Air Transportation Infrastructure Systems Worldwide; Opportunities for Infrastructure and Technology Improvements

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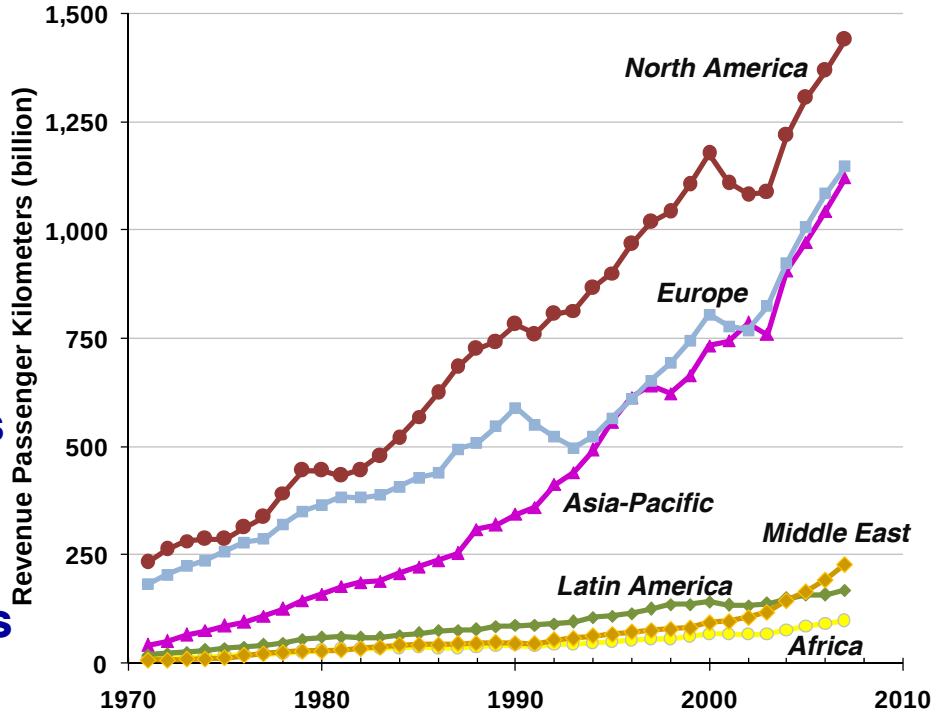
MIT Global Airline Industry Program - Industry Advisory Board Meeting
Massachusetts Institute of Technology
Nov. 6th 2008

Motivation & Research Objectives

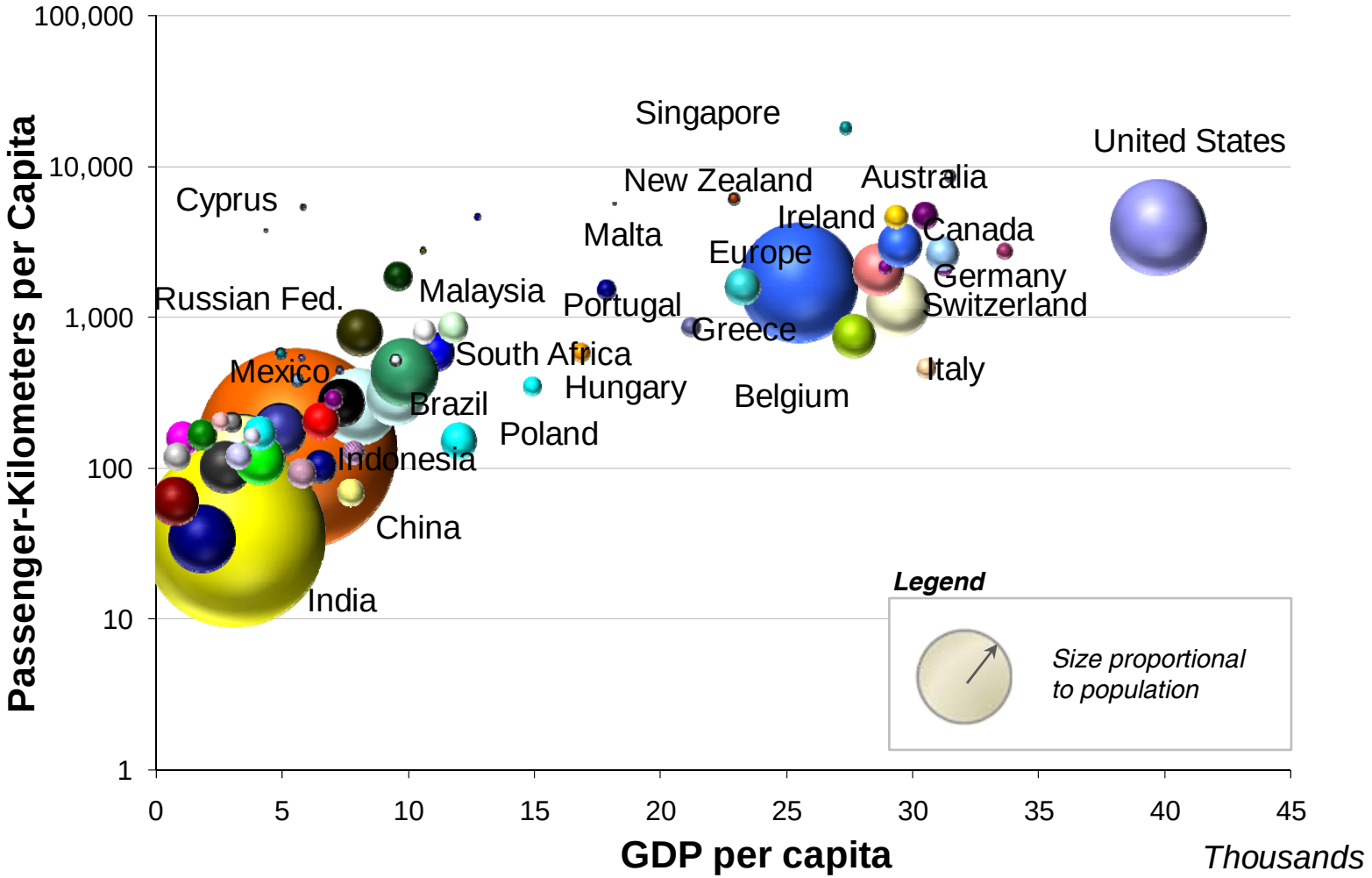
- **Increasing demand for air transportation**
- **Key air transportation infrastructure constraints (i.e. capacity)**
- **Implications:**
  - congestion,
  - degradation of the passengers' quality of travel experience,
  - economic impacts.
- **Air transportation system is a vital underlying infrastructure of a country's economy**
- **Analyze the characteristics and capabilities of national airport networks worldwide.**
- **Evaluate the opportunities and the implications of next generation air transportation technologies to improve the access to these airport systems.**

Historical Evolution of Passenger Traffic
(Revenue Passenger Kilometers - RPKs)
from 1971 to 2007



Data sources: ICAO (1971-2005) and IATA (2006-2007)

Passenger Transport Activity (Revenue Passenger Kilometer per capita) vs. GDP per capita

