be separated from the existing

infrastructure, but the new alignment will be shared with freight rail and slower rail. These upgrades will certainly improve punctuality on the corridor, but the mixed speeds of service will continue to limit the reliability of HSR service. In addition, in this bundle, the high-speed rail service continue to be operated by Amtrak. Amtrak's historically tight finances are likely to be a factor in the new HSR service; this may limit Amtrak's ability to properly maintain the rolling stock. As a result, the reliability of JR East's new rolling stock could quickly deteriorate.

While there will likely a few feasible alternatives to mitigate the risks to JR East's brand (e.g. requiring the JR East's name is not used), JR East's brand is a significant reason that the NEC stakeholders would purchase JR East's rolling stock. It would not be prudent for JR East to withhold the use of its brand from the stakeholders of the NEC. The research team believes there would be no prudent alternatives for JR East to mitigate the risks to its reputation for reliability.

**Hospitality:** As JR East's business role for CLIOSjre bundle 5.1 is to provide rolling stock, JR East will have no direct involvement in the operation of the new HSR system. JR East's employees will not interact with HSR customers, and JR East's reputation for prompt and professional hospitality will not be at risk.

**Environment:** As JR East will only provide rolling stock for the new HSR system, JR East will have only modest control over the system's environmental performance. Many of JR East's environmental mitigation technologies are embedded in the rolling stock. However, as these mitigation technologies require regular maintenance, the performance of these technologies will likely be closely tied to Amtrak's maintenance procedures. It is possible that JR East will be able to reduce the maintenance requirements of these technologies, but there will be, at best, a few prudent alternatives to mitigate the risk to JR East's reputation for environmental stewardship.

**Summary:** Of the five key elements of JR East's brand, three will be at risk in CLIOSjre bundle 5.1. For environmental stewardship, there will be a few prudent alternatives to mitigate the risk. However, for safety and reliability, there will be only a few feasible alternatives and no prudent alternatives.

As this bundle has elements of representative outcome C and representative outcome E, the research group assigns CLIOSjre bundle 5.1 the grade D for Metric 9.

### *CLIOSjre Bundle 6.1*

**Speed:** For CLIOSjre bundle 6.1, JR East will operate a private HSR system on the NEC by purchasing track capacity from the infrastructure owners. This bundle will allow 180 mph service on the full NEC: a speed consistent with JR East's standards in Japan. If JR East observes that the infrastructure is not sufficient to sustain 180 mph speed, JR East can choose not to operate a private HSR service on the NEC. Thus, because JR East has complete discretion to participate in the market, JR East's reputation for high-speed service will not be at risk.

**Safety:** JR East's role for CLIOSjre bundle 6.1 is to operate a system by purchasing capacity from a separate infrastructure owner. As a result, JR East will work with the infrastructure provided by another company. As the infrastructure may be subpar, JR East's reputation for safety will be at risk. However, this new infrastructure will be separated from the existing infrastructure and will be dedicated to high-speed trains. Level crossings will be eliminated from the corridor, and freight traffic will be prevented from operating on the new tracks. These upgrades will certainly improve the safety of the corridor and raise them to international standards.

In addition, because the infrastructure will be designed and partially complete before JR East is invited to bid on track capacity, JR East could decide not to bid on the service if the design or technology is insufficient to meet JR East's safety standards. JR East will be able to provide its own rolling stock for the service, and this rolling stock could mitigate many of the safety issues with the infrastructure. These feasible and prudent alternatives will mitigate the risk to JR East's reputation for safety.

**Reliability:** JR East's role for CLIOSjre bundle 6.1 is to operate a system by purchasing capacity from a separate infrastructure owner. The infrastructure may be subpar or poorly maintained resulting in signal failures and or operating issues, and JR East's reputation for punctual service will be at risk. However, this new infrastructure will be separated from the existing infrastructure and be dedicated to high-speed trains. Service will not be interrupted by freight traffic or slower-speed regional service. These upgrades will improve the punctuality of the corridor and raise them to international standards.

In addition, because the infrastructure will be designed and partially complete before JR East is invited to bid on track capacity, JR East could decide not to bid on the service if the design or technology is insufficient to meet JR East's standards. JR East will be able to provide its own rolling stock for the service, and this rolling stock could mitigate many of the issues with the infrastructure. These feasible and prudent alternatives will mitigate the risk to JR East's reputation for safety.

**Hospitality:** JR East will be a private operator in CLIOSjre bundle 6.1 but will not control the infrastructure. Thus, JR East's reputation for prompt and professional hospitality is at risk. JR East will have some control over the operations quality in the NEC. And if the infrastructure provider causes any operational issues (with speed, safety, or reliability), JR East's employees can compensate for a poor rider experience. JR East's employees will have the latitude to change reservations if trains are delayed, provide refunds for poor experiences, and offer replacement services for cancelled trains. JR East will be able to guide its employees' interactions with customers and therefore protect JR East's reputation for hospitality. As JR East will have almost complete control over the employee procedures, there will be many feasible and prudent alternatives to mitigate risk to JR East's reputation.

