Simulating Global Hypersonic Point-To-Point Transportation Networks

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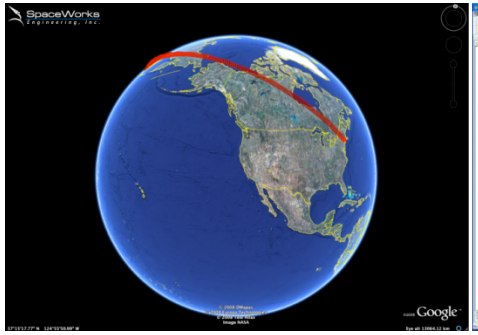
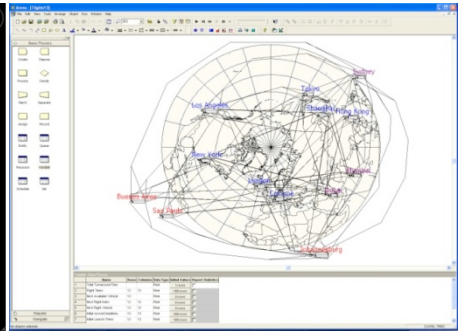
- A **pre-competitive** volunteer group of interested parties who maintain an active discussion of global high speed point-to-point cargo/passenger delivery markets

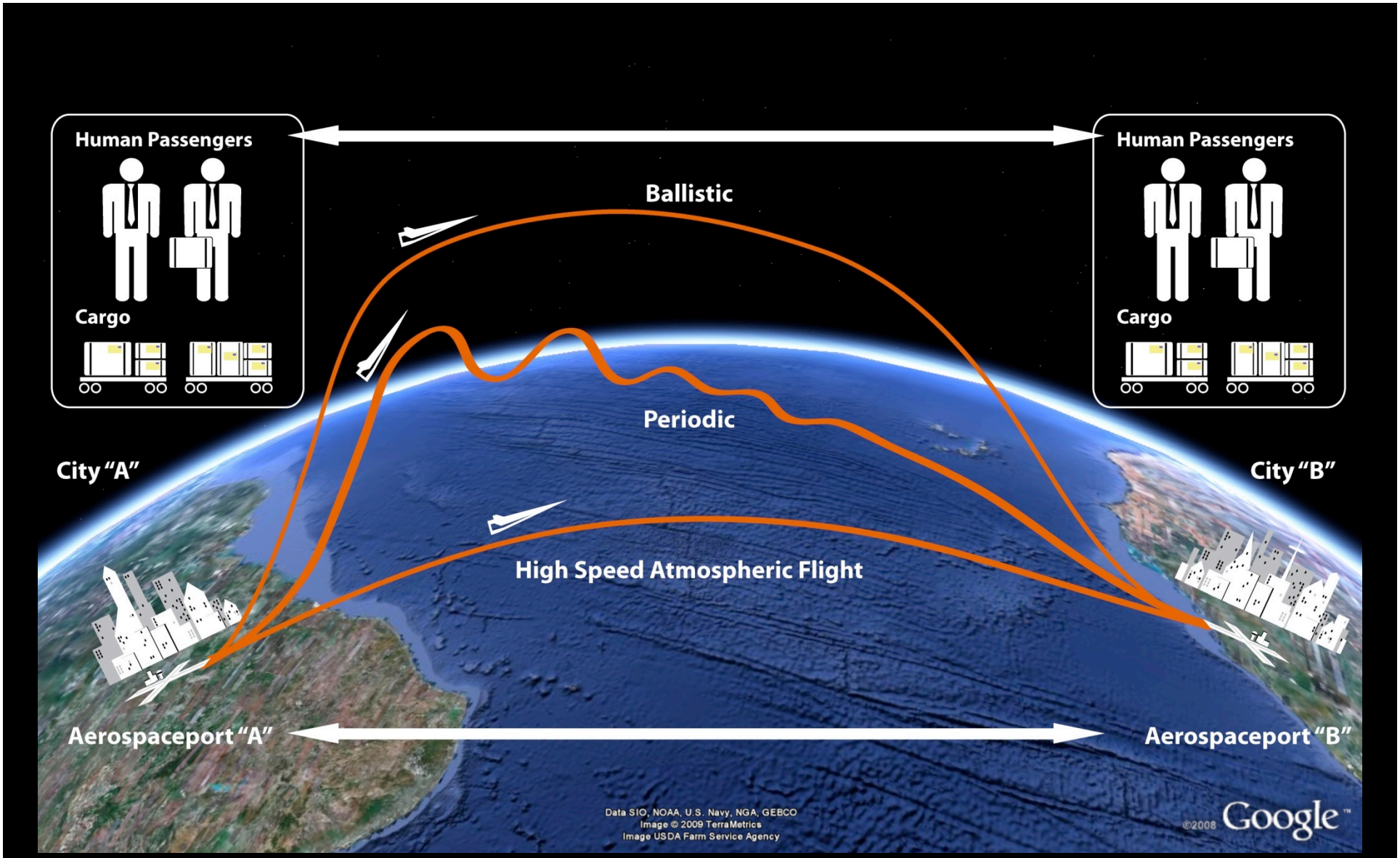
- **Public/Private** participation spanning entrepreneurial space, traditional primes, consultants, spaceports, and federal agencies