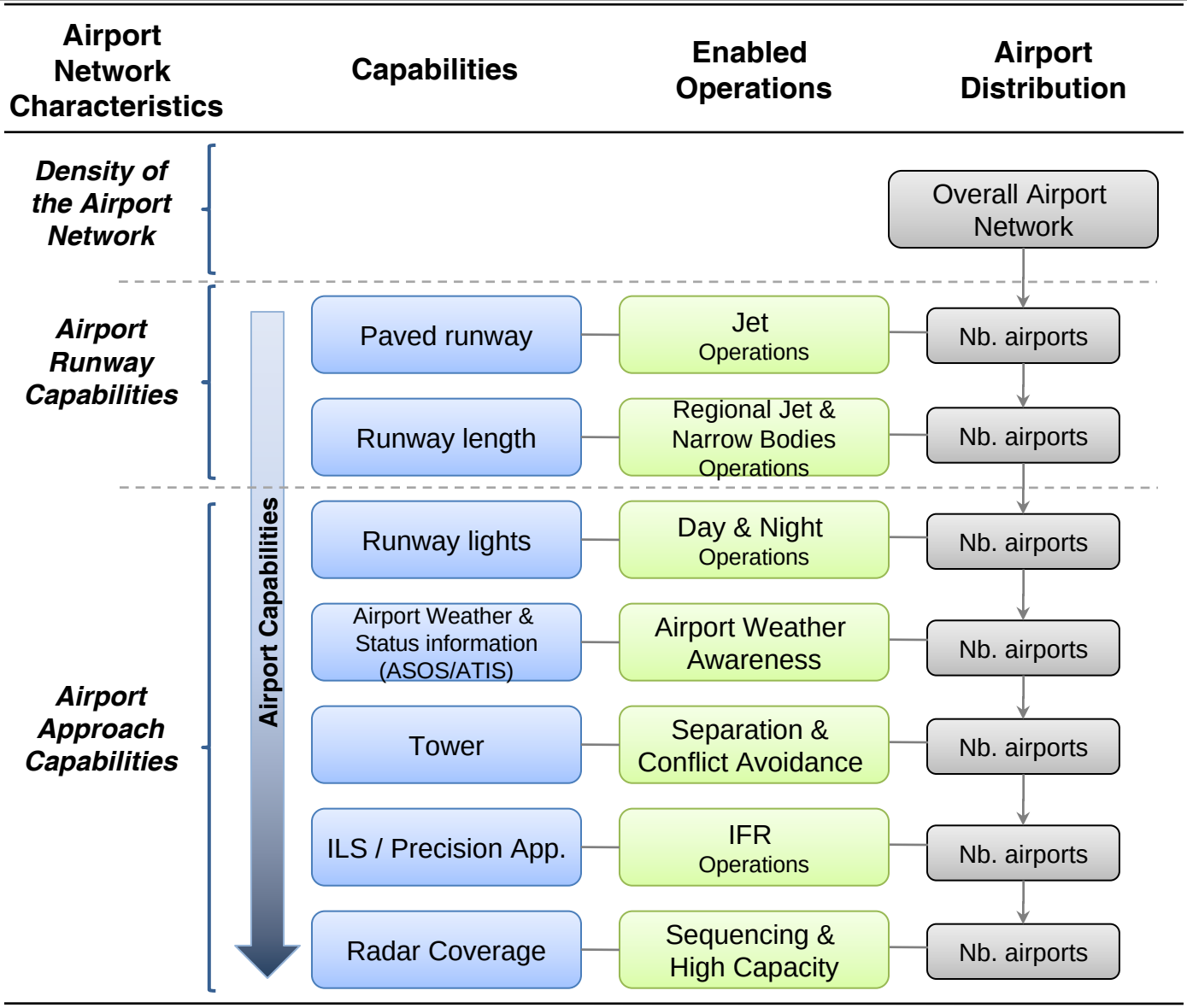


Data sources: ICAO (2005), CIA (2005)

Approach

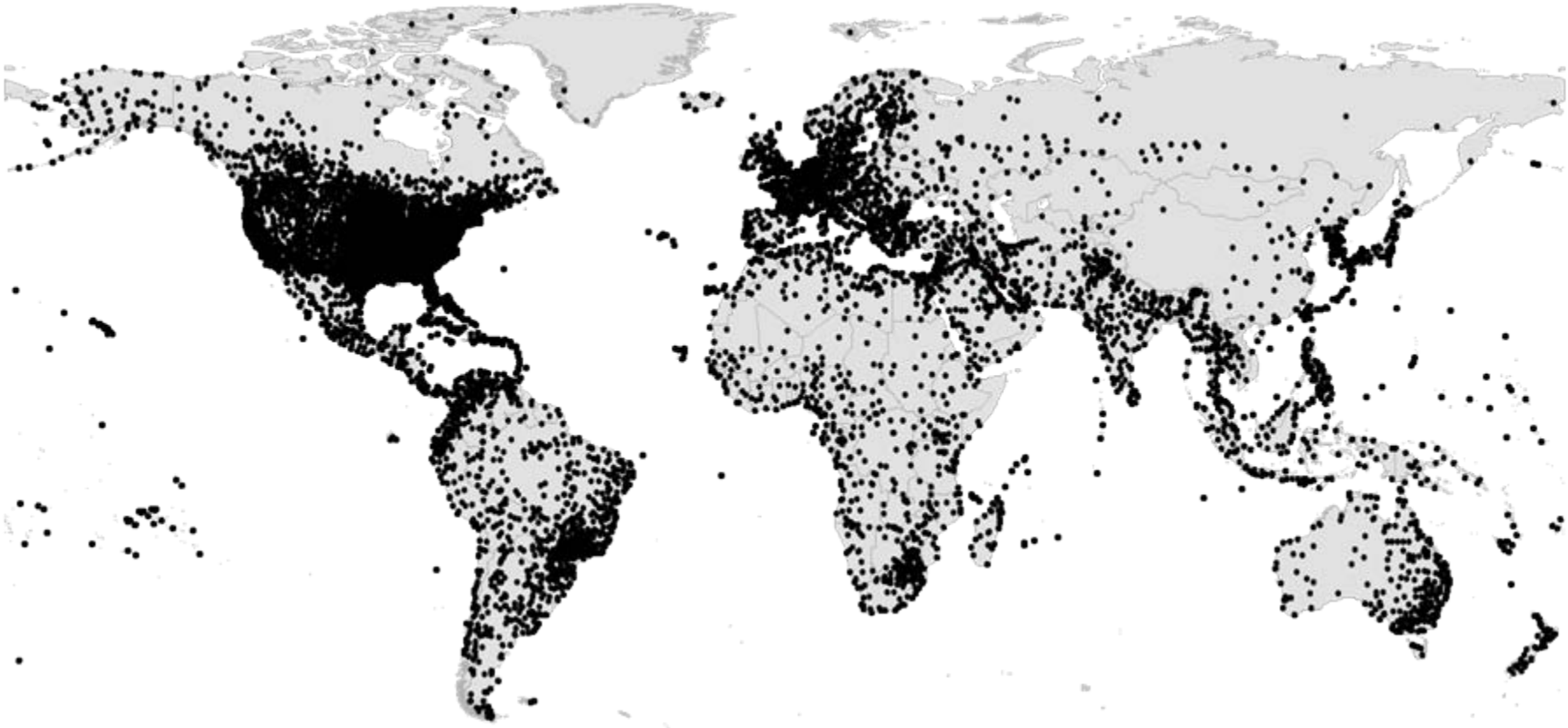
- **Analyzed of the current characteristics and the capabilities of the national airport networks of 190 countries worldwide,**
  - Data sources:
    - *Worldwide airport database; Digital Aeronautical Flight Information File (DAFIF 2005),*
    - *Population and aggregate airport data from the Central Intelligence Agency (CIA) World Fact Book database (CIA 2006).*
- **Performed a detailed multiple case study analysis of the national airport networks from 8 countries**
  - Countries selected based on their characteristics and potential for improvement (identified in phase 1 of the approach),
  - Cases illustrate and contrast the opportunities and the implications of these technologies and capabilities across different types of air transportation systems,
  - Wide array of detailed population distribution databases,
  - Country specific information was used in each case study.
- **Reviewed and analyzed next generation air transportation system technologies and capabilities**
  - Literature review,
  - Discussion of the implications for potential improvements identified in phase 1 and 2.

