MIT Global Airline Industry Program

The Planning of Ground Delay Programs Subject to Uncertain Capacity

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Advising Committee:

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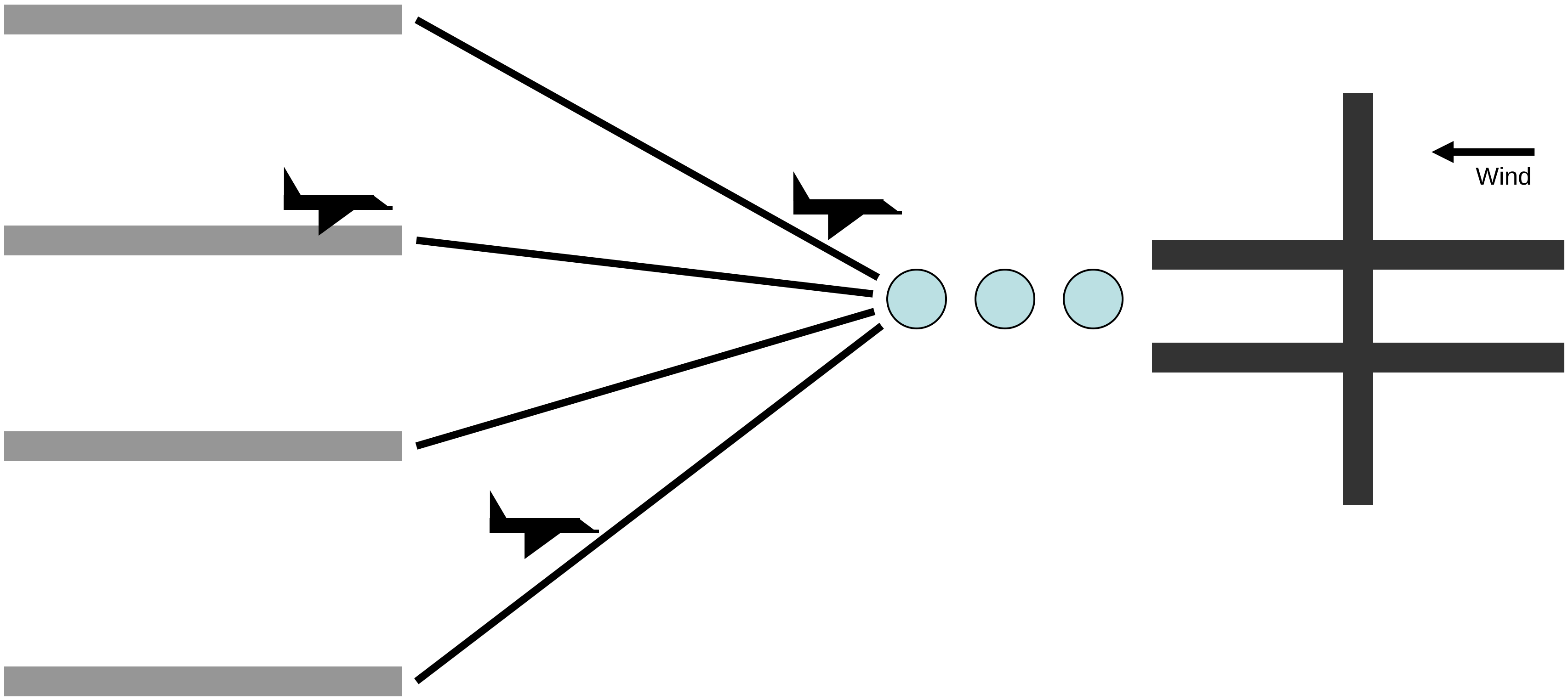
Source: http://www.apo.data.faa.gov/aspm, 23 May 2006

