Future ATS Strategy Analysis

December 31, 2003

Jesse Johnson
Logistics Management Institute
Technology Assessment &
Resource Analysis Group
703-917-7424
jjohnson@lmi.org

Presentation Overview

- **Pathfinder Background and Study Goals**
- 3x Strategies Description
- Scenario Development and Analysis
- Strategy to Scenario Analysis
- Backup Charts

Pathfinder Prelude

- NASA HQ began Pathfinder Project in Spring 2003
- Analysis framework for the Aeronautics Technology (AT) Theme
- Goal
  - Link AT Theme planning and strategy to an aeronautics investment strategy

First Pass Pathfinder Results

- From the LMI 3x system capacity study
  - A set of possible technology strategy solutions
- But developed and analyzed under only one scenario
  - Are they robust
    - In an uncertain future?
    - Under different scenarios?

Future/Alternative Scenarios

- Developed by
  - FAA-NASA Joint Planning Office
  - LMI
    - "A Method for Evaluating Air Carrier Operational Strategies and Forecasting Air Traffic with Flight Delay," October 1999
  - LMI – GRA
    - "Airline Scenarios for Transportation Demand and Economic Analysis," January 2003

Scenarios are representative, but not exhaustive

Study Goal and Questions

- Examine the robustness of the 3x capacity solution strategies against other scenarios
  - Are they robust?
  - Are additional strategies needed?

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3x Strategies

- Non-stop, point-to-point routing
- Next generation ATM technology
- Regionalized large hub airports
- Service to secondary/local airports
- Introduce new vehicle types to the NAS

Non-Stop, Point-to-Point Routing

- Assuming 3x growth occurs gradually over a 25-year period
  - P-2-P routing is a natural evolution
    - Regional jets support that trend today
  - Starting with today's hub and spoke
    - Increase in demand allows more direct flights while maintaining enough demand to protect hubs
    - Without such a spin off, the frequency of flights on the spokes eventually chokes the hub
    - Each additional direct flight adds another degree of passenger connectivity to the operator's network (it is now a hub-to-hub flight) and at the limit, each airport functions like a pseudo hub

Technology Underpinnings

- Regional jets exhibit one aspect of an enabler
  - Economically serve smaller markets via non-stop, P-2-P routing
- Implicit technology underpinnings
  - Constant marginal increases in demand allow new markets to meet the threshold for service
    - That threshold is in part determined by the smallest economical aircraft
    - Each additional new market aircraft adds to volume of the aircraft flow, and possibly leads to a different aircraft mix
  - Current markets allow for a choice of service levels
    - A tradeoff between smaller or larger aircraft vs. frequency of service
  - Complete P-2-P network uses fewer operations than hub and spoke, but the aircraft fleet mix is different

Next Generation ATM Technology

- Assumes IMC capability equivalent to visual approach conditions (VMC)
- LMI calculated VMC-level runway capacity increases
  - 17% at the five most constrained airports
    - LAX, SFO, EWR, ORD, LGA
  - 102-airport weighted average increase is 14%
  - Individual airports increases vary from 1% to 49%
- Increases in both departure and arrival capacities are needed

Technology Underpinnings

- Hypothesize that data accuracy and communications are greatly improved, which is modeled by:
  - Approach and departure speeds standard deviation reduced by half
  - Positional uncertainties eliminated
  - Communications delay and standard deviations virtually eliminated
  - Standard deviation of wind speed reduced by half
- Arrival runway occupancy time reduced to 38 seconds, standard deviation reduced by half
- Taxi delays reduced in proportion to runway capacity increase
- Input stream gaps eliminated

Regionalized Large Hub Airports

- Areas with multiple large hub airports may increase total operations by
  - Shifting some demand from congested airports to uncongested airports
  - Operating multiple airports as one large airport to maximize total regional operations

Technology Underpinnings

- Mix of demand management and technical issues
- For such a system to work, there must be efficient, fast, all-weather, reliable transportation within the region
  - service via rail, bus, air or sea
- Set of new technologies, concepts, procedures, and rules to link and optimize multiple runways 25 to 75 miles apart

Service to Secondary/Local Airports

- Initiate or expand service to local and/or secondary airports in areas with large congestion or sufficient demand

Technology Underpinnings

- Aircraft capable of using available short runways
- Aircraft and other technologies capable of
  - Reducing perceived noise and emissions to “community acceptable” levels
  - Increasing perceived safety to “customer acceptable” and “community acceptable” levels
- ATM technology capable of
  - Managing aircraft in smaller terminal areas
  - Supporting efficient IFR operations
- Technology able to provide efficient ground operations at smaller airports