- Group started meeting in **October 2008**. Goal is white paper/position paper on this emerging market in 2009





FastForward Study Overview



How: Global High Speed Point to Point Cargo/Passenger Travel

- Tier 1 Cities (7). Chosen as the initial study set based on current express package market sizes.
- Tier 2 Cities (3). Emerging regions that would be best candidates to expand the delivery network.
- Tier 3 Cities (3). Additional regions to result in more global capabilities.

Sources:
-Olds, J., Charania, A., Webber, D., Wallace, J., Kelly, M., "Is the World Ready for High-Speed Intercontinental Package Delivery (Yet)?," IAC-08-D2.4.5, 59th International Astronautical Congress, Glasgow, Scotland, September 29 - October 3, 2008.

Global City Pairs: Candidate Nodes in a PTP Cargo Delivery System

GHoST Calculator

- **Global Hypersonic Shipping Time (GHoST) Calculator models:**
  - **Intercontinental point-to-point transportation routes**
  - **Package delivery services possible based on vehicle and network parameters**
  - **Level of improvement over existing services**

- **Once network is established (e.g. FF cities), research yields data input including:**
  - **Great circle distances between city pairs**
  - **Fastest possible standard service available from UPS and FedEx, including time and price**

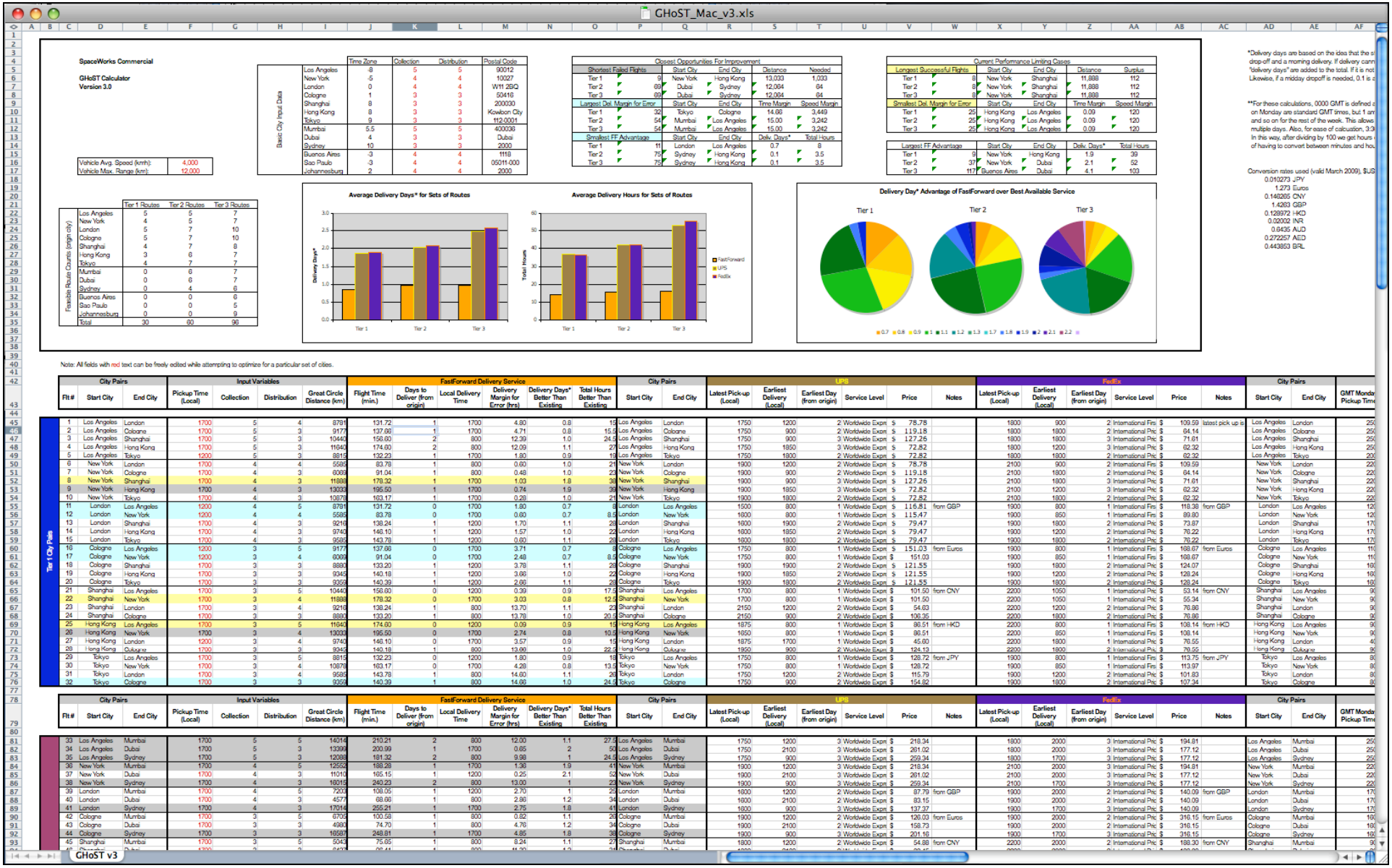
GHoST Calculator Overview

- To accurately describe package delivery service, standardized time metrics are needed
- Delivery Hours
  - Number of real-time hours that pass from package dropoff to delivery
  - If a stopwatch was shipped, what time it would read at delivery
- Delivery Days
  - Assumes service paradigm is afternoon pickup, morning delivery
  - Within paradigm, “next day” is 1 delivery day, etc
  - Delivery by noon adds 0.1 delivery days, end of day adds 0.2
  - Requiring noon pickup also adds 0.1 delivery days

Delivery Time Metrics

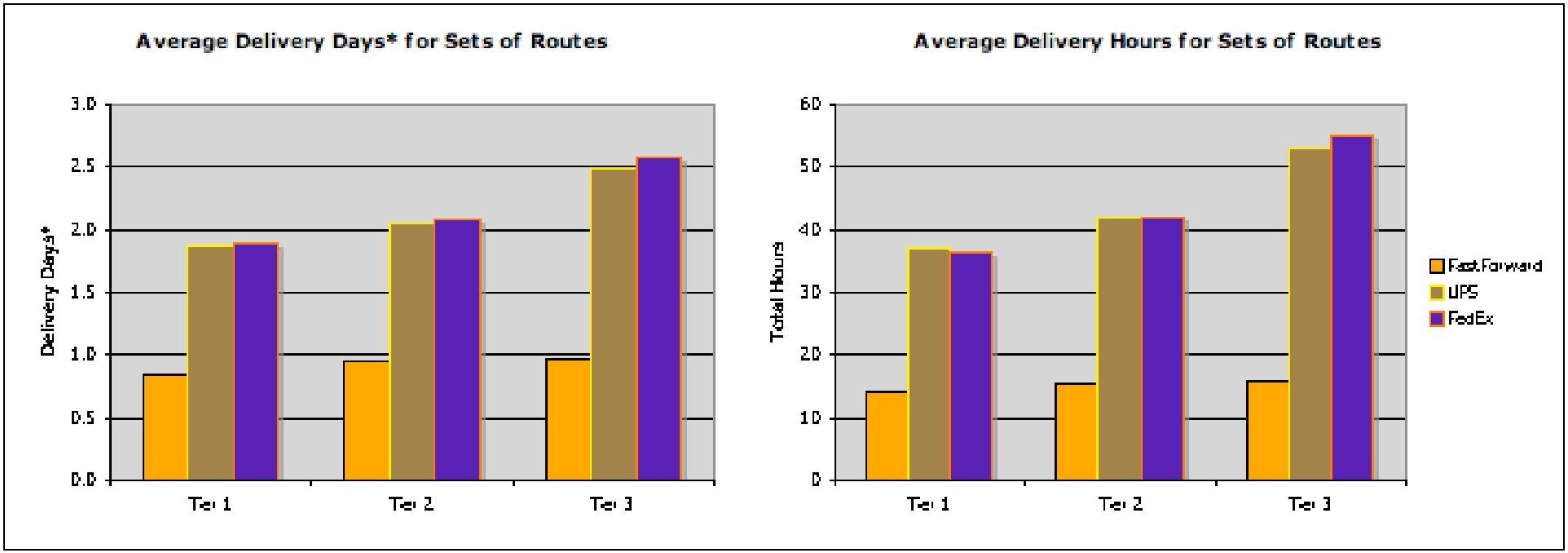
- To analyze a particular proposed vehicle and program, GHoST requires user inputs of:
  - Maximum vehicle range
    - Unfeasibly-long routes are not considered by the calculator
  - Average vehicle cruising speed
    - Used to calculate time required for all feasible flights
  - Local/ground network logistics times for each city
    - Collection time needed from package pickup to plane wheels up
    - Distribution time needed from wheels down to package delivery
    - Both are added to flight time for each leg
  - Desired latest-available dropoff time for each route
    - Earliest delivery based off of these dropoff times
    - These often are adjusted in later stages of analysis