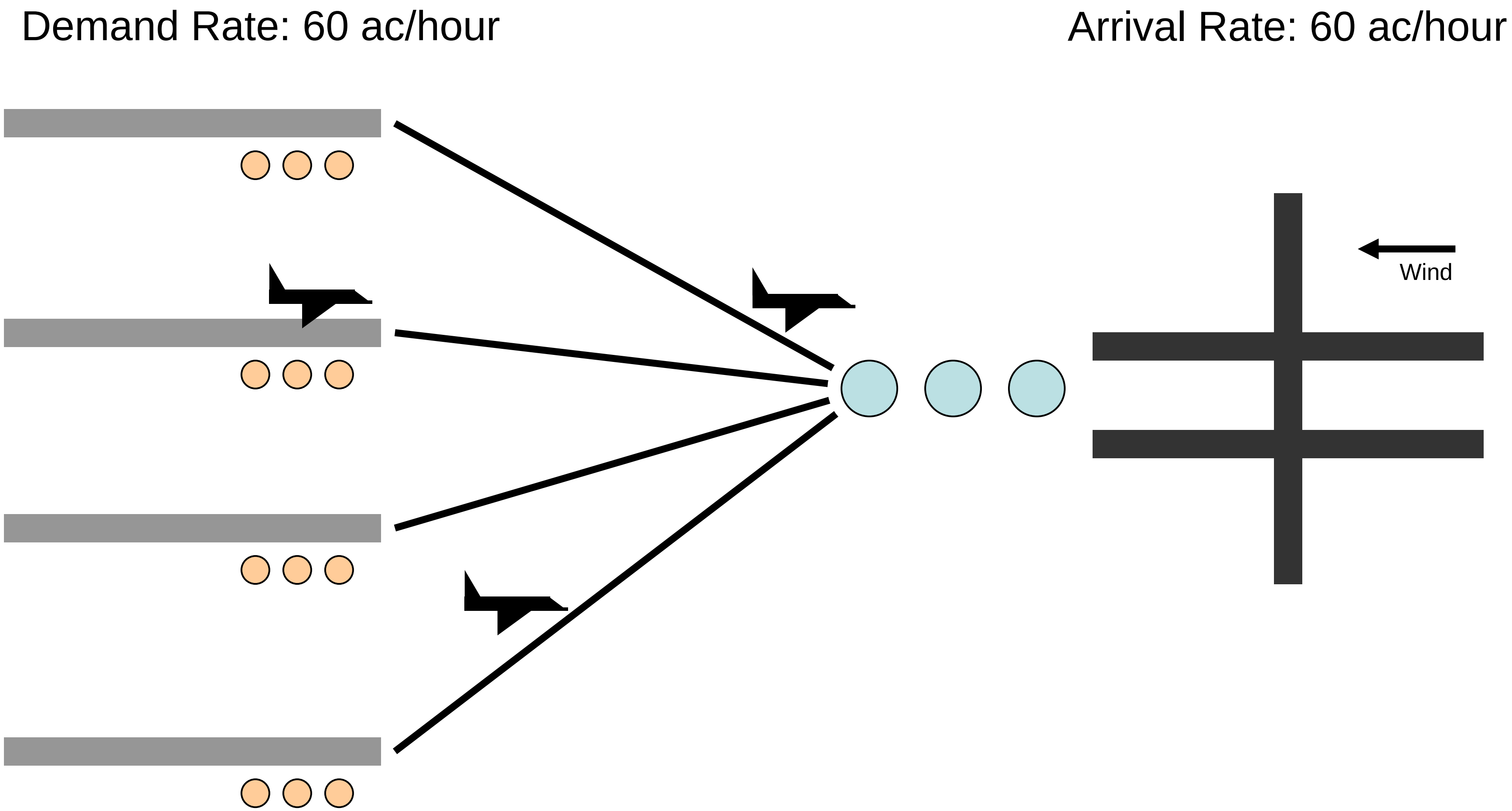
Delays occur when arrival demand exceeds capacity