Framework for Analyzing Airport Infrastructure Capabilities and Potential for Improvements



World Airport Network

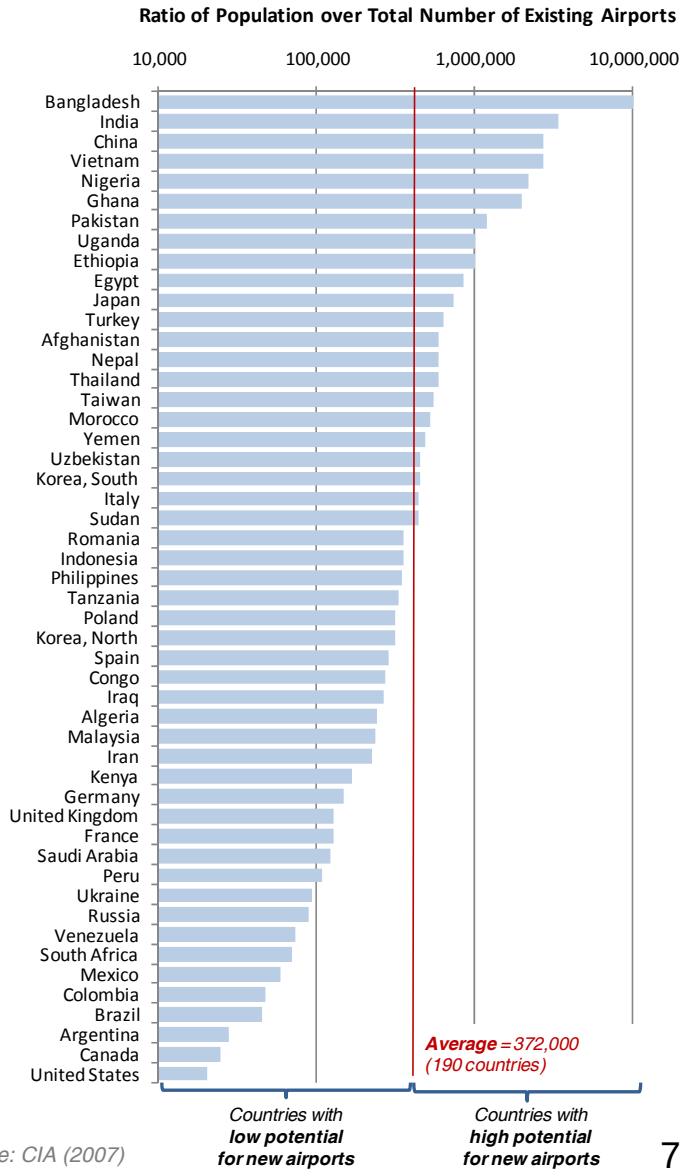
- **World airport network in numbers:**
  - 45,813 airports,
  - 14,000 airports with at least one paved runway,
  - 6,750 airports with at least one paved runway longer than 5,000 ft,
  - 950 airports with at least one paved runway longer than 10,000 ft.



Data source: DAFIF (2005)

Analysis of Airport Network Density

- **Computed ratio of population over the total number of existing airports for each country.**
  - Metric that better reflects the adequacy between potential supply of air transportation services and potential demand.
- **Great diversity in this ratio, indicative of the ability of different countries to accommodate future demand.**
- **All else being equal, countries with high ratio of population to number of existing airports are more likely to need the construction of new airports.**
  - e.g. China and India will require significant future development of airport infrastructure as their GDP per capita increases.
  - United States and Europe generally have airport networks that are large enough compared to their population basins that they can rely on existing airports to accommodate future growth.

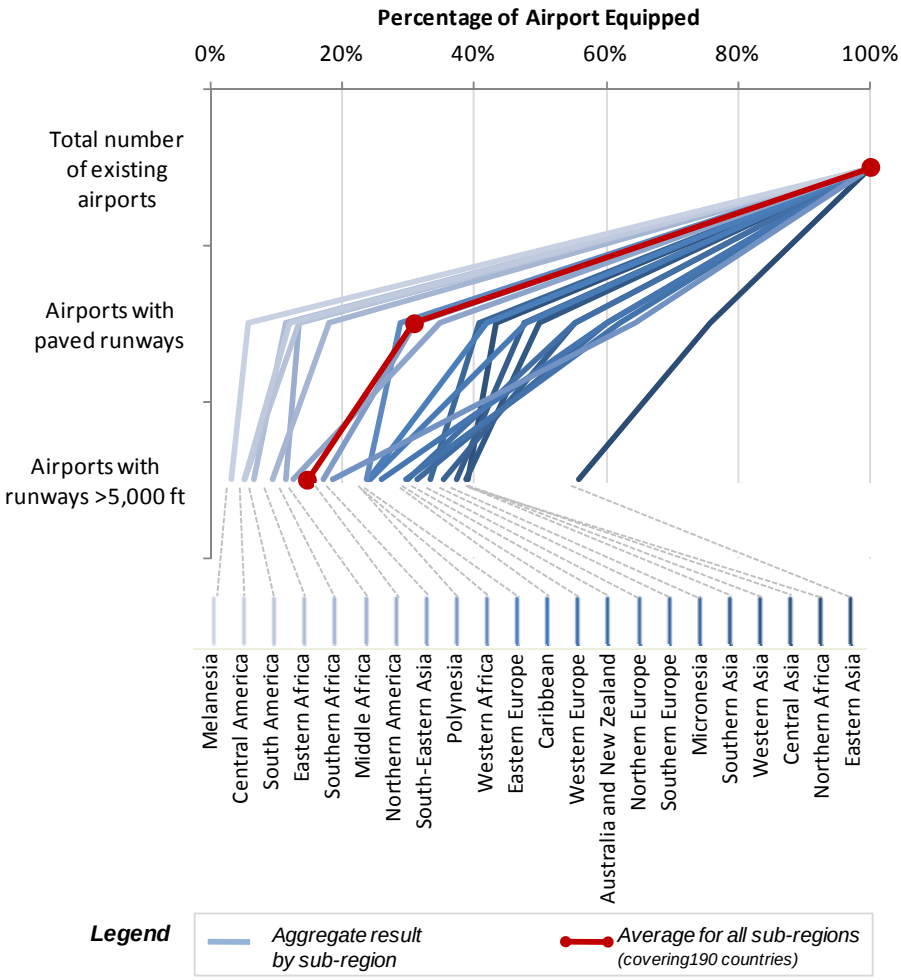


Data source: CIA (2007)

Analysis of Airport Runway Capabilities

- **Analysis based on data from the Central Intelligence Agency (CIA) World Fact Book database,**