New Vehicle Types

- Economical long-haul, small (less than 30-seat) passenger aircraft
- STOL vehicle for short runway secondary airport operations
- Runway independent aircraft for congested airport operations
  - Without stub runways – VTOL capability
  - With stub runways – VTOL not necessary

Technology Underpinnings

- Technologies to enable new vehicle types capable of meeting noise, safety, and economic standards
- ATM technologies, concepts, and procedures capable of safely integrating all new vehicle types into NAS
- Technologies capable of producing efficient ground operations and maintenance for all new vehicle types

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Scenarios

- Defined in “Airline Scenarios for Transportation Demand and Economic Analysis” (NS 255)
  - 4 drivers from relevant economic activity
    - Gross domestic product (GDP) growth
    - Airline yield changes
    - Limits to aviation system growth
    - Substitutes for commercial air travel
  - All defined as high or low
  - Drivers yield 16 possible scenarios
    - 5 plausible and likely (80% collective probability)
    - 3 plausible, but low probability
    - 8 implausible

Joint Planning Office S-EDF Demand Forecasts

- LMI and GRA developed alternate demand forecasts
  - Baseline, high, and low
  - Monte Carlo simulation technique
    - But bounded t cover the 80% cone
- JPO scenarios do not explicitly account for all four economic drivers
  - All drivers are implicitly included in the initial Monte Carlo analysis
  - NS 255 scenarios represent extreme outliers – beyond the 80% cone

Alternative Scenarios Network Types

Scenario	Title	Type of Domestic Network
2	Best of Both Worlds	Mixed H-S & Point-to-Point
4	Economic Growth/Airlines Recover	Hub-Spoke
7	Substitutes Take Share	Mixed H-S & Point-to-Point
12	Growth Limits Prevail	Mixed H-S & Point-to-Point
13	Low-Cost Carriers Dominate	Point-to-Point

Alternative Scenarios - Drivers

Scenario	Plausibility *	GDP growth	Airline yields	Limits to aviation system growth	Substitutes to commercial air travel
2	no	High	High	Few	Poor
4	yes	High	High	Many	Poor
7	yes	High	Low	Many	Good
12	yes	Low	High	Many	Poor
13	yes	Low	Low	Few	Good

* = subjective probabilities determined by study authors

Scenario 2 Description "Best of Both Worlds"

- High GDP growth
- Poor substitutes for commercial service
  - Airlines raise yields (fares)
- Aviation system growth limits are overcome
- Industry matches supply to an increasing demand
- Passengers are not overly price sensitive
- All aviation modes prosper
  - Low-cost carriers (LCC) exist
  - On-demand options are developed
    - But not at the expense of the traditional old-line carriers
- GA passenger miles nearly double

Scenario 4 Description
"Economic Growth/Airlines Recover"

- High economic/GDP growth
- Many limits to aviation system growth
- Poor substitutes for commercial service
- Airlines raise yields (fares)
- Most favorable plausible scenario for major network carriers
- GA passenger miles double

Scenario 7 Description "Substitutes Take a Share"

- Strong economic/GDP growth coupled
- Many limits to aviation system growth
- Many attractive substitutes
- Low fares (and yields)
- On-demand modes experience strong growth
- GA passenger miles more than double

Scenario 12 Description "Growth Limits Prevail"

- Low economic/GDP growth
  - Low/no growth continues beyond 2004
- High limits to aviation system growth
- Poor substitutes to airline travel
- Aviation system growth will be low
- Fares and yields are high
- No introduction of on-demand systems
- GA passenger miles increase 50%

Scenario 13 Description "Low-Cost Carriers Dominate"

- Low economic/GDP growth
- Few limits to aviation system growth
- Few attractive substitutes
  - Low growth of traditional airlines
- Fares and yields are low
- Demand is price sensitive
  - Travel continues to shift to LCC
- GA passenger miles increase by 60%

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Strategy to Scenario Analysis

- All scenarios potentially involve multiple strategies
  - No single strategy drives any scenario
  - No single scenario drives the need for a strategy
- Interactive relationship between the two
  - Any strategy would be implemented over time
  - How the NAS evolves would depend on interactions between the strategies and the scenarios over time
  - Changes in the NAS may alter a strategy and affect the evolution of a scenario

Development of the scenarios over time is not considered in this analysis

Strategy Mapping Criteria

- High – H
  - Strategy enables scenario
  - Scenario not fully functional without strategy
- Medium – M
  - Strategy supports scenario
  - Scenario is more viable with the strategy
- Low – L
  - Strategy marginally affects scenario
  - Scenario is not dependent on the strategy

"Best of Both Worlds" Strategy – Scenario Interaction

- Strong economic growth
- Demand increase in all aviation modes
- Mixed H&S and P-2-P network
- Both old-line and LCC coexist
- New ATM technology handles increase in traffic volume and differing vehicle types
- Additional capacity from
  - Regionalized large hub airports
  - Local and secondary airports
- Unique combination of profits and demand
  - At least three new vehicle types
    - Each thoroughly integrated into the NAS
    - Used by appropriate customer class