Demand Rate: 60 ac/hour

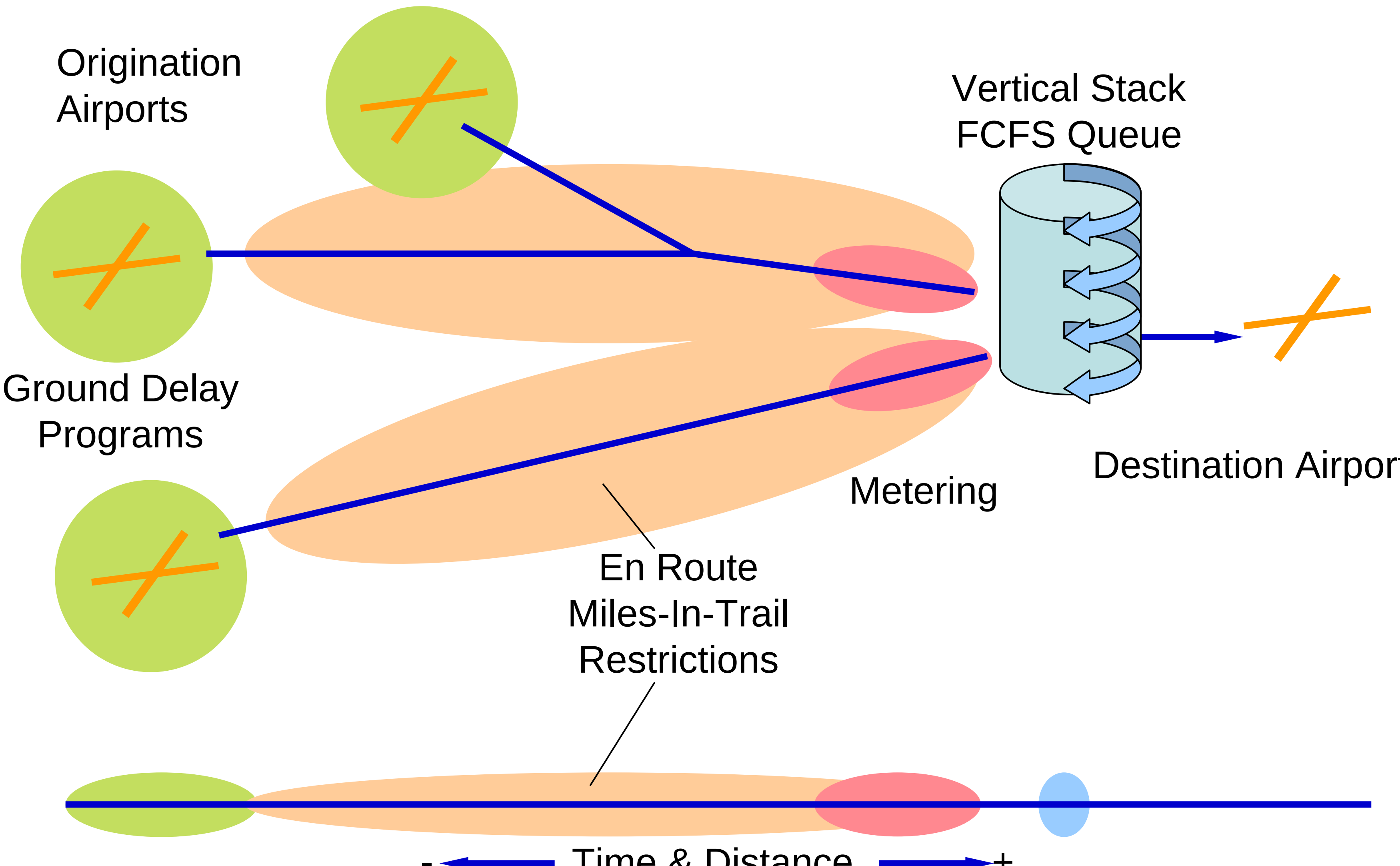
Arrival Rate: 60 ac/hour



GDPs create ground delays to avoid those in the air



Ground Delay Programs require more advance planning than other ATFM tools



GDP design considers two key questions

- How much ground delay should be assigned?
  - Too much causes additional, unnecessary delays
  - Too little and expensive airborne delays may occur

- When should the GDP be created?
  - Waiting means that flights depart and cannot be delayed
  - Additional, improved capacity information becomes available over time

GDPs are both stochastic and dynamic

Academic literature highlights the use of optimization techniques

- Uncertain forecast arrival capacities can be quantified
  - MIT Lincoln Laboratory (2004): use airport-specific meteorological data
  - Hansen and Liu (2006): use historical AARs

- Linear programming techniques can model GDPs with uncertain arrival capacities
  - Odoni and Richetta (1993): stochastic and dynamic conditions
  - Mukherjee and Hansen (2004): aircraft based model

- GDPs with uncertain arrival capacities can be analyzed
  - Hanowsky (2006): Analysis of GDPs with uncertain capacity

Existing literature is concerned with system efficiency

Model IV Objective Function

Minimize: $$\sum_{Q} p_q \times \sum_{F} \left(TDC_{fq} + ADC_{fq} + GDC_{fq} \right)$$

Minimize the weighted sum of delay costs for all flights

Subject To: **DELAY COST**

$$TDC_{fq} = \sum_{t=DT_f}^{T-1} \left(\left(1 - \lambda_{ftq}\right) \times \left(\tau_{t-DT_f+1} - \tau_{t-DT_f} \right) \right) \quad \forall f \in F; q \in Q$$