**Environment:** As JR East will provide rolling stock for the new HSR system and operate the system, JR East will have control over the system's environmental performance. Many of JR East's environmental mitigation technologies are embedded in the rolling stock. Thus, JR East will be able to make use of its technology to achieve solid environmental performance. In addition, because JR East will be operating on the infrastructure with another operator (or other operators), JR East will be able to demonstrate its superior environmental performance (quieter trains, lower energy requirements, etc.) to some degree. Although JR East's reputation for environmental stewardship and energy efficiency will be at risk, bundle 6.1 provides a number of feasible and prudent alternatives to mitigate this risk.

**Summary:** Although four of the five key elements of JR East's brand will be at risk in bundle 6.1, there are many feasible and prudent alternatives to mitigate this risk.

Therefore, the research team assigns bundle 6.1 a grade of B for Metric 9.

### *CLIOSjre Bundle 6.2*

**Speed:** As JR East has nearly complete control over CLIOSjre bundle 6.2, JR East's reputation for high-speed service will not be at risk. Bundle 6.2 will bring 180 mph service to the full corridor; this speed is consistent with JR East's standards in Japan. During design and engineering of the service, JR East will have the opportunity to ensure that the infrastructure and rolling stock is capable of 180 mph service. If these speed standards are not met, JR East will be able to alter the designs or abandon the project.

**Safety:** CLIOSjre bundle 6.2 will bring international quality high-speed rail to the full Northeast Corridor. Because JR East will provide infrastructure, rolling stock, and operations for bundle 6.2, JR East will not have any trouble with subpar design, technology, or maintenance. This new infrastructure will be separated from the existing infrastructure and be dedicated to high-speed trains. Level crossings will be eliminated from the corridor, and freight traffic will be prevented from operating on the new tracks. These upgrades will dramatically improve the safety of the corridor and raise them to international standards. In theory, JR East should be able to duplicate its impeccable Japanese safety record in the Northeast Corridor. Although other private operators on the infrastructure may not initially meet JR East's standards, JR East's advantageous position as infrastructure manager in any negotiation will ensure that other private operators do not impact system safety. Based on this understanding of the system, the research team believes that JR East's reputation for safety will not be at risk.

**Reliability:** As discussed above, JR East will provide infrastructure, rolling stock, and operations for bundle 6.2, JR East will not have any trouble with subpar design, technology, or maintenance. In theory, JR East should be able to duplicate its impeccable reliability record in the Northeast Corridor. JR East's upper hand in any negotiation will ensure that other operators will not impact system punctuality. Based on this understanding of the system, the research team believes that JR

East's reputation for safety will not be at risk.

**Hospitality:** As JR East will be the primary HSR operator for CLIOSjre bundle 6.2 and JR East controls both the infrastructure and rolling stock, JR East's reputation for prompt and professional hospitality will not be at risk. Other operators on the system may not adhere to JR East's strong requirements for professionalism, but with almost complete control over the system operating procedures, JR East will be able to mitigate any risk to its reputation for prompt and professional hospitality.

**Environment:** As JR East will provide infrastructure, rolling stock, and operations for the new HSR system, JR East will have complete control over the system's environmental performance. In theory, JR East will be able to make use of its technology to achieve an environmental performance on par with its existing services in Japan. In addition, because JR East will be operating on the infrastructure with another operator (or other operators), JR East will be able to demonstrate its superior environmental performance (quieter trains, lower energy requirements, etc.). The research team believes that JR East's reputation for environmental stewardship and energy efficiency will not be at risk.

**Summary:** Based on the above analysis, none of the five key elements of JR East's brand will be at risk. This qualifies the bundle for a finding of "no significant impact" to JR East's reputation. However, our analysis for CLIOSjre bundle 6.2 is based on the understanding that JR East will be able to deliver Japanese quality HSR on the NEC. It is possible that factors beyond JR East's control (e.g. cultural differences, federal regulations including Buy America, local opposition) will pose a significant risk to one or more of the key elements of JR East's brand. If these external factors interfere with JR East's ability to deliver Japanese quality HSR, there will still be many feasible and prudent alternatives for JR East to mitigate risk to its reputation. This situation is most similar to representative outcome B. This possible measurement error is reflected in Table 6-42.

The research team assigns bundle 6.2 the grade A for Metric 9.