“Economic Growth/Airlines Recover” Strategy – Scenario Interaction

- Old-line carriers dominant
  - Minor movement toward P-2-P operations
  - Continued growth in the H&S system
- LCC carriers serve lower yield markets
- Demand shifting and secondary/local airport strategies not needed
- No on-demand modes
  - No new vehicle types

“Substitutes Take a Share” Strategy – Scenario Interaction

- Airline demand lags GDP growth
  - Lower growth rate of traffic
- Aviation system growth limits overcome
  - Alternative vehicles
  - On-demand service
  - Secondary airports
- Hub airports stagnate
  - P-2-P network gains share
  - LCC gain share

"Growth Limits Prevail" Strategy – Scenario Interaction

- All airline sector demand growth lags GDP growth
- Weak demand
  - No introduction of on-demand systems
  - No introduction of alternative vehicles
- Old-line hub carriers shrink
  - Short and medium haul routes outsourced to RJ operators
- LCC gain shares from majors
- New ATM technology enables the increase in operations resulting from the RJ shift

“Low-Cost Carriers Dominate” Strategy – Scenario Interaction

- Low economic growth and weak economy
- Hub airlines falter
  - Market share lost to LCC
  - Medium- and short-haul operations outsourced to RJ operators
  - ATM technology handles the RJ shift
- Few limits on aviation system growth
  - On-demand modes (and their vehicle classes) maintain share

Strategy Mapping

	"Best of Both Worlds"	"Economic Growth Airlines Recover"	"Substitutes Take a Share"	"Growth Limits Prevail"	"Low-Cost Carriers Dominate"
Strategy 1 P-2-P	M	L	M	M	M
Strategy 2 ATM	H	M	H	H	M
Strategy 3 Regional Hubs	M	L	M	L	M
Strategy 4 Local Airports	M	L	H	L	M
Strategy 5 New Vehicles	H	L	H	L	M

Strategy Summary

	H	M	L
Strategy 1 P-2-P	0	4	1
Strategy 2 ATM	3	2	0
Strategy 3 Regional Hubs	0	3	2
Strategy 4 Local Airports	1	2	2
Strategy 5 New Vehicles	2	1	2

Strategy Gap

- "ATM Technology" represents the most important strategy in this set, driving three of the five scenarios and a key role in the other two
- "New Vehicles" enable two scenarios, but does not affect two of the remaining three
- "Local/Secondary Airports" drives one scenario and important in two others
- "Point-to-Point and "Regionalized Hubs" are not key drivers of any scenario
  - But "Point-to-Point" is slightly more important because there are relatively few regions capable of supporting the regionalized hub concept

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“Best of Both Worlds” Alternative Description

- Traffic growth level
  - Airline demand exceeds historic relationship with GDP growth
- Locus of growth
  - Further growth in both hub-and-spoke and P-2-P networks
  - Growth by both LCC and old-line carriers as all available airports come online
    - All carriers share a piece of an enlarging pie
- New systems
  - On-demand modes with a variety of specialized vehicles are developed to serve niche customers and special markets

"Best of Both Worlds" Metrics

Parameter	Base Value	2022 Value	Annual Growth Rate (%)
Domestic Passenger RPMs	513 B	1,153 B	4.6
Type of Domestic Network	Hub-spoke	Mixed H-S & Point-to-Point	
International Passenger RPMs	181 B	599 B	6.5
Domestic Cargo RTMs	14.7 B	45.7 B	6.5
International Cargo RTMs	14.5 B	49.0 B	7.0
Belly versus all cargo split			
Domestic cargo	30/70	25/75	
International cargo	50/50	50/50	
GA passenger miles (@ 65 percent LF)	13.9 B	24.7 B	3.2
Single-engine	2.9 B	5.1 B	3.2
Multi-engine	4.4 B	7.9 B	3.2
Jet-engine	6.6 B	11.7 B	3.2

“Economic Growth/Airlines Recover” Alternative Description

- Traffic growth level
  - Tracks GDP growth closely
- Locus of growth
  - Further growth in hub-and-spoke system
  - Growth by LCCs and others serving low-yield sectors at secondary airports
- New systems
  - On-demand modes do not improve relative to scheduled service