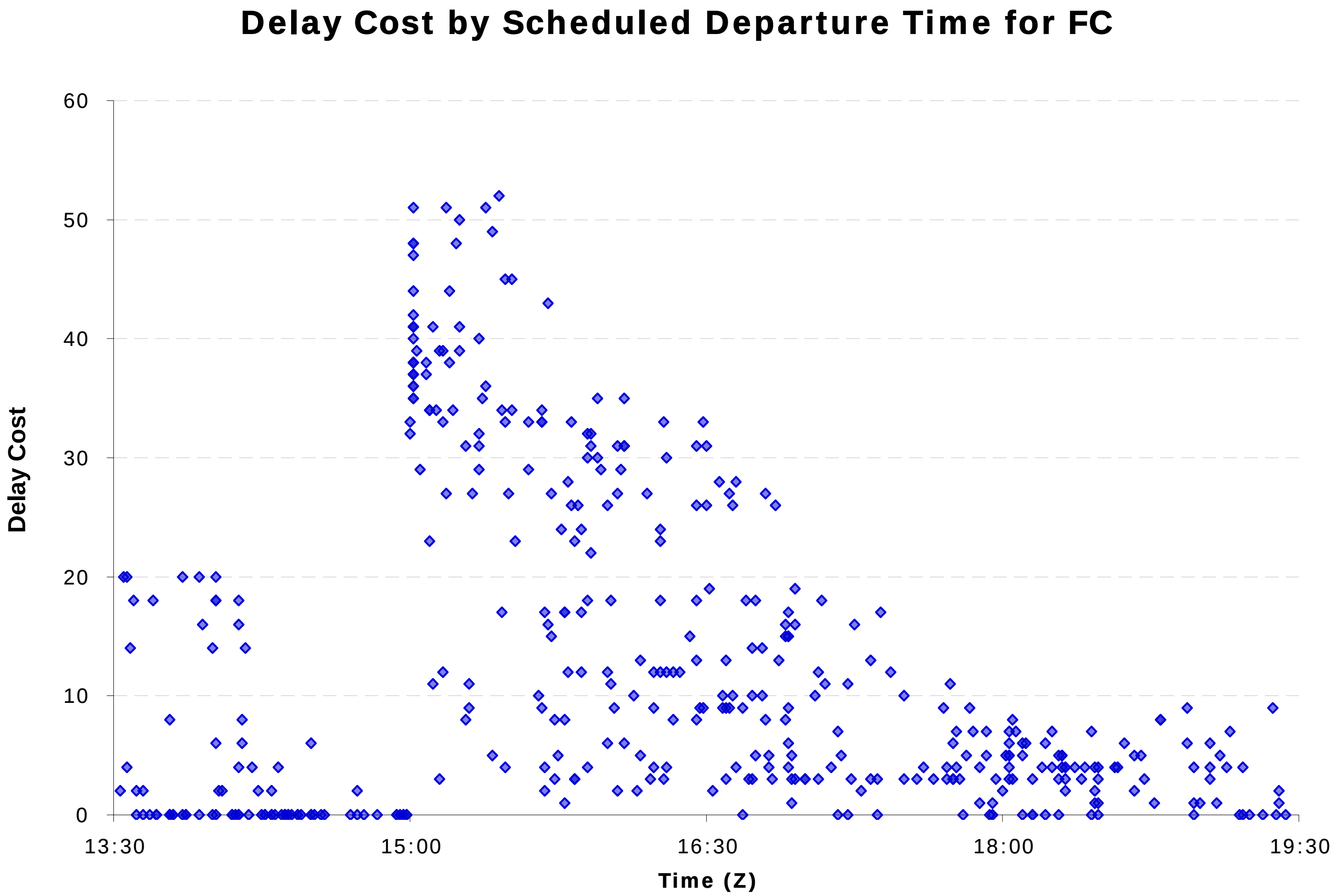
$$GDC_{fq} = \sum_{t=DT_f-ERT_f}^{T-ERT_f-1} \left(\left(1 - d_{ftq}\right) \times \left(\gamma_{t-DT_f+ERT_f+1} - \gamma_{t-DT_f+ERT_f} \right) \right) \quad \forall f \in F; q \in Q$$

$$AD_{fq} = \sum_{T} \left(\delta_{ftq} - \lambda_{ftq} \right) \quad \forall f \in F; q \in Q$$

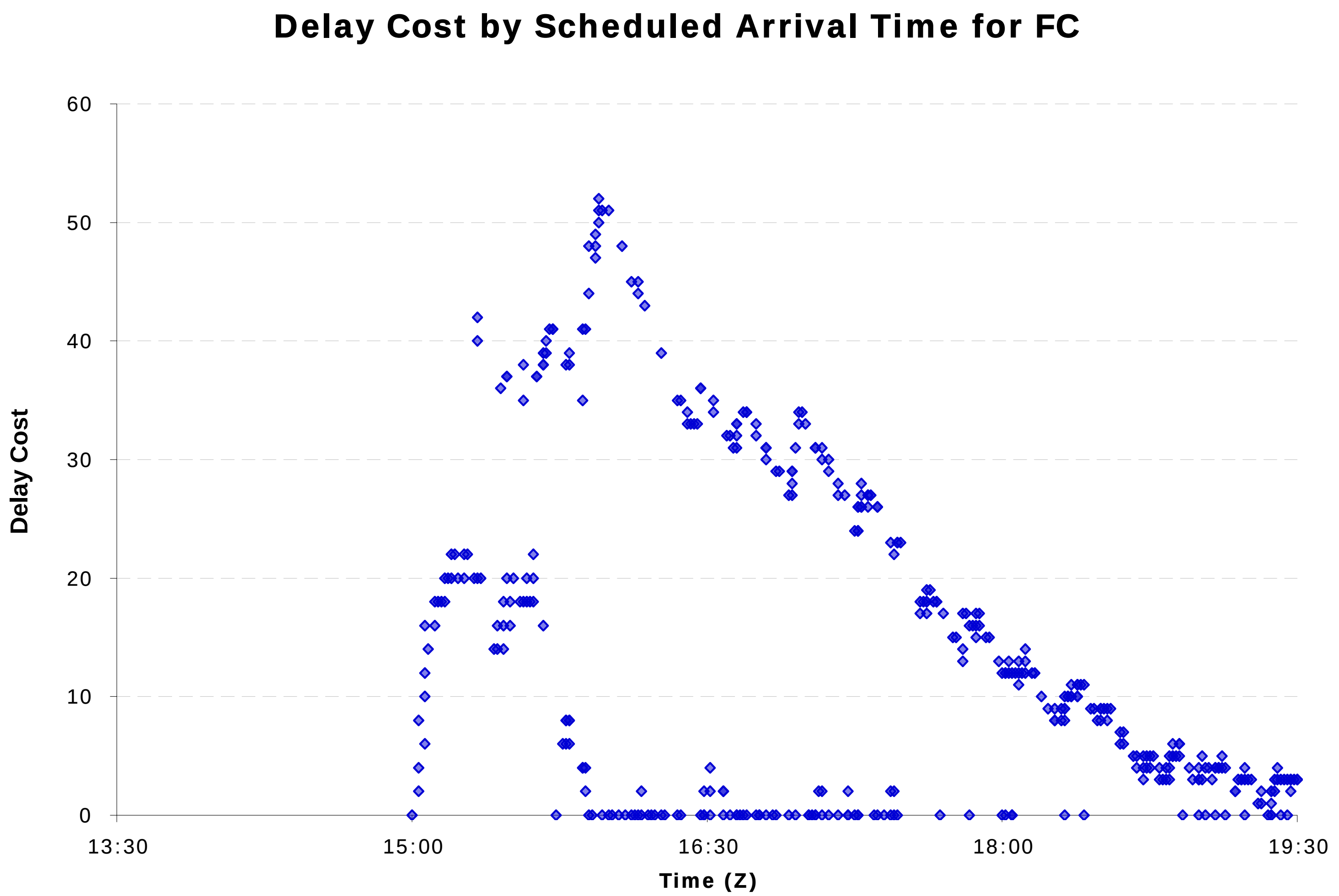
$$ADC_{fq} \geq m_t \times AD_{fq} + b_t \quad \forall f \in F; t \in T; q \in Q$$