## *Metric 10. Humans Resource Development*

[Continued from Chapter 6]

### *ATR Analysis of the Seven CLIOSjre Bundles*

Using these three elements of effective human resource development as a framework for analysis, the research team performed a Human Resource Analysis of the seven CLIOSjre bundles. The results of this analysis are below.

#### *CLIOSjre Bundle 1.1*

For CLIOSjre bundle 1.1, JR East will not be involved in the NEC market. Thus, JR East will not

have any opportunities to attract or train new, highly capable employees. JR East's existing employees will not have an opportunity to gain new experience in a foreign environment.

This bundle is identical to representative outcome F, so the research team assigns bundle 1.1 the grade F for Metric 10.

### *CLIOSjre Bundle 1.2*

For CLIOSjre bundle 1.2, JR East assumes the role of a planning and engineering consultant on the NEC HSR system. As a consultant, JR East is likely to employ a number of consultants locally in the United States to help system stakeholders design and engineer a better system. These consultants may come from within JR East, from Japan, or be hired directly in the United States. Indeed, it is likely that JR East consultants will come from all three locations. As JR East already has its own domestic consulting arm (JR East Consultants Company or JRC) and has an international consulting subsidiary (Japan International Consultants for Transportation or JIC), we suspect that most of these employees will be existing employees of one of these two companies. For our analysis, the research team assumed that the majority of JR East consultants for bundle 1.2 are JIC employees and the remainder are new hires from the United States with market-specific knowledge.

The opportunities presented by this bundle are different for these two groups of employees. Current employees of JIC will gain experience in a new HSR market and acquire a better understanding of the United States rules and regulations. These highly capable employees will receive some training from JR East to learn about the specific applications of JR East technology. The JIC consultants will likely remain with JIC for the long term and apply their experience to future international HSR projects. Thus, JR East will retain the institutional knowledge gained by the JIC employees.

US-based employees with market-specific knowledge will have a different role than the JIC employees. JR East will invest a great deal in the training of these consultants to familiarize them with JR East's organization and technology. However, when the work is complete on the project, most of these consultants will leave JR East to move on to other projects in the US.

Depending on the size of the consulting contract, this analysis most closely resembles representative outcome D or C.

Because of the small number of employees hired and trained for the consulting business role, the research team assigns CLIOSjre bundle 1.2 a grade of D for Metric 10.

### *CLIOSjre Bundle 3.1*

For CLIOSjre bundle 3.1, JR East will provide a turnkey system to the NEC HSR system. This business role requires all of the consulting and engineering work discussed above for CLIOSjre

bundle 1.2. In addition, bundle 3.1 requires the delivery of rolling stock and the construction of the infrastructure on the segment of the route from New York City to Boston.

Rolling stock delivery will require designs and engineering from Japan Transport Engineering Company (J-TREC). As a wholly owned subsidiary of JR East, the research group considers any new employees for J-TREC to be new employees for JR East. However, as J-TREC regularly designs and manufactures rolling stock for the Japanese market, it is unlikely that J-TREC will need to hire new Japanese employees to cover this contract. In addition to the design and engineering work for the rolling stock, Buy America requirements will likely mandate that JR East assemble the rolling stock in the United States. Nearly all of the employees for system assembly will be skilled labor from the United States, and JR East will have the opportunity to train them according to JR East's standards. However, unless JR East wins other rolling stock contracts in the US, these employees will not remain with JR East once the NEC rolling stock is complete.

The construction of infrastructure in the Northeast Corridor will require JR East to send many current employees to the corridor to oversee construction. These existing employees will benefit from new training and new international experience. As they are already JR East employees, these highly capable managers will likely remain with the company long term. However, unless JR East wins other international construction contracts, this new experience overseas will have only limited benefit for the employees or JR East.

In addition to these Japanese managers, JR East will hire a large number of new employees in the United States to perform construction. It is likely that JR East will subcontract much of the construction work to US companies and thus JR East will not hire many new employees. For the employees JR East does hire as part of construction, JR East will have an opportunity to train them to JR East standards. However, these employees are not likely to remain with JR East once the HSR project is complete.

In summary, this CLIOSjre bundle offers JR East the opportunity to hire and train a large number of new consultants, new rolling stock assembly technicians, and new construction managers within the United States. However, because JR East will no longer be involved in the market once the company turns over the keys of the new HSR system, most of these employees will leave JR East once the project is complete.

Based on this analysis, the research team assigns bundle 3.1 the grade C for Metric 10.