User Inputs



GHoST Calculator Partial Screenshot

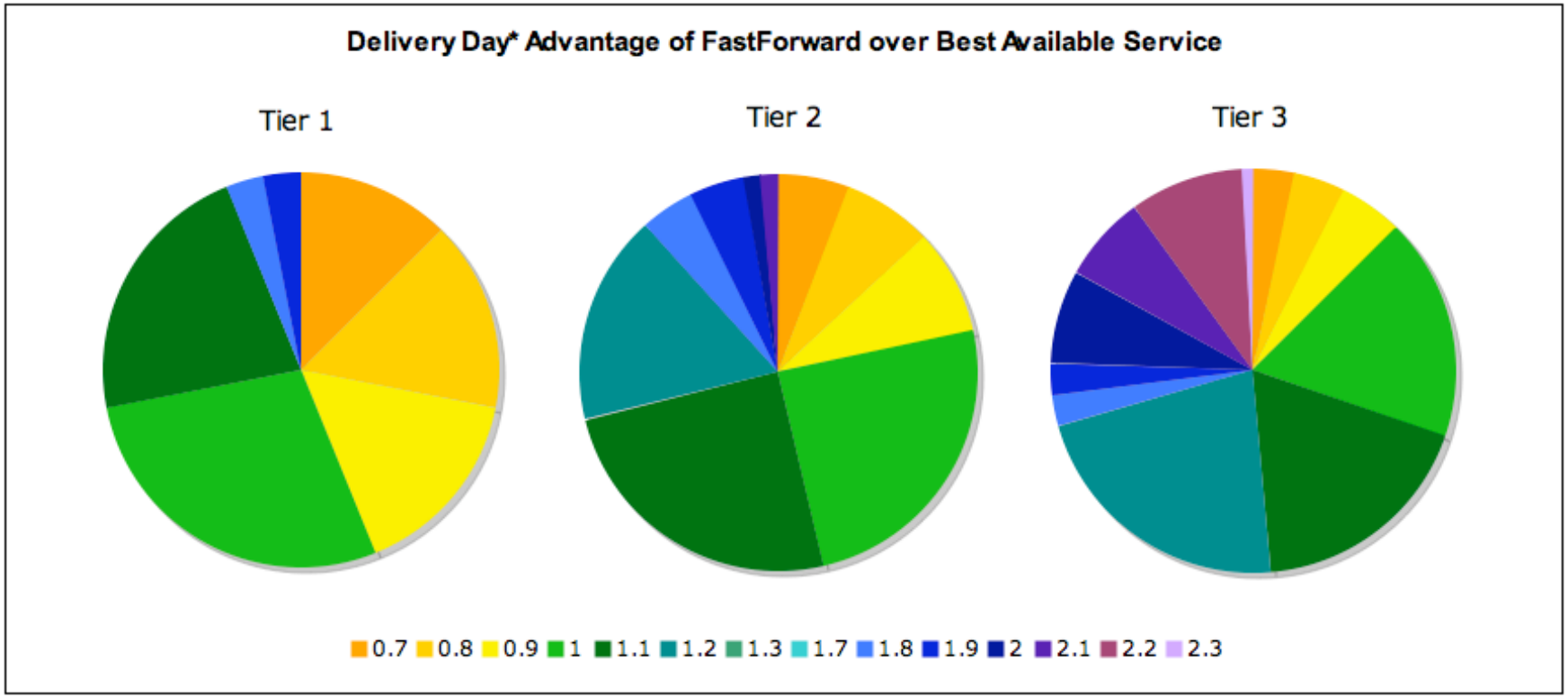
–Comparison of average delivery speed



–Shows new service's average delivery time across feasible routes and existing service average times along same set of routes

Outputs: Average Improvements

– **Distribution of new service's improvement over best available existing service**



– **Yellow tones indicate small advantages, <1 delivery day**
– **Greens and blues are larger advantages**

Outputs: Advantage Over Existing

- GHoST generates tables of two kinds of critical routes
- 'Opportunities' table shows routes that could have improved service with small changes
  - Extended range, earlier pickup time, or faster speed

Closest Opportunities For Improvement					
Shortest Failed Flights		Start City	End City	Distance	Needed
Tier 1	9	New York	Hong Kong	13,033	1,033
Tier 2	69	Dubai	Sydney	12,064	64
Tier 3	69	Dubai	Sydney	12,064	64
Largest Del. Margin for Error		Start City	End City	Time Margin	Speed Margin