From a system perspective, we seek to minimize the total expected cost

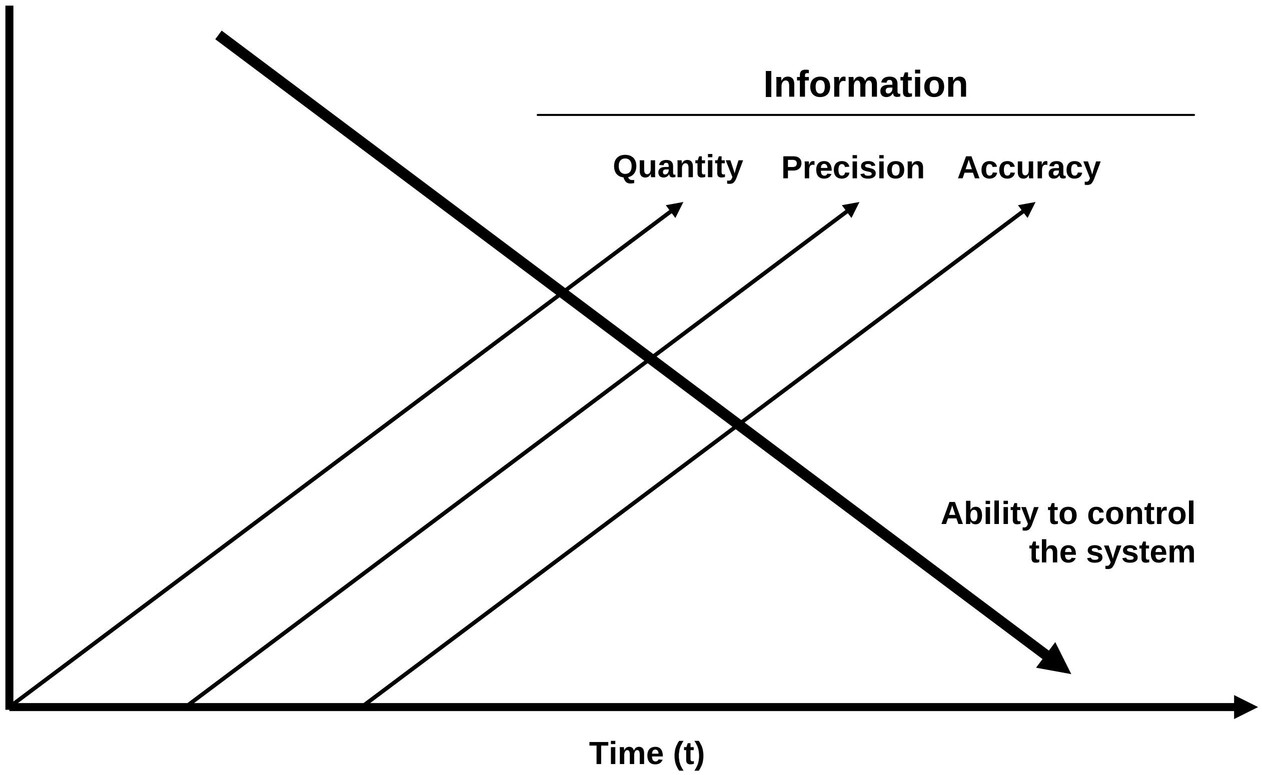
Flight delay by scheduled departure time



