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# Technology Policy and Economic Growth in Air Transportation:

## *Towards Metrics & Investment Incentives*

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CENTER FOR AIR TRANSPORTATION  
SYSTEMS RESEARCH



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# Motivation 1

- **JPDO: What are *investment incentives* for industry (airlines, vendors) in ATS modernization (e.g. NGATS)?**
- What is the *Return on an Investment*?
- What are *Costs and Benefits* of modernization?
- What is *impact of modernization initiatives* on the Air Transportation System (ATS)?
- What are *Economics of ATS*?

# Motivation 2

- ATO Strategic Management Process
  - **4.1 Assure a Sustainable Air Traffic System**
  - 4.5 Develop Alternative Biz Concepts
- Sustainability by definition is the ability to adapt to emerging changes as part of the process
  - Ability to predict, change, innovate
  - Process Maturity (Humphreys)
    - 1-Chaotic, 2-Repeatable, 3-Deterministic, 4-Robust, 5-Innovative)
- Metric for Sustainability of the Air Traffic System
  - Leads to alternative biz concepts

# Motivation 3

- Interactions and dynamics of ATS are not well understood
  - Media, political staffers, managers & engineers in supply chain

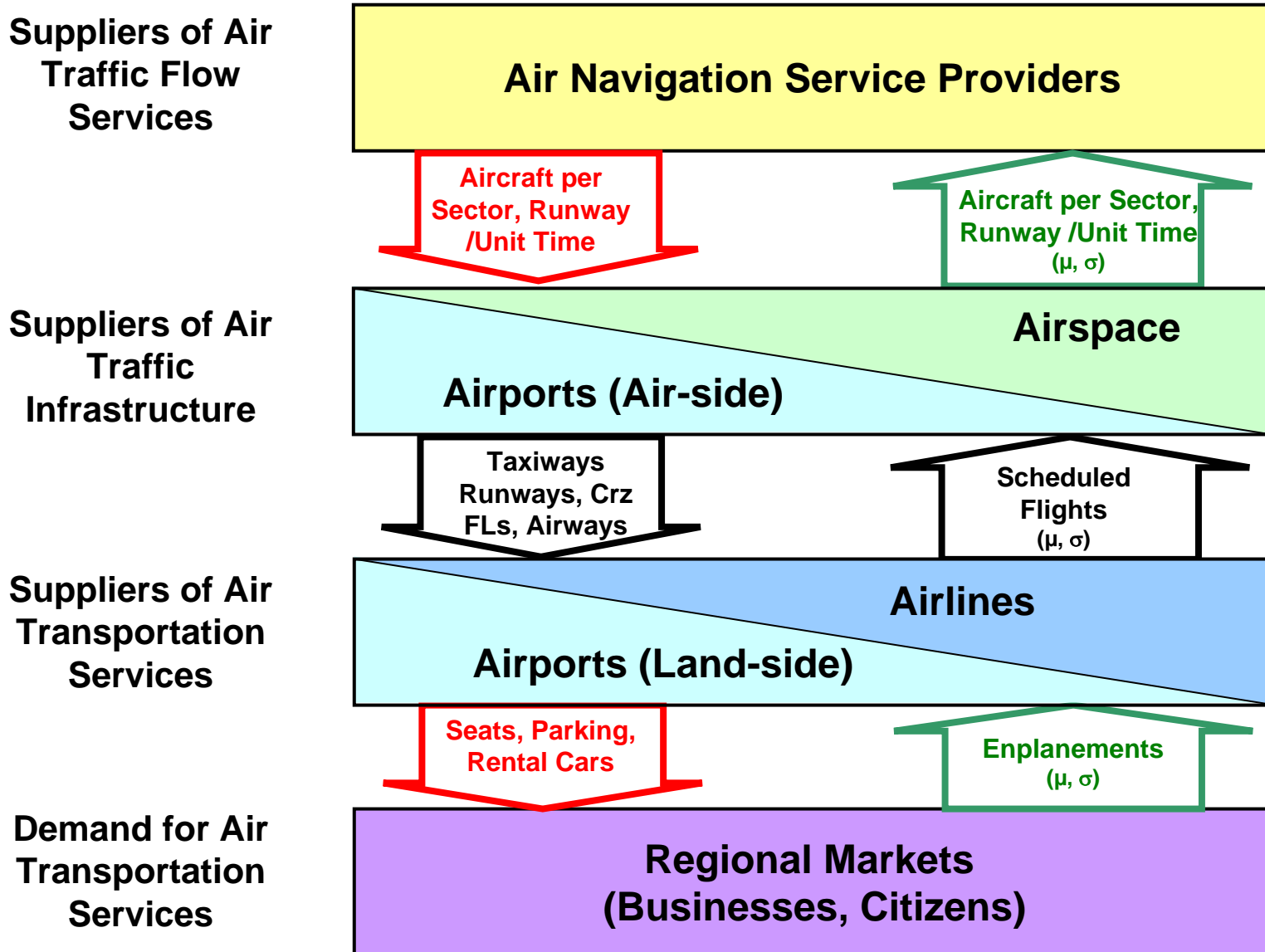
# Note on Metrics Philosophy

- Categories of Metrics
  1. States of network System
    - e.g. # Aircraft in Taxi-out Queue, #ATCS
  2. Performance of Network System
    - e.g. Productivity, Throughput, Delays, Indices
  3. Explanatory/Diagnostic Performance of Network System
    - e.g. Network Velocity Metric

# Research Approach

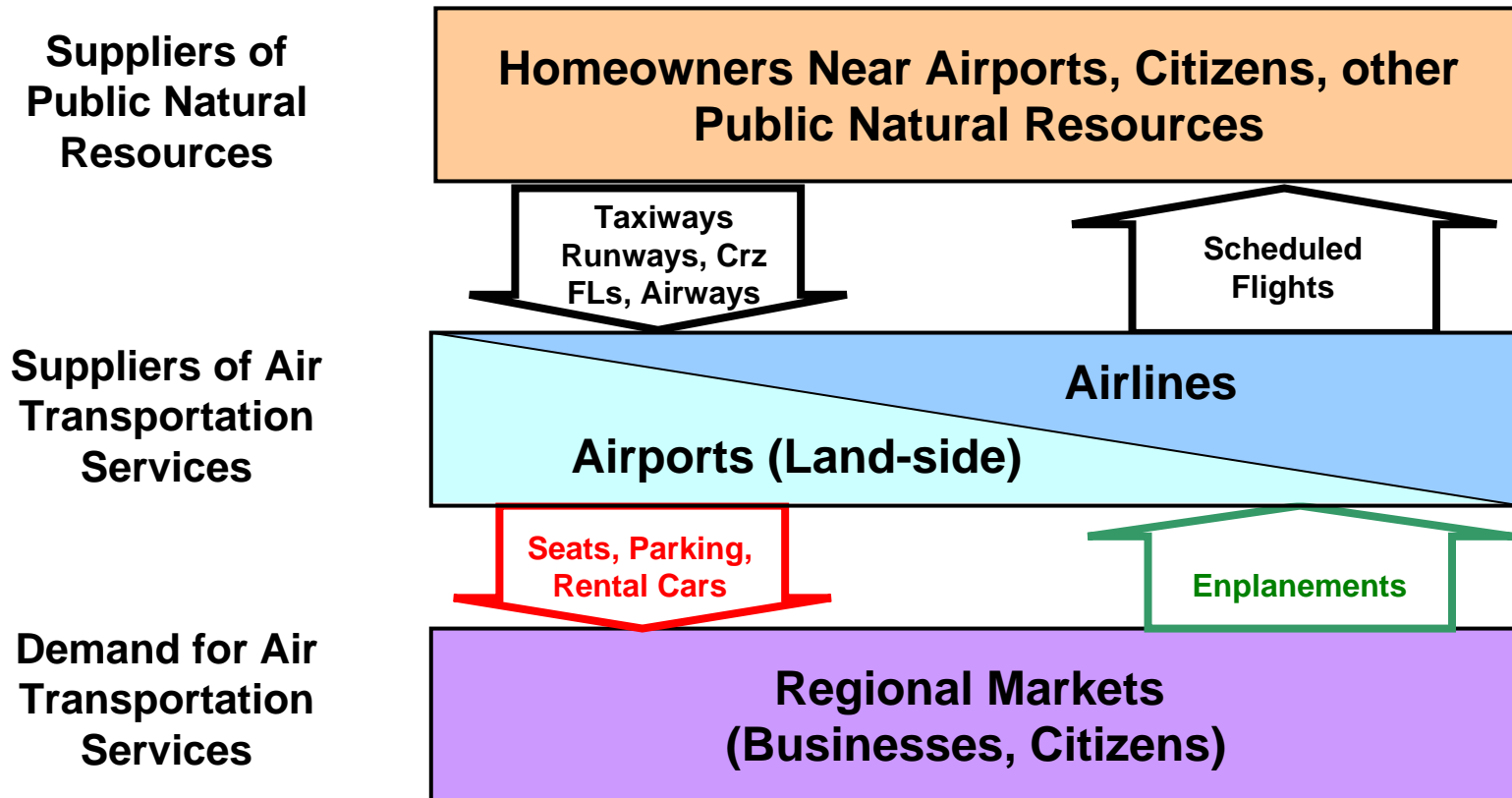
- **Develop model of ATS** (Morrison & Winston, Button, Goldner/Knorr/Yablonski/NEXTOR, Janic, ...)
  - Agents in economic system:
    - Passengers/Cargo, Airlines, Airports, Airspace, Air Traffic Control, Homeowners near Airports, Citizens, Wildlife
  - Functions/Dynamics of ATS Model:
    1. *demand/supply relationships* (Morrison & Winston, Bernadino)
      - » Includes dynamics (e.g. time constants)
    2. *signals* that balance demand/supply relationships (Golaszewski)
    3. *market forces* that drive signals (Porter)
    4. *innovation* mechanisms (Burgelman)
- **Use Model to conduct to:**
  - Develop metric(s)
  - Investment Incentives/Strategies (van den Poel)