Tier 1	32	Tokyo	Cologne	14.66	3,449
Tier 2	54	Mumbai	Los Angeles	15.00	3,242
Tier 3	54	Mumbai	Los Angeles	15.00	3,242
Smallest FF Advantage		Start City	End City	Deliv. Days*	Total Hours
Tier 1	11	London	Los Angeles	0.7	8
Tier 2	75	Sydney	Hong Kong	0.1	3.5
Tier 3	75	Sydney	Hong Kong	0.1	3.5

Current Performance Limiting Cases					
Longest Successful Flights		Start City	End City	Distance	Surplus
Tier 1	8	New York	Shanghai	11,888	112
Tier 2	8	New York	Shanghai	11,888	112
Tier 3	8	New York	Shanghai	11,888	112
Smallest Del. Margin for Error		Start City	End City	Time Margin	Speed Margin
Tier 1	25	Hong Kong	Los Angeles	0.09	120
Tier 2	25	Hong Kong	Los Angeles	0.09	120
Tier 3	25	Hong Kong	Los Angeles	0.09	120

Largest FF Advantage		Start City	End City	Deliv. Days*	Total Hours
Tier 1	9	New York	Hong Kong	1.9	39
Tier 2	37	New York	Dubai	2.1	52
Tier 3	117	Buenos Aires	Dubai	4.1	103

- 'Limiting cases' table shows routes that define service sensitivity to decreasing vehicle performance
  - Minimum range, speed, collection/distribution times