Flight delay by scheduled arrival time

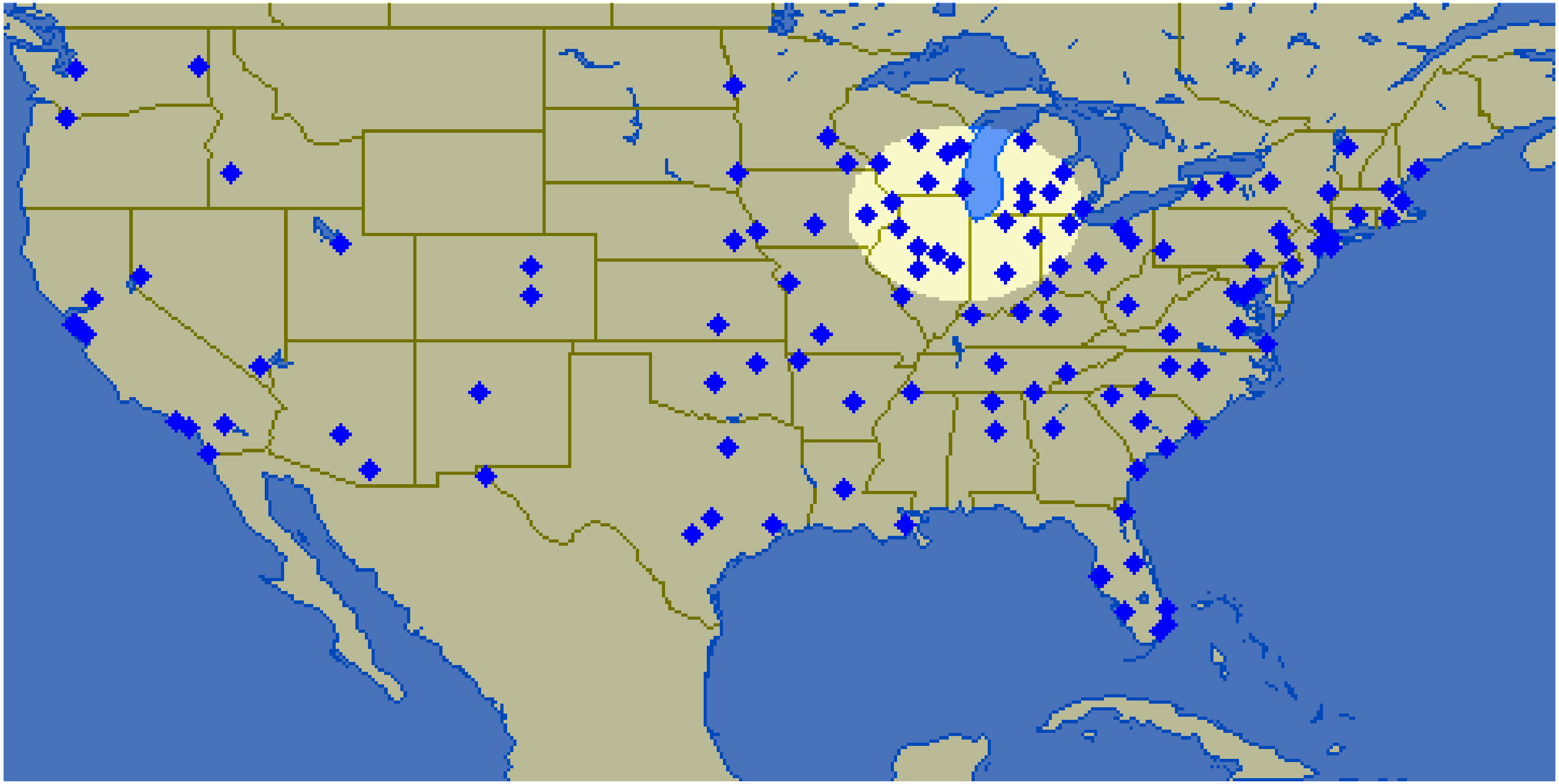


The “wait and see” approach avoids uncertainty

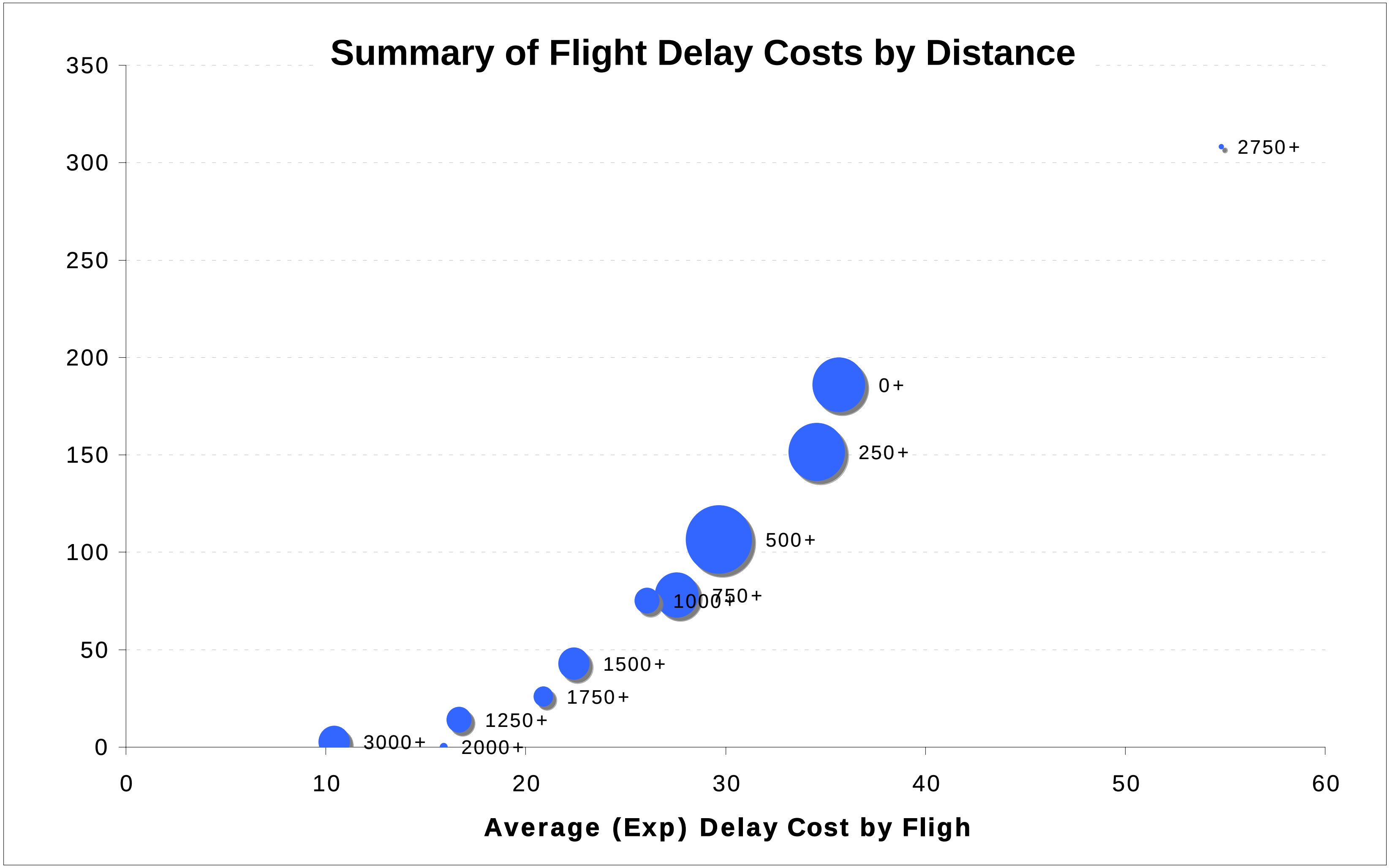


