Transformation in Transportation Systems of the 21st Century

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JPDO Heritage

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U.S. Public Law HR 2115 Section 709-710

Integrated Plan for the Next Generation Air Transportation System
Outline

1. What is transformation?
2. How do we lead transformation?
3. How do we think about transformation?

*Network theory considerations offer additional understanding about strategic thinking for complex, adaptive systems, and their transformation*
Anticipated Growth in Airport Congestion

- 18 airports that will need additional capacity
- 8 metro areas that will need additional capacity
Whither or Wither?

US Airlines Net Profit Model - 2002
Best Fit of Undamped Oscillation
Cycle Period = 11.3 yr  eFolding Time = 7.9 yr

Predictions
2003 ($14.3B)
2004 ($13.2B)
2005 ($ 7.0B)

NB: Predictions are in constant 2000 dollars.
The Widening Gap Between Legacy and Low Cost Carrier Operating Costs

Cost vs. Stage length

What’s Really Happening Here?

Trends in Aircraft Size

Data source: Form 41 Traffic data from Bureau of Transportation Statistics (includes Regional Jets and Turboprops)
The Notional Life Cycle
of The Innovation Called Airline Travel

Cumulative Growth in Air Travel
Through Improvements, Efficiencies, & Economies

Fleet Management (Bankruptcies)

Demand Management

New Fare Structures

Regional Jets

Frequent Flier Programs

Low Cost Carriers

Hubbing

Deregulation

Turboprops

VHF Communication

VOR Navigation

Turbojets

ILS

Radar Surveillance

1950

2010

Pretzels

Internet Sales
Notional Life Cycles in Transportation

Cumulative Intercity Transit Market Growth
Diverted & Induced

Model T Assembly Line DC-3 First VORs
Cars Displace Trains
Jet Transports

Propliners Displace Cars
Jetliners Displace Props

Transformation in Air Mobility


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Comparison of Actual and Theoretical Speed of Doorstep-to-Destination Travel

Great Circle Distance, nm

On-Demand
Jet-Taxi
Hub-Spoke
Rules of the Game Are Changing

“Sir, the following paradigm shifts occurred while you were out.”

MANKOI
Technological Underpinnings for Transformation

1. Moore’s Law on microprocessor cost/performance
2. Gilder’s Law on bandwidth performance
3. Metcalf’s Law on network performance
4. The unwritten law of abundance
5. The unwritten rule of gridlock
6. Kurzweil’s Law of Accelerating Returns
7. The Golden Rule of the information age
A Perfect Storm

Delays
Congestion
Demand Management

Technologies

Growth in Air Travel
Through Improvements, Efficiencies, & Economies

Security
SARS
Avian Flu

On-Demand Jet-Taxi
Hub-Spoke

Great Circle Dist

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Why Transformation?

• The current aviation system does not scale to meet future needs related to*
  - Aircraft
  - Airports
  - Airspace
  - Commerce and Business models
  - Environmental considerations
  - Security and safety considerations

• Evolution and modernization plans do not lead us to the changes needed beyond 2015

• Transformation requires change across government agencies

• The results of transformation produce new business models, new regulatory models, and new uses of airspace, airports, and aircraft

• The outcome of transformation is to enable scalability to meet the nation’s needs in commerce, mobility, security, and safety

The pace of change in today’s world demands context-derived strategic thinking.

**Incremental Execution**
- Negotiation-Derived Strategies

**Strategic Thinking**
- Context-Derived Strategies

Context-derived strategies create relentless execution toward a vision
And
Help avoid failures of imagination.
Building the JPDO Scenario Space

Drivers are coalesced into dimensions for plausible future worlds

- World Economy and Market Environment
- Political Instability
- International Trade Environment
- Global Transportation Infrastructure
- Global Distribution of Power & Technology
- U.S. International Policies
- Prevalence of Violence, Terrorism, and War
- U.S. Military Posture
- State of the Environment
- US population growth rate
- US migration patterns
- US population distribution by age
- US population distribution by urban/suburban/rural areas
- US population distribution by geographic region
- US population migration relative to hub-and-spoke locations
- US population distribution by heritage and family origins (travel implications)
- US population by distribution of knowledge-worker (value of time)
- US population by distribution of leisure time (value of time)
- Education trends
- Congestion as a decision factor in quality of life
- Family structure, dynamics, distance
- Value of time
- Urban, Suburban, Rural quality of life factors
- Inequalities, inequities
- US GDP growth rate
- World GDP growth rate
- International trade environment
- Extent of 'globalization' of business and finance
- Land use patterns, constraints, and competition
- World Economy and market environment
- Availability of & Climate for capital for innovation (Venture, Angel, Commercial)
- Public investment in R&D
- Equity in mobility by geography, by income
- Transportation energy sources
- Environment
- Geopolitics
- Technology
- Aviation System Factors

Scenario Dimensions
- U.S. Economy
- Pace of Globalization
- Global Trend in Transportation Architecture
- Impediments to Aviation Growth and Development

Five Worlds of 2025
Work as a set to define an environment for strategy synthesis
**JPDO Strategies for Transformation**