“Economic Growth/Airlines Recover” Metrics

Parameter	Base Value	2022 Value	Annual Growth Rate (%)
Domestic passenger RPMs	513 B	1,056 B	4.1
Type of domestic network	Hub-spoke	Hub-spoke	-
International passenger RPMs	181 B	500 B	5.5
Domestic cargo RTMs	14.7 B	38.5 B	5.5
International cargo RTMs	14.5 B	41.4 B	6.0
Belly versus all cargo split			
Domestic cargo	30/70	25/75	-
International cargo	50/50	50/50	-
GA passenger miles (@ 65 percent LF)	13.9 B	28.2 B	4.2
Single engine	2.9 B	4.5 B	2.6
Multi-engine	4.4 B	6.8 B	2.6
Jet engine	6.6 B	16.9 B	5.7

“Substitutes Take Share” Description II

- Traffic growth level
  - Airline demand exceeds historic relationship with GDP growth
- Locus of growth
  - Hub airlines grow
  - LCC grow
  - Expanded point-to point travel in domestic and international markets
- New systems
  - Point-to-point travel by carriers implies smaller average aircraft sizes; growth in on-demand modes lags growth of scheduled services because there are few limits to aviation system growth and substitutes are unattractive

“Substitutes Take Share” Metrics

Parameter	Base Value	2022 Value	Annual Growth Rate (%)
Domestic passenger RPMs	513 B	1,232 B	5.1
Type of domestic network	Hub-spoke	Mixed H-S & Point-to-point	-
International passenger RPMs	181 B	599 B	6.5
Domestic cargo RTMs	14.7 B	45.7 B	6.5
International cargo RTMs	14.5 B	49.0 B	7.0
Belly versus all cargo split			
Domestic cargo	30/70	25/75	-
International cargo	50/50	50/50	-
GA passenger miles (@ 65 percent LF)	13.9 B	26.4 B	3.9
Single engine	2.9 B	5.5 B	3.9
Multi-engine	4.4 B	8.4 B	3.9
Jet engine	6.6 B	12.5 B	3.9

“Growth Limits Prevail” Alternative Description

- Traffic growth level
  - Airline growth lags the historic relationship with GDP growth; on-demand systems (SATs, fractionals, etc) will grow rapidly from small base levels
- Locus of growth
  - Hub airports stagnate
  - Non-hub airports have high growth
  - LCC and P-2-P modes gain share
- New systems
  - On-demand modes take an increasing share of short and medium haul trips by air because there are many limits to aviation system growth and substitutes are attractive

"Growth Limits Prevail" Metrics

Parameter	Base Value	2022 Value	Annual Growth Rate (%)
Domestic passenger RPMs	513 B	1,056 B	4.1
Type of domestic network	Hub-spoke	Mixed H-S & Point-to-Point	-
International passenger RPMs	181 B	599 B	6.5
Domestic cargo RTMs	14.7 B	45.7 B	6.5
International cargo RTMs	14.5 B	49.0 B	7.0
Belly versus all cargo split			
Domestic cargo	30/70	22/78	-
International cargo	50/50	50/50	-
GA passenger miles (@ 65 percent LF)	13.9 B	33.8 B	5.4
Single engine	2.9 B	3.9 B	1.7
Multi-engine	4.4 B	5.2 B	1.0
Jet engine	6.6 B	24.7 B	8.1

“Low-Cost Carriers Dominate” Alternative Description

- Traffic growth level
  - LCC grow relative to network carriers
  - Network carriers stagnate and try to shift parts of their networks to RJs
- Locus of growth
  - Secondary carrier airports
- New systems
  - On-demand modes maintain shares because there are few limits on aviation system growth

"Low-Cost Carriers Dominate" Metrics

Parameter	Base Value	2022 Value	Annual Growth Rate (%)
Domestic passenger RPMs	513 B	828 B	2.7
Type of domestic network	Hub-spoke	Point-to-Point	-
International passenger RPMs	181 B	348 B	3.5
Domestic cargo RTMs	14.7 B	27.3 B	3.5
International cargo RTMs	14.5 B	32.0 B	4.0
Belly versus all cargo split			
Domestic cargo	30/70	27/73	-
International cargo	50/50	50/50	-
GA passenger miles (@ 65 percent LF)	13.9 B	22.1 B	2.8
Single engine	2.9 B	3.5 B	1.2
Multi-engine	4.4 B	5.3 B	1.1
Jet engine	6.6 B	13.3 B	4.2

Scenario Dependence on Strategies

	"Best of Both Worlds"	"Growth with Airline Recovery"	"Substitutes Take a Share"	"Growth Limits Prevail"	"Low-Cost Carriers Dominate"
H	2	0	3	1	0
M	3	1	2	1	5
L	0	4	0	3	0

Scenario Gaps

- “Best of Both Worlds”, “Substitutes Take a Share” and “Low-Cost Carriers Dominate” are strongly affected by all five strategies - their evolution is conditional on the development of all or most of the strategies
- “Growth with Airline Recovery” and “Growth Limits Prevail” depend only on the development of the P-2-P and ATM technology strategies