# Scope of ATS Model

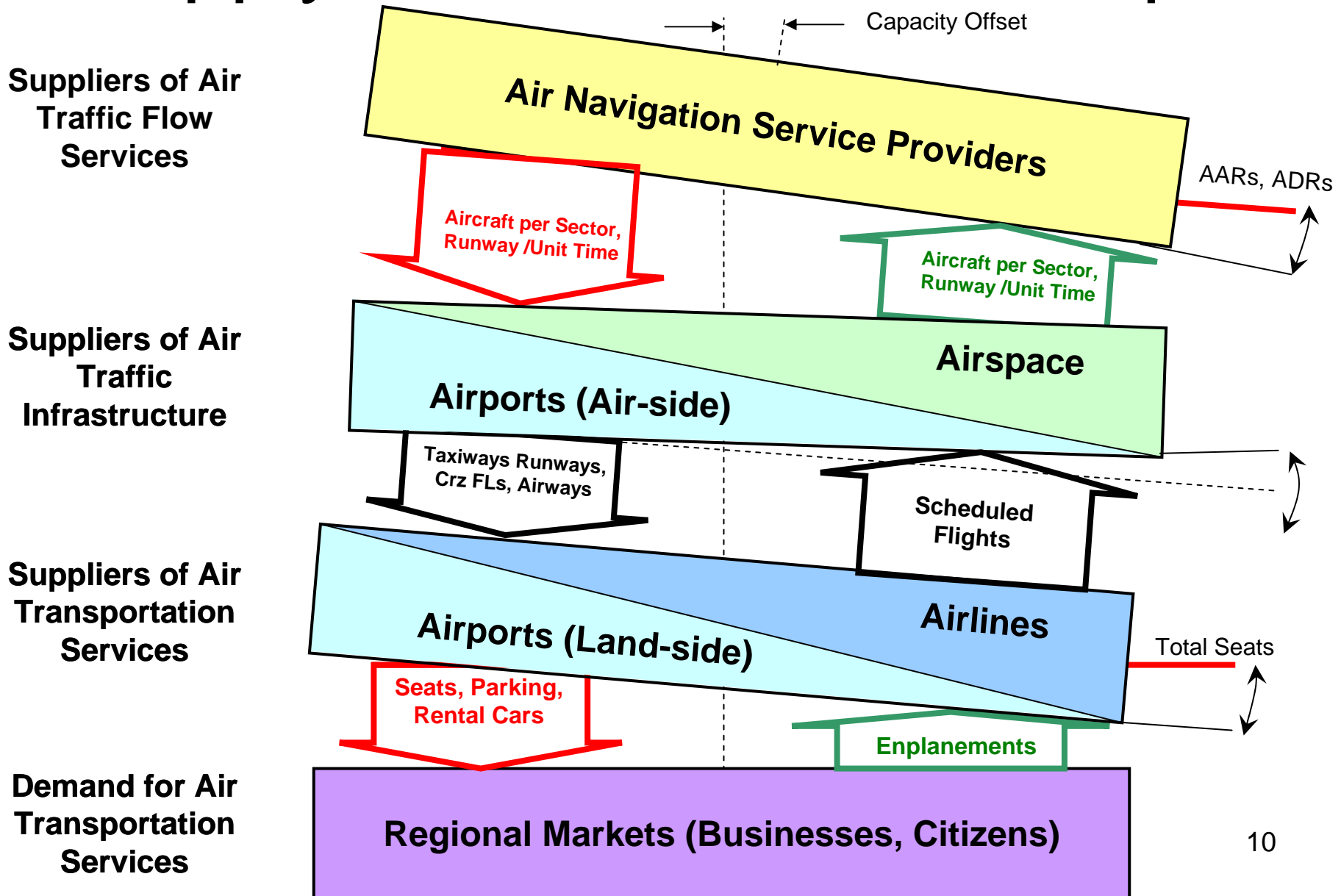