1. Harmonize **Equipage and Operations** Globally
2. Enable Innovative **Airport** Planning & Management
3. Integrate Air Transportation **Security** Activities
4. Develop **Air Traffic Management** that can Respond to Market Changes
5. Establish User-specific **Situational Awareness**
6. Establish a Comprehensive Proactive **Safety** Management Approach
7. **Accelerate** Adoption of New Operations and Technologies
8. Develop **Environmentally Friendly** & Sustainable Technology
9. Develop System-wide Capability to Reduce **Weather** Impacts
   - Create a national enterprise architecture for transformation
An Ecosystem Illustrates The Need for Topology

“Laws of Form” lead to individual actions that lead to the behavior of complex adaptive systems
ISO (or OSI) Stack

LonTalk ISO-Model Protocol Stack

1. Physical
2. Link
3. Network
4. Transport
5. Session
6. Presentation
7. Application

As a metaphor for a transportation system topology
Physical Layer
For Three Air Transportation Networks

A. Hub-and-Spoke
Directed, Scheduled, Aggregated
Jet Routes
User-Determined
Direct

Legacy Carriers
Hub-and-Spoke
CFAR 25, 121, 139

B. Point-to-Point
Directed, Scheduled, Aggregated

Low-Cost Carriers
“Focus Cities”
CFAR 25, 121, 139

C. Distributed
Undirected, On-Demand
Dis-Aggregated

Un-piloted Air Vehicles
GA, Business, Corporate Fleets
New Very Light Jet Fleets
Runway Independent Aircraft
Supersonic Overland
Micro Air Vehicles
A Proposed Air Transportation Network Topology

Domain Layers

- Mobility Layer (Passengers, Cargo/Internet-Telcomm)
  - A. Hub-and-Spoke: Directed, Scheduled, Aggregated
  - B. Point-to-Point: Directed, Scheduled
  - C. Distributed: Undirected, On-Demand, Disaggregated

- Operator Layer (Pilots-Crew/VHF Comm)

- Transport Layer (Aircraft/Radar)

- Physical Layer (Airports/Routes)

Business Model Stacks

- Physical Layer
- Transport Layer
- Operator Layer
- Mobility Layer

Network Management

- Communication
- Navigation
- Surveillance

Airspace Architecture

- Airspace Services
- Airspace Procedures
- Commercial Services

As a guide for HOW to think about transformation
Distributed (Scalable) Air Mobility

• 93% of population within 30 minutes of SATS-type airport
• 22% within 30 minutes of major/hub airport
• ~700 airports with Instrument Landing Systems
Q: What policy and technology strategies reduce the friction, or improve the impedance matching between the layers?

Scalability: On-Demand
A. Hub-and-Spoke
Directed, Scheduled, Aggregated
B. Point-to-Point
Directed, Scheduled, Undirected, On-Demand, Dis-Aggregated
C. Distributed
Investors
Customers
Directors
Value
Chain

Scalability: Single-pilot

Scalability: Lower $/mph

Scalability: Every Runway End/Airport

Scalability: Every Runway End/Airport

Policy Changes Enable Scalability of Business Stacks
## Transformation
### As a Campaign Against the 20th Century

<table>
<thead>
<tr>
<th>System</th>
<th>20th Century</th>
<th>21st Century</th>
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<tbody>
<tr>
<td>Communication</td>
<td>Analog, Voice, Shared Frequencies</td>
<td>Digital, VXML, Addressable</td>
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<tr>
<td>Airport networks</td>
<td>Hub-and-Spoke</td>
<td>Widely Distributed</td>
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<tr>
<td>Air Traffic Services</td>
<td>Ground-Centric</td>
<td>Airborne-Centric</td>
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<tr>
<td>(Separation and Sequencing)</td>
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<tr>
<td>Air Transportation Services</td>
<td>Scheduled</td>
<td>On-Demand</td>
</tr>
<tr>
<td>Air Crews</td>
<td>Two-Pilot</td>
<td>Single-Pilot Un-Piloted</td>
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<tr>
<td>Network Tools</td>
<td>Linear</td>
<td>Non-Linear</td>
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<tr>
<td>Cargo &amp; Package Delivery</td>
<td>High-density markets, next-day service</td>
<td>Thin markets, same-day service</td>
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<tr>
<td>Economic Opportunity</td>
<td>Centralized</td>
<td>Diffused</td>
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<tr>
<td>System Responsiveness</td>
<td>Brittle</td>
<td>Resilient</td>
</tr>
<tr>
<td>System Growth</td>
<td>Constrained</td>
<td>Scalable (Up or Down)</td>
</tr>
</tbody>
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Hierarchical networks require strong links for high performance in conditions of certainty, and perform weakly in conditions of ambiguity, uncertainty, disruption.

Multi-scale networks require “weak links” for high performance in conditions of ambiguity, uncertainty, disruption, and perform poorly in conditions of certainty and stability.
The vision includes expanding scalability along all dimensions.
Integrated Plan for the Next Generation Air Transportation System

For More Information: http://www.jpo.aero
Summary


2. A Transportation Topology Serves as a Framework for Strategic Thinking

3. Strategies for Transformation Work as “Laws of Influence”

Network theory considerations offer additional understanding about strategic thinking for complex, adaptive systems.
Thank You