Outputs: Critical Routes

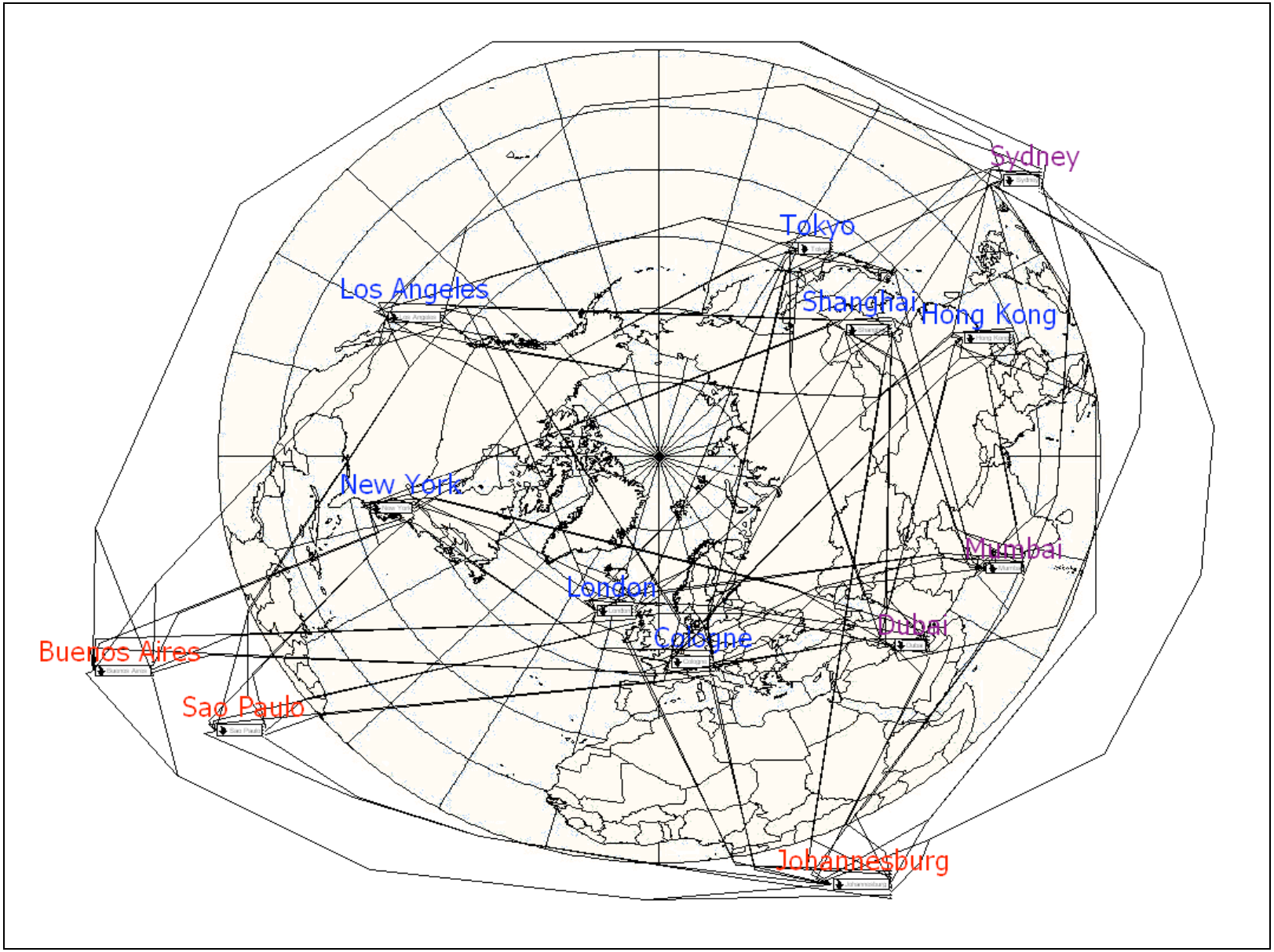
GHoST Calculator Demonstration

GHoST Demonstration

Discrete Event Simulation Model

- Discrete Event Simulation (DES), or the 'Event Scheduling Approach,' is a modeling tool from the Industrial Engineering community
- Any complex system can be represented as a series of discrete events
  - System conditions change at each event
  - System conditions remain constant in between events
  - Some events lead to scheduling of more events
- Can model various entity/resource interactions
- Can use probability distributions to fit real-world randomness
- Applications include supply chains, manufacturing facilities, airports, healthcare facilities… and global point-to-point transportation networks