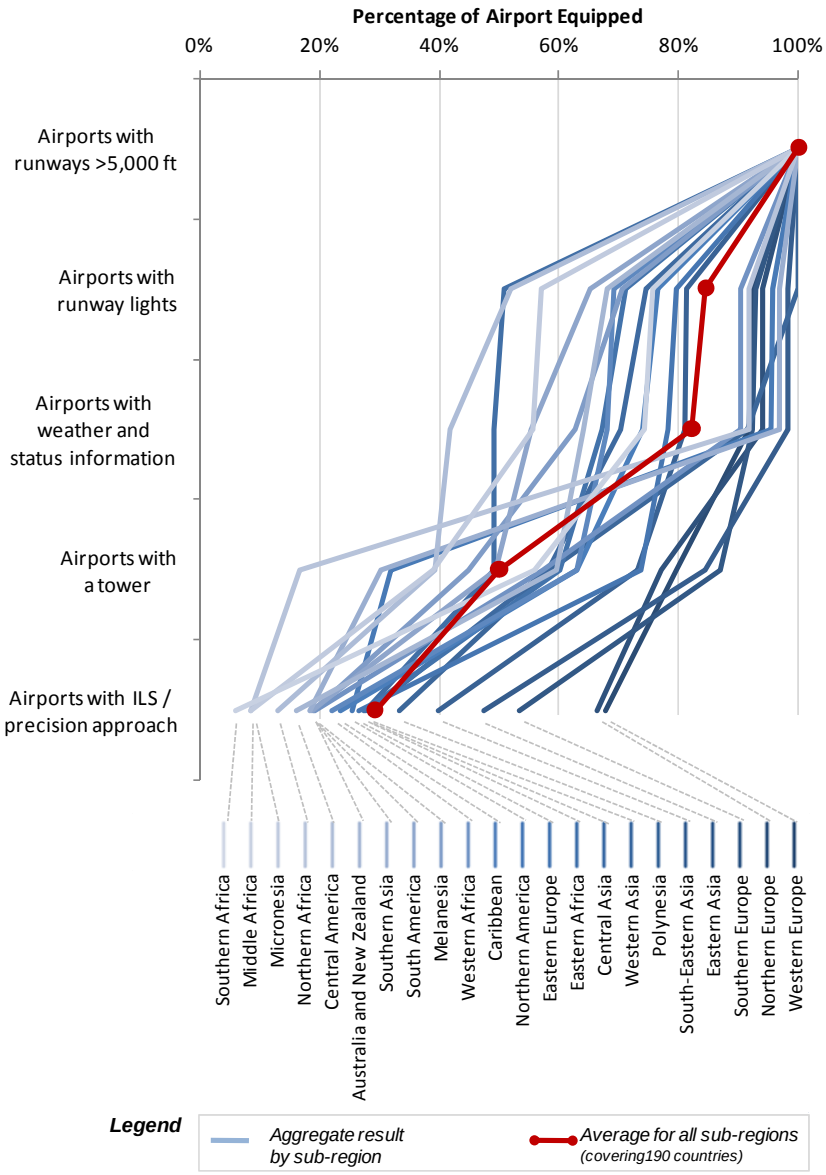
- **Results aggregated into 17 world sub-regions.**
  - On average worldwide, 30% of all airports have paved runways and 15% have at least one runway longer than 5,000 ft.
  - Low end, Melanesia (6% of its airport equipped with paved runway and 3% with runways longer than 5,000 ft). Followed closely by Eastern Africa and Central America.
  - Opposite end, in Eastern Asia (despite having high potential for new airports) 76% of all airports have paved runways and 56% have runways longer than 5,000 ft.



Data source: CIA (2007)

Analysis of Airport Approach Capabilities

- **Safe and reliable airside access (i.e. approach) to airports can be achieved using a set of technology based capabilities,**
- **Analysis of airport approach capabilities for 190 countries using world airport database (DAFIF 2005).**
- **Of the set of airports with paved runways and at least one runway longer than 5000 ft ,**
  - 85% have runway lights that allow night operations.
  - 82% of the airports with broadcasting weather and airport status services,
  - 50% have a tower
  - 29% have at least one ILS or precision approach system.



Data source: DAFIF (2005)

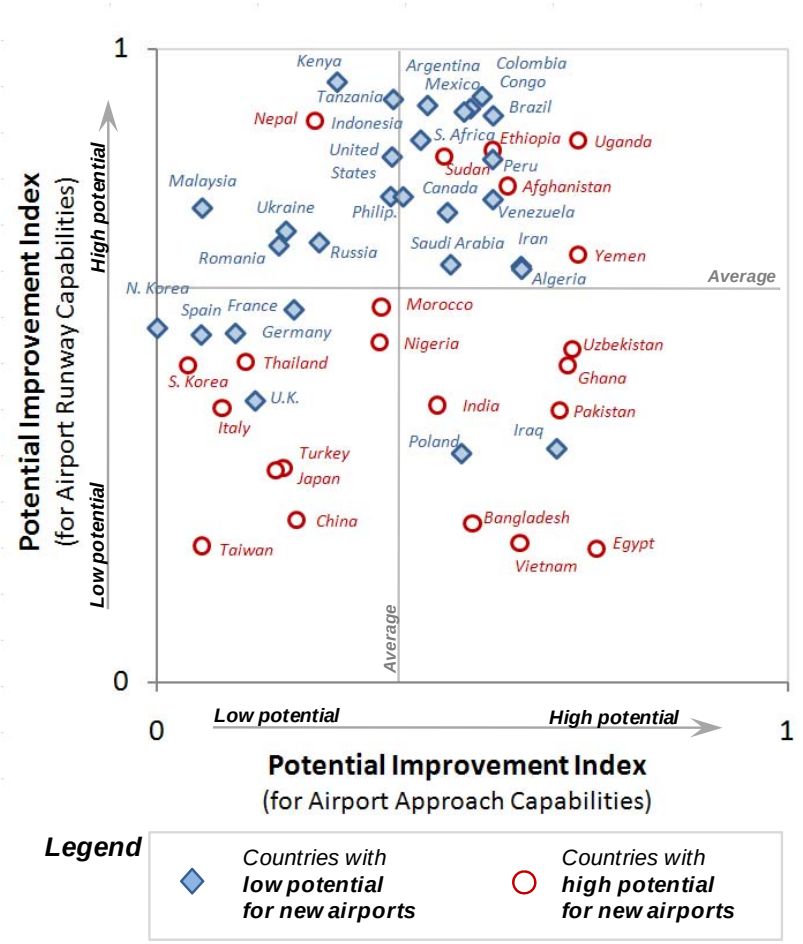
Potential Improvements of National Airport Network Capabilities

- **Comparative analysis of capabilities and potential improvement across national airport networks based on the analyses of:**
  - (1) the density of the airport network with regard to population in each country,
  - (2) the airport runway capabilities of existing airports,
  - (3) the airport approach capabilities,

- **Used a Potential Improvement Index (PII)**

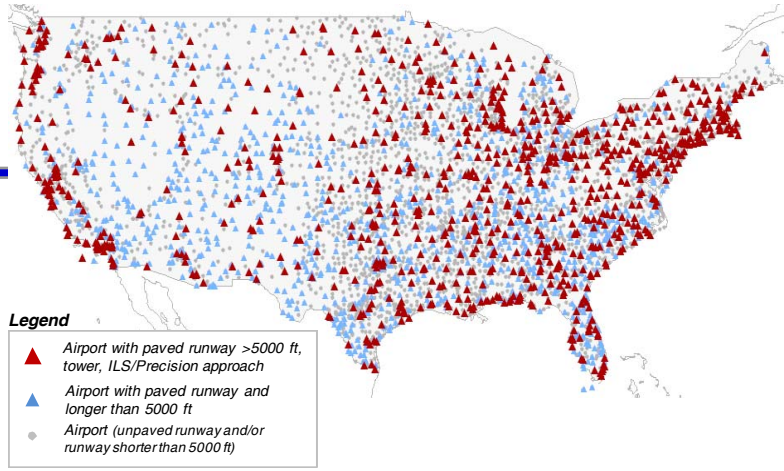
$$PII_c = \frac{\sum_{i=1}^{n}(1 - P_{i,c})}{n}$$

  - where $P_{i,c}$ is the percentage of airports equipped with capability i in the set c,
  - n is the number of capabilities in this set c
  - Index ranges from 0 to 1.
    - *0 = no potential improvement (airports in the airport network are fully equipped),*
    - *1 = full potential for improvement (exhibit none of the capabilities)*