“Wait and see” is reinforced in practice by GDP “scope”

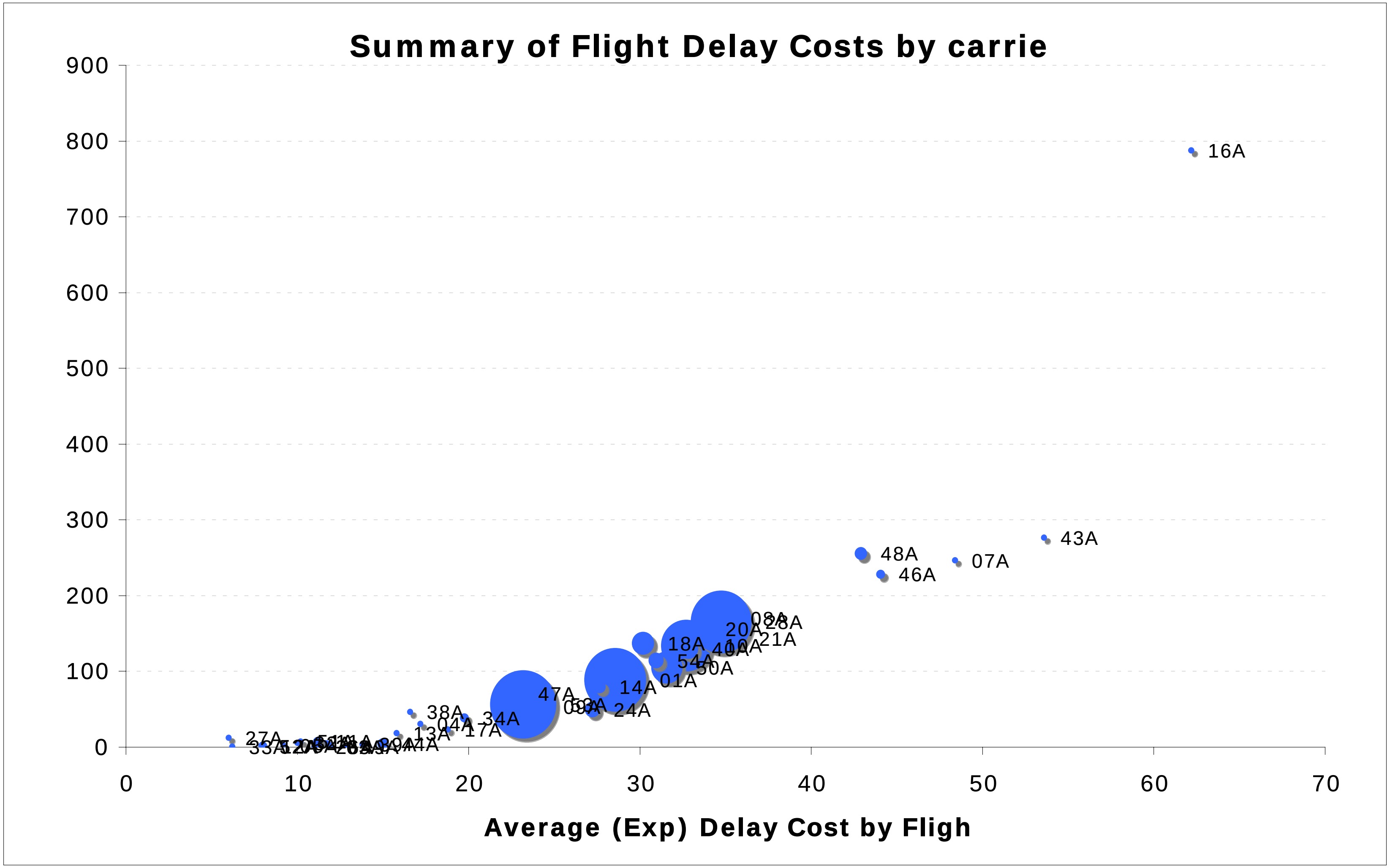
The “wait and see” approach also sets a scope