### *CLIOSjre Bundle 3.2*

For CLIOSjre bundle 3.2, JR East will operate a system under concession. In order to operate the system, JR East will send current JR East employees to the United States to train and oversee operation. These employees will gain experience with the US culture, labor market, and rail regulations and will be able to apply this experience to other HSR operating contracts. In

addition, based on other concession contracts in the United States, the concession contract for NEC HSR will likely be several decades long. Current JR East employees that move to the United States will have the opportunity to continue to learn and apply their experience throughout the life of the contract. This longer-term horizon may also allow JR East to give this valuable international experience and training to multiple generations of employees.

To operate the system, JR East will also need a large number of new employees (both for maintenance and operations). As this opportunity to work with a prestigious high-speed rail company is unique in the United States, JR East will likely attract highly capable employees from the US market. In addition, JR East will be able to train these employees to the standards of performance of JR East. Because of the expected length of the concession contract, JR East will be able to retain these employees in the company for the long-term and build institutional knowledge.

For CLIOSjre bundle 3.2, because of the large-scale and long-term nature of their business role, JR East will be able to attract, train, and retain a large number of highly capable employees.

Based on this analysis, the research team assigns bundle 3.1 the grade A for Metric 10.

#### *CLIOSjre Bundle 5.1*

For CLIOSjre Bundle 5.1, JR East will deliver HSR components (such as rolling stock) for the NEC HSR system. As with CLIOSjre bundle 3.1, rolling stock delivery will require designs and manufacturing from J-TREC. It is unlikely that J-TREC will need to hire new domestic employees to cover this contract.

In addition to the design and engineering work for the rolling stock, Buy America requirements will mandate that JR East assemble the rolling stock here in the United States. Nearly all of the employees for rolling stock assembly will be highly capable skilled labor from the United States, and JR East will have the opportunity to train them according to JR East's standards. However, unless JR East wins other rolling stock contracts in the US, these employees will not remain with JR East once the NEC rolling stock is complete.

Thus, for CLIOSjre bundle 5.1, JR East will be able to attract and train some highly capable employees from the US, but these employees are not likely to remain with the company beyond the life of the contract.

Mapping this to the grade spectrum for Metric 10, the research group assigns bundle 5.1 the grade D.

#### *CLIOSjre Bundle 6.1*

For CLIOSjre bundle 6.1 JR East operates a system by purchasing track capacity from an infrastructure manager. This business role requires that JR East provide rolling stock for the



system and operate and maintain that rolling stock. Unlike CLIOSjre bundle 5.1, this rolling stock may not be subject to Buy America requirements. JR East can design, engineer, and assemble the rolling stock in Japan and ship the rolling stock to the United States for operation. Because J-TREC already manufactures rolling stock for the Japanese market, it is unlikely that JR East would need to hire additional domestic employees. The current J-TREC employees would benefit from the experience of manufacturing to different railcar standards that are required in the United States. However, since US rail regulations are very different from regulations elsewhere in the world, this experience is unlikely to translate into other international HSR markets.

In addition to manufacturing rolling stock, JR East will need to provide ongoing operations for the HSR system. As the infrastructure will be operated and maintained by a separate owner, JR East will only need to furnish the train operation, maintenance, and support staff. This relatively small group will be composed of current JR East employees with experience in HSR operations and new locally hired employees. The current JR East employees will gain experience in international operations and management, and as they are current employees, will likely remain with JR East and the company will retain institutional knowledge. As JR East can be selective when hiring a small operations staff, new employees of the company will be highly capable and will be trained to perform at JR East's standards. As JR East will continue operating in the NEC indefinitely, even new employees from the US may remain with the company and contribute to JR East's institutional knowledge.

Based on this analysis, JR East will be able to attract, train, and retain a modest number of employees in CLIOSjre bundle 6.1.

Thus, the research team assigns bundle 6.1 the grade B for Metric 10.

### *CLIOSjre Bundle 6.2*

For CLIOSjre bundle 6.2, JR East will construct, operate, and maintain a private HSR system on the full NEC spine. This business role requires that JR East not only engineer and build the full infrastructure for the NEC HSR system and provide rolling stock (analogous to CLIOSjre bundle 3.1), but also operate and maintain the system (as with CLIOSjre bundle 6.1). This massive undertaking will require many new employees from within the company and in the United States at all levels of the organization. As a project of this scope is unique to the US (and perhaps to the world), JR East will be able to attract highly capable employees for planning, engineering, operations, and maintenance. In addition, because JR East will be sole proprietor of the project, JR East will be able to ensure that all new employees are trained to JR East's standard. JR East will continue to operate and maintain the infrastructure once the new HSR system is built. Therefore, many of the new employees will remain with JR East and build institutional knowledge.

Based on this understanding, CLIOSjre bundle 6.2 offers JR East significant opportunities to attract, train, and retain highly capable employees.

The research team assigns CLIOSjre bundle 6.2 the grade A for Metric 10.

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This concludes our detailed analysis of the ten CLIOSjre Metrics.

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