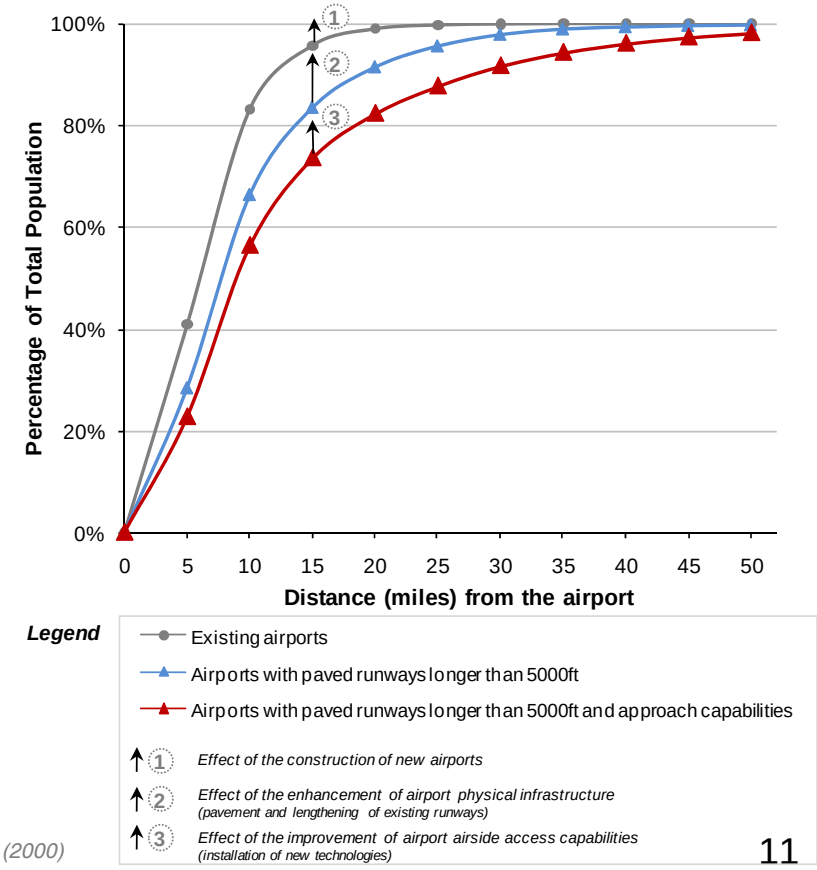


Data sources: CIA (2007), DAFIF (2005)

Airport System in the United States



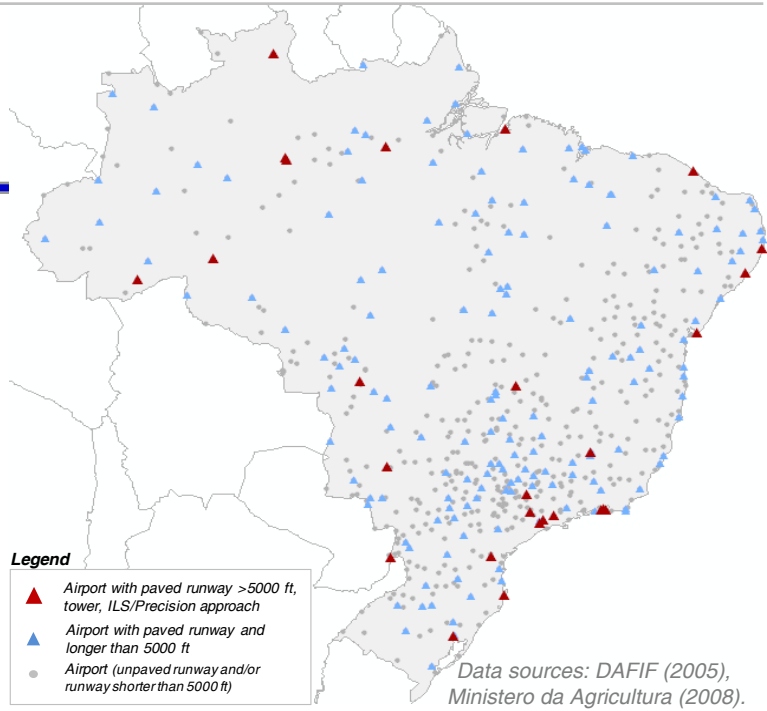
- **Density of the airport network:**
  - 14,800 airports,
  - Very low ratio of population over number of airports (i.e. 20,300),
- **Airport runway capabilities:**
  - 5100 with paved runways,
  - 1800 with a runway longer than 5,000 ft.
- **Airport approach capabilities:**
  - 96% have runway lights making them accessible by night VFR operations,
  - 95% have airport information services,
  - 33% have a tower,
  - 28% have at least one ILS or precision approach.
- **Generally, there is very good access to airports in the United States**
- **Limited potential improvement of airport access**

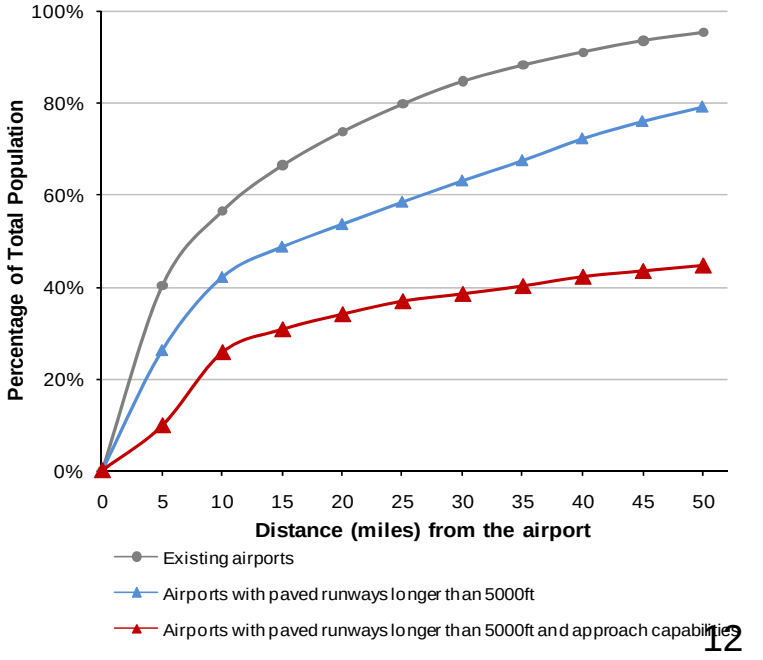


Data sources: DAFIF (2005), U.S. Census (2000)

Airport System in Brazil

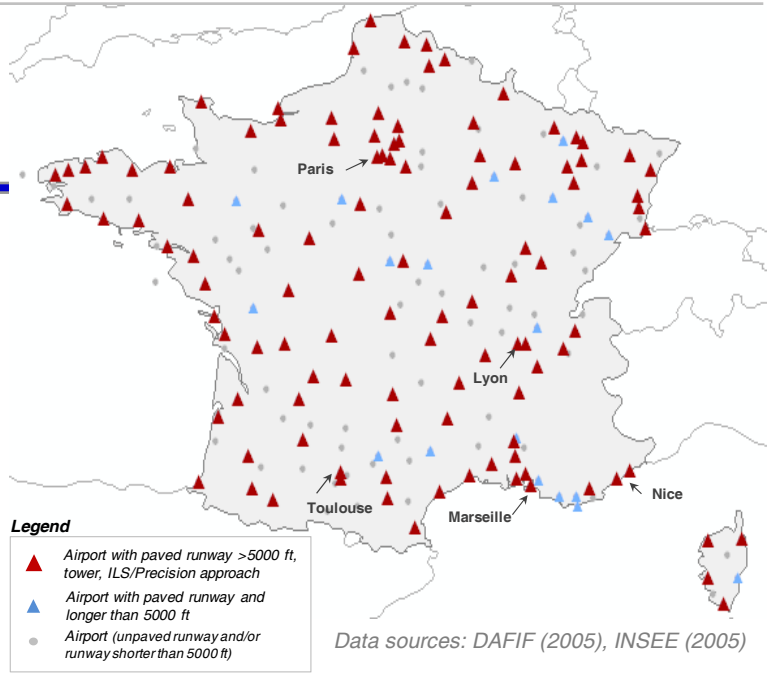
- **Density of the airport network:**
  - 4200 airports,
  - Low to medium ratio of population over number of airports (i.e. 42,000),
- **Airport runway capabilities:**
  - 700 with paved runways,
  - 200 with a runway longer than 5,000 ft.
- **Airport approach capabilities:**
  - 54 have a tower,
  - 26 have at least one ILS or precision approach.
- **High potential for improvements on the runway and approach fronts.**
  - Without building any new airport, technology driven improvements of the airside access could almost double the coverage of population living within 50 miles of suitable airports (from 42% to 80%).