Discrete Event Simulation



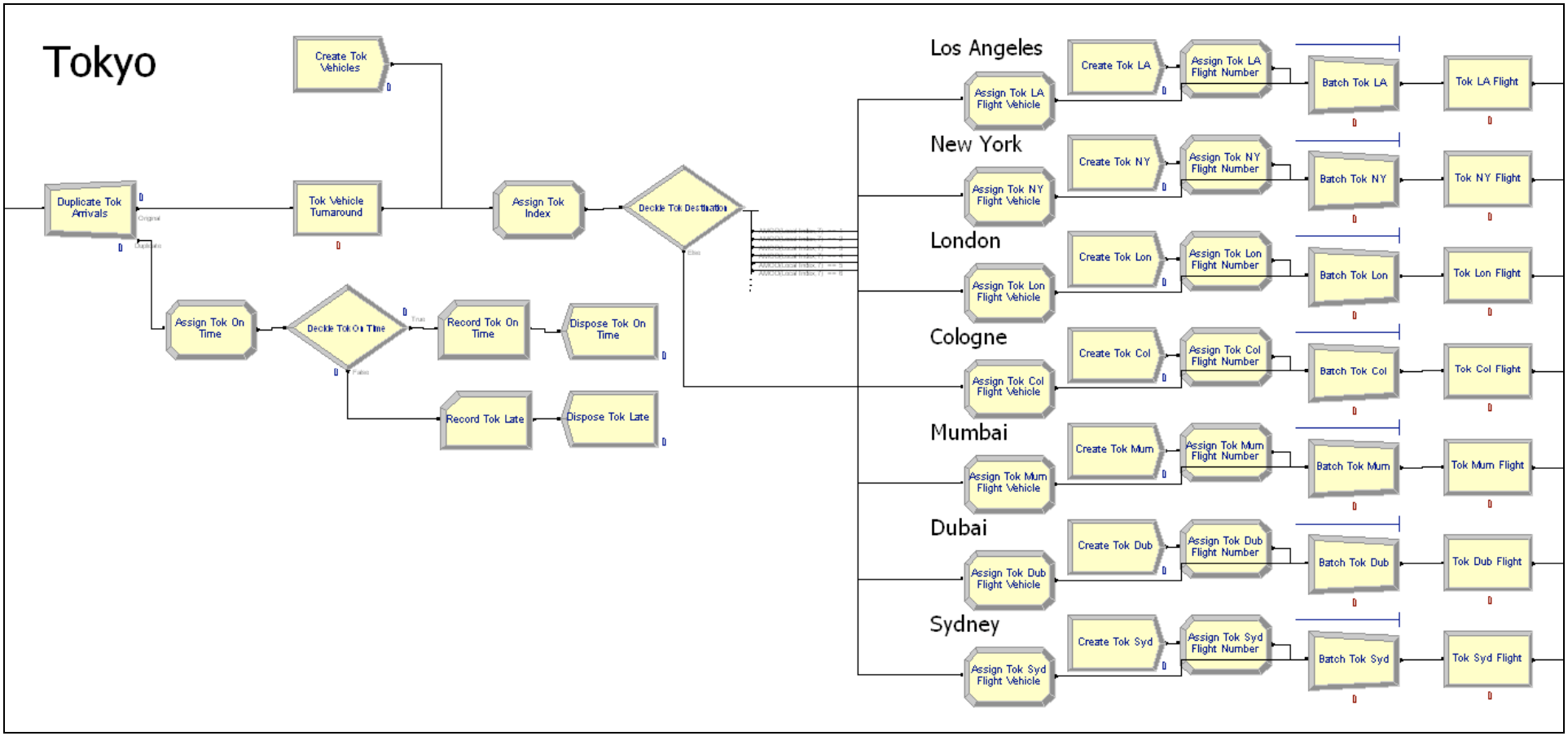
DES Screenshot

- Starts at time 0000
  - Time 0000 defined as midnight Sunday night GMT
  - 2400 = midnight Monday, 4800 = midnight Tuesday
- Runs for one week, or five flights per route
- "Flight" entities generated at set time
- "Plane" entities generated at starting location
  - Planes take flights when both are available in same place
- Plane/flight combination travels to destination city
  - Arrival is checked for on-time/late status
  - Plane is turned around for next flight, then combined with a new flight entity