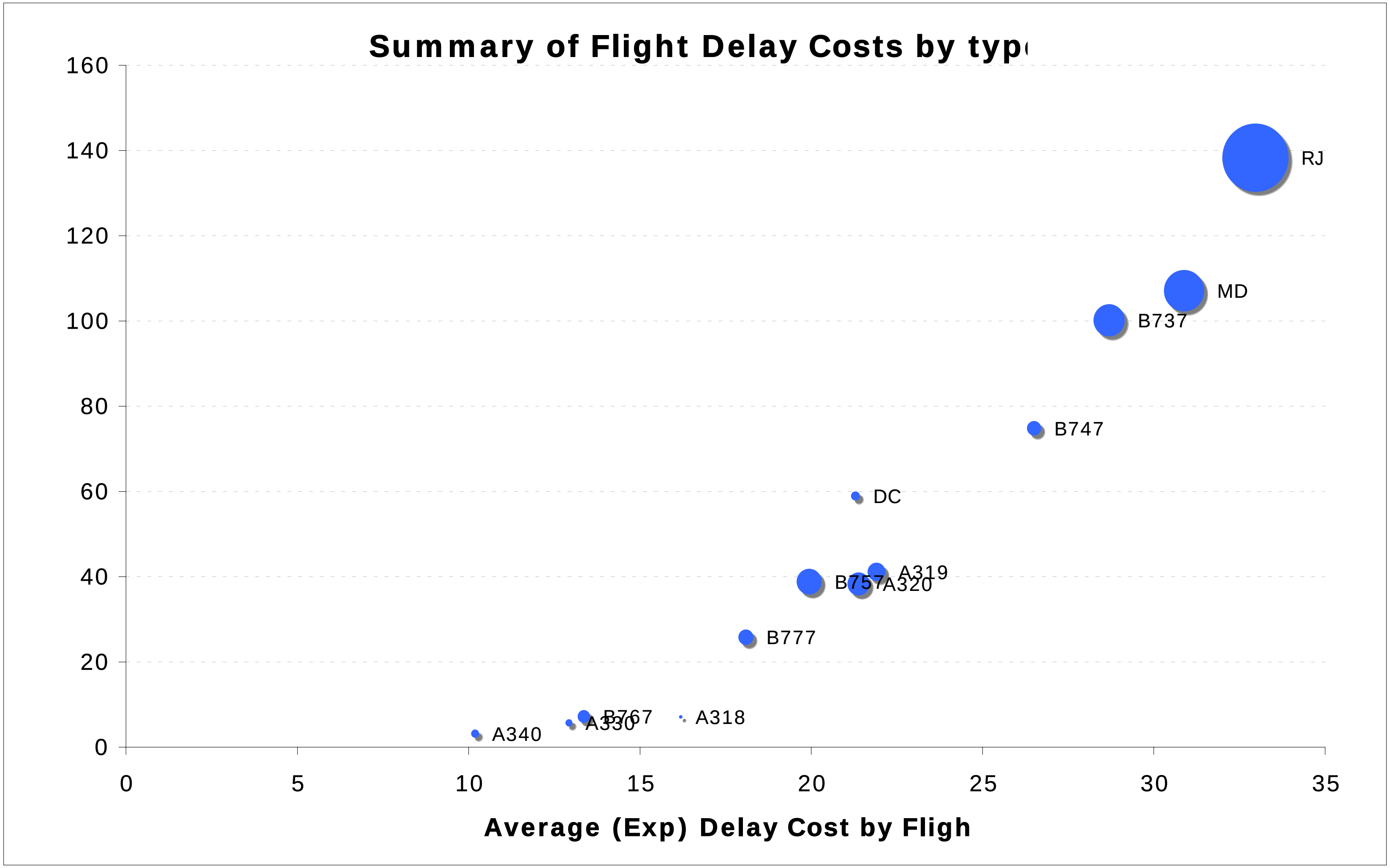
Average and StDev of delay by flight distance



Average and StDev of delay by flight carrier



Average and StDev of delay by aircraft type



GDP-TFM Model Results