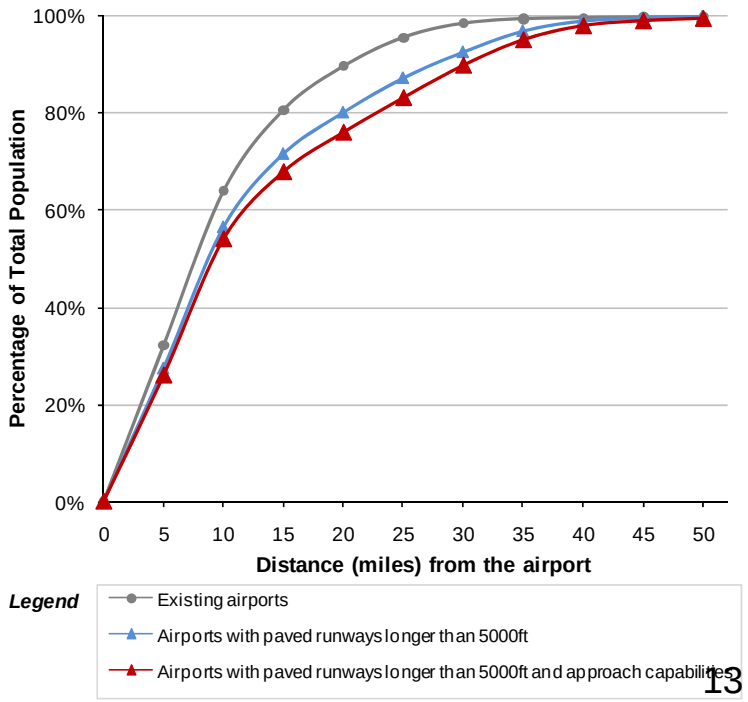


Airport System in France

- **Density of the airport network:**
  - 470 airports,
  - Low to medium ratio of population over number of airports (i.e. 128,000),
- **Airport runway capabilities:**
  - 61% with paved runways,
  - 30% with a runway longer than 5,000 ft.
- **Airport approach capabilities:**
  - 78% have at least one ILS or precision approach.
- **Very good access to equipped airports in France;**
  - 99.8% of the population living within 50 miles of an airport,
  - 99.5% within 50 miles of a "fully" equipped airport.
- **Very limited potential for improving access to airports.**

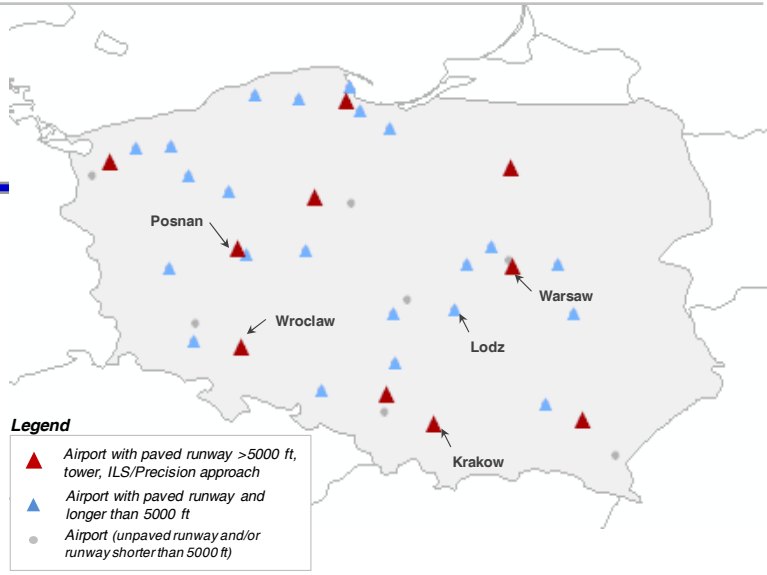


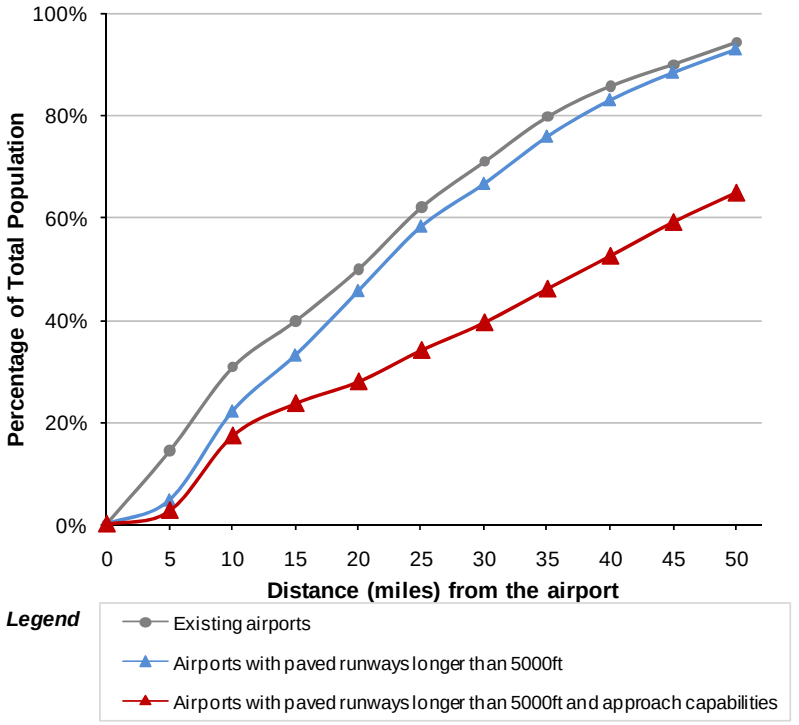
Data sources: DAFIF (2005), INSEE (2005)



Airport System in Poland

- **Density of the airport network:**
  - 122 airports,
  - Medium ratio of population over number of airports (i.e. 312,000),
- **Airport runway capabilities:**
  - 68% with paved runways,
  - 60% with a runway longer than 5,000 ft.
- **Airport approach capabilities:**
  - 43% have a tower,
  - 33% have at least one ILS or precision approach.
- **Next generation air transportation system technologies have potential to improve access to airports.**