DES Model Flow

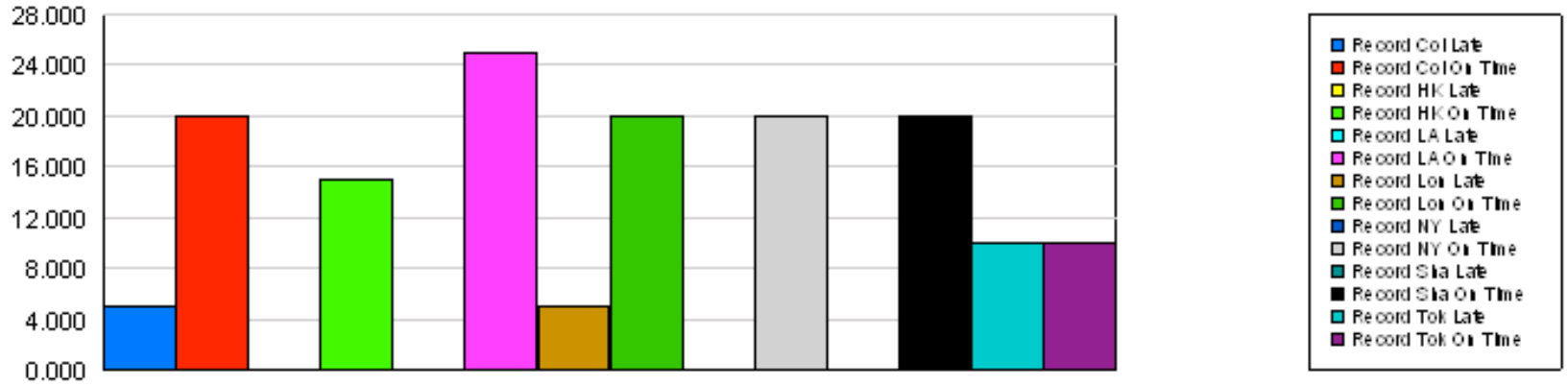
- **Number of planes starting at a city**
  - Generally start with 1 per scheduled daily flight, then adjust up or down
- **First available launch times for each flight**
  - Defined based on local time zone, dropoff time, collection network time
- **Late arrival threshold times for each flight**
  - Defined based on local time zone, distribution network time, desired delivery time
- **Point-to-point flight times**
  - Defined by average speed and great circle distance
- **Vehicle turnaround time**

DES Model Inputs

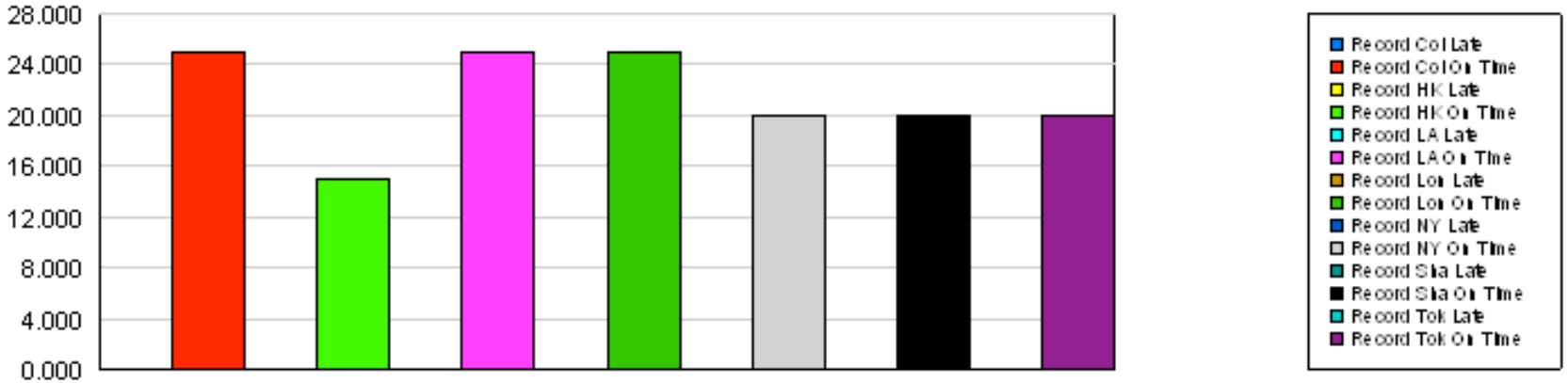


Example: Tokyo Submodel

- **Starting with one plane per route in each city:**
  - **Turnaround time of 18 hours shows some planes are late**



  - **Turnaround time of 6 hours implies slack in system**



Example Scenario

GHoST and DES Applications

- GHoST and the DES used to generated inputs for SEI's Cost and Business Analysis Module (CABAM)
- Inputs included:
  - Vehicle quantities needed
  - Level of service attainable
- CABAM also incorporates:
  - Market demand estimates
  - Availability of funding (private and government)
  - Discount rates and other economic factors
- End result of Net Present Value (NPV) estimates for a point-to-point network

FastForward Support

- GHoST/DES both applicable to various kinds and scales of networks
  - E.g. supersonic business jet point-to-point service
- Insights into importance of program metrics beyond vehicle performance
  - Turnaround time as primary driver of vehicle quantity
  - Collection/distribution time as significant driver of service availability
- Delivery days are a useful way of describing package delivery service
  - Flexible enough for worldwide network
  - Conform to existing industry standard services

Key Outcomes


EAST
FORWARD