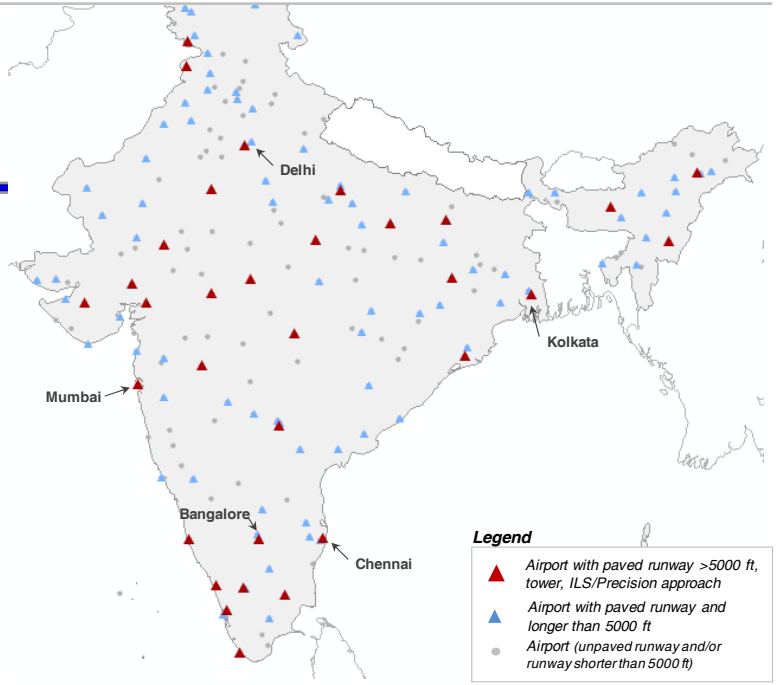


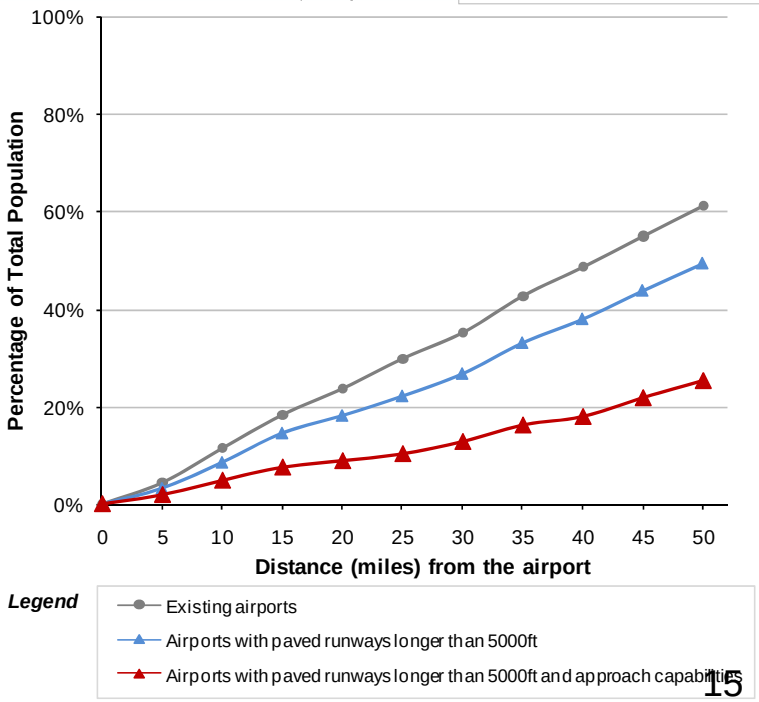


Data sources: Polish Central Statistical Office (2008), National Imagery and Mapping Agency – Poland (2003), DAFIF (2005).

Airport System in India

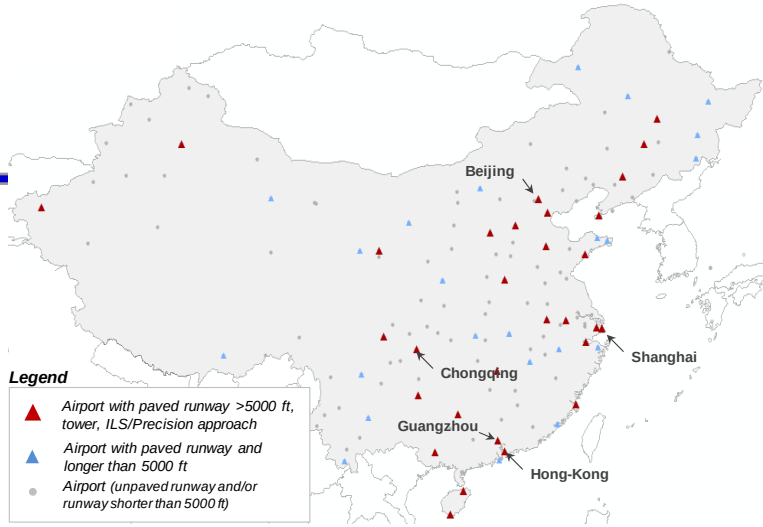
- **Density of the airport network:**
  - 341 airports,
  - Very high ratio of population over number of airports (i.e. 3.3 million),
- **Airport runway capabilities:**
  - 240 with paved runways,
  - 140 with a runway longer than 5,000 ft.
- **Airport approach capabilities:**
  - 26 have at least one ILS or precision approach.
- **Significant potential for technology driven improvement of the airport airside access.**
  - 60% of the Indian population lives within 50 miles of an airport.
  - Equipping current airports with airside access technologies would significantly improve access to airports (fully equipped airports) from 25% to 50%.





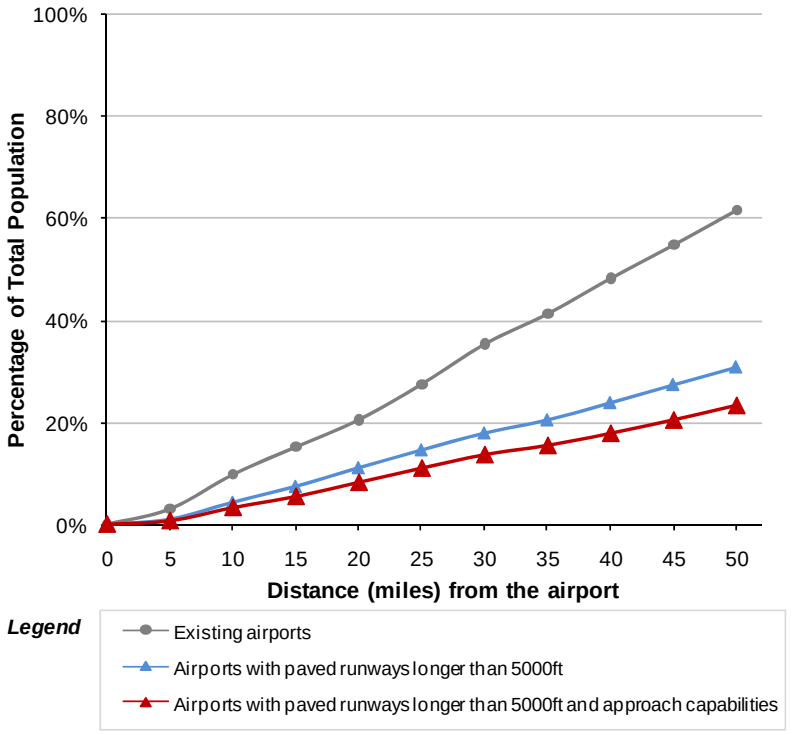
Data sources: DAFIF (2005), ML Infomap, (2002).

Airport System in China



Data sources: DAFIF (2005), All China Marketing Research Co., (2003).

- **Density of the airport network:**
  - 480 airports (140 open to civil operations),
  - High ratio of population over number of airports (i.e. 2.7 million),
- **Airport runway capabilities:**
  - 66% with a paved runway longer than 5,000 ft.
- **Airport approach capabilities:**
  - 16% have at least one ILS or precision approach.
- **Significant improvements are feasible in all three categories;**
- **Initial efforts to address these needs are underway in China.**
  - Plan to increase the density of the national airport network (i.e. 97 new airports by 2020),
  - Development of RNP approaches into several regional airports (e.g. Lhasa, Linzhi, Jiuzhaigou)



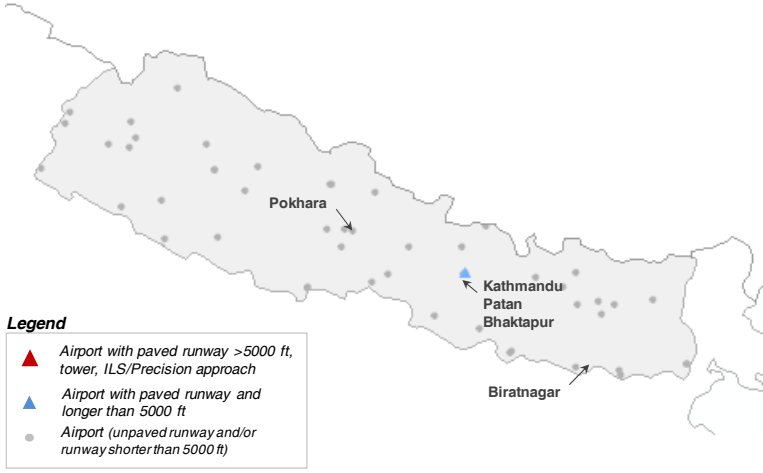
Airport System in Nepal

- **National airport network**
  - 48 airports,
  - 10 with paved runways,
  - 1 with a runway longer than 5000ft,
  - 0 airport with ILS.

- **Due to difficult terrain conditions** (i.e. hilly and mountainous terrain in the northern two-thirds of the country) **the ground transportation network is limited and expensive to build.**

- **Nepal relies heavily on air transportation for regional transport and tourism.**

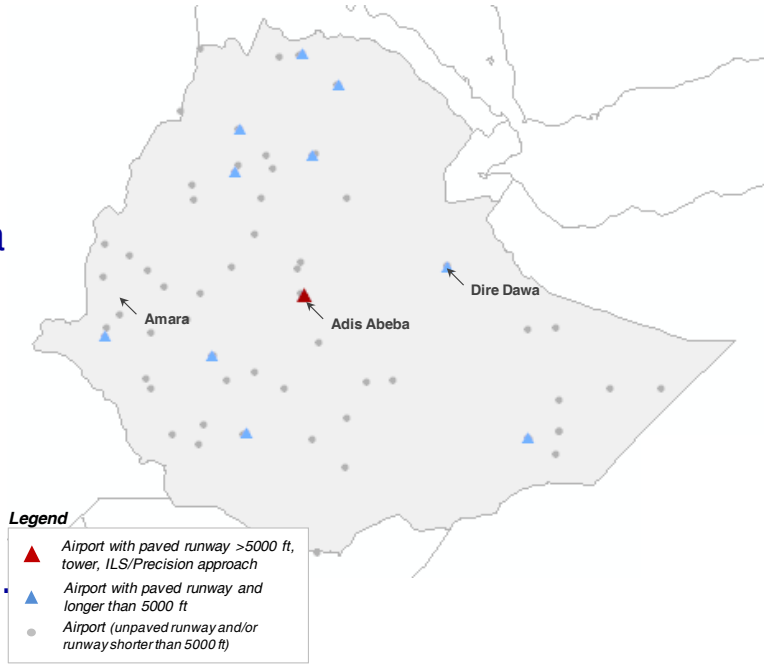
- **Next generation technologies could be used to improve access to existing airports and provide reliable and safe approaches in Nepal's airports.**



Data sources: DAFIF (2005), World Airport Codes (2008).

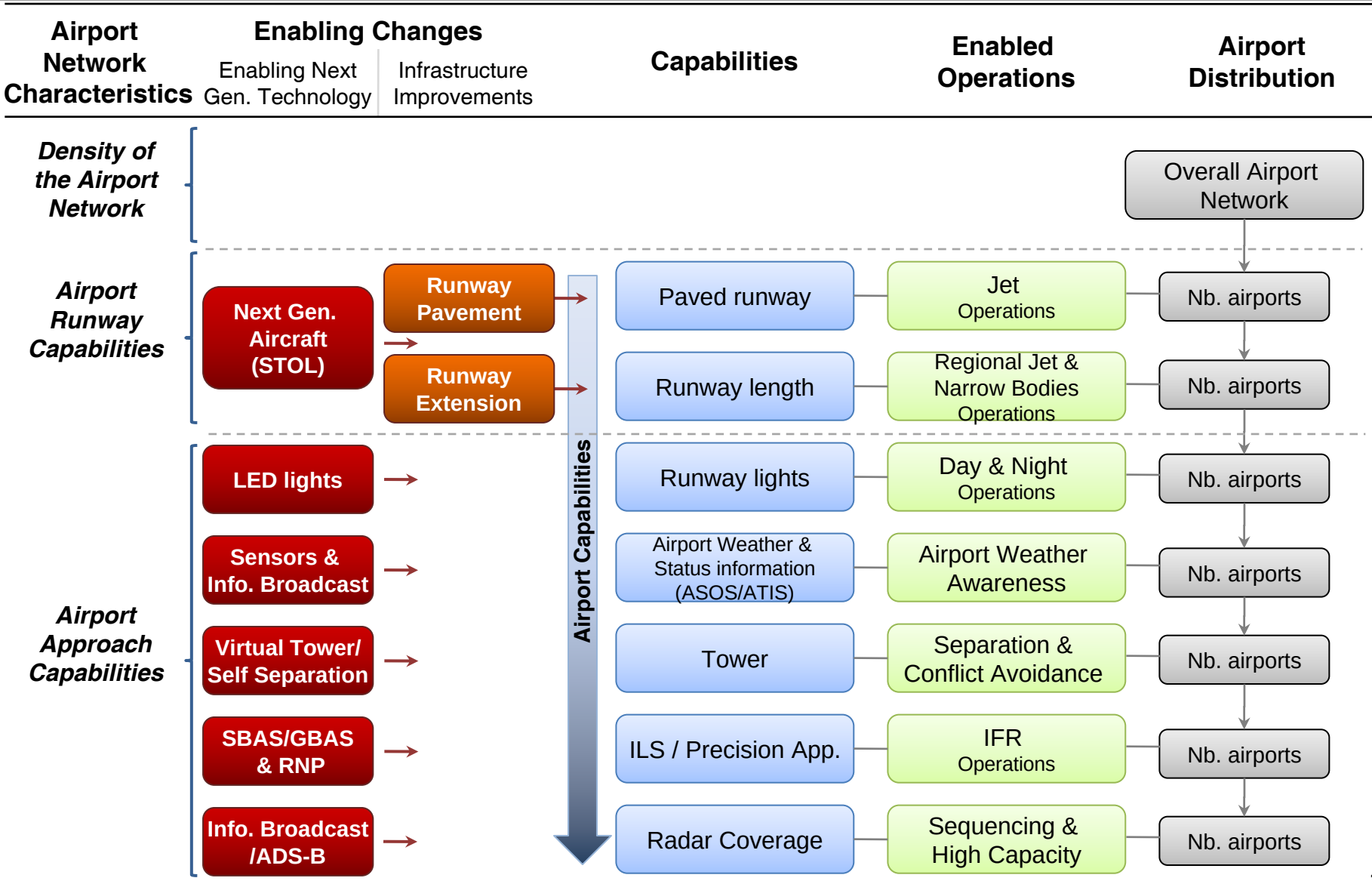
Airport System in Ethiopia

- **National airport network**
  - 84 airports,
  - 13 have runways longer than 5,000 ft,
  - 1 airport is fully equipped.
- **Population: 83 million (in 2007)**
  - second most populous country in Africa after Nigeria
- **Country characterized by an inadequate road transport network.**
  - Fifth lowest road network length per capita in the world,
  - Poor conditions with only 4300 miles of paved roads.
- **Air transportation is an important part of the Ethiopian transportation network.**
- **Improvements in the air transportation network and infrastructure would lead to positive economic impact in Ethiopia.**



Data sources: DAFIF (2005), World Airport Codes (2008).

Opportunities for Infrastructure and Technological Improvements



Conclusions

- **Analyzed**
  - current characteristics and capabilities of 190 national airport systems worldwide,
    - *(1) the density of the airport network with regard to population in each country,*
    - *(2) the airport runway capabilities (of existing airports),*
    - *(3) the airport approach capabilities (of existing airports).*
  - investigated the opportunities for infrastructure improvements including using next generation air transportation system technologies.

- **Analyses showed significant differences between the nature and the capabilities of airport infrastructure across world regions.**
  - North American and the European systems exhibit good access to air transportation due to high density of airports.
  - In other regions such as Asia (e.g. China, India), a latent need for the construction of new airports was identified.

- **Potential from new technologies and capabilities;**
  - improve the efficiency of operations in regions with more mature air transportation infrastructure systems but marginal improvements for enhanced access.
  - in developing and emerging regions that these technologies and capabilities are more likely to have the greatest impact on improved access to air transportation by opening up the set of non-utilized and under-equipped airports.

Questions
&
Comments

Thank you!