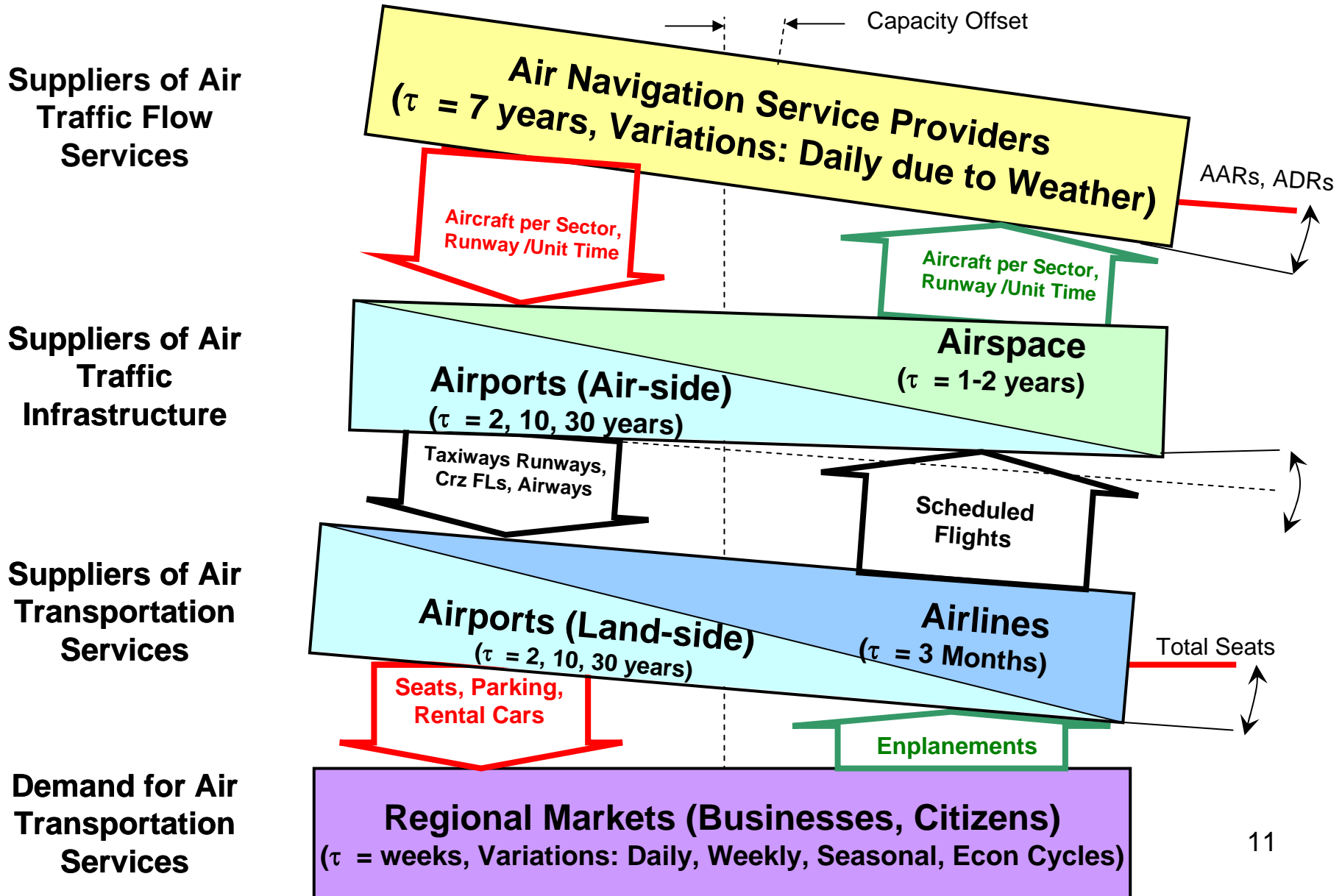
# Scope of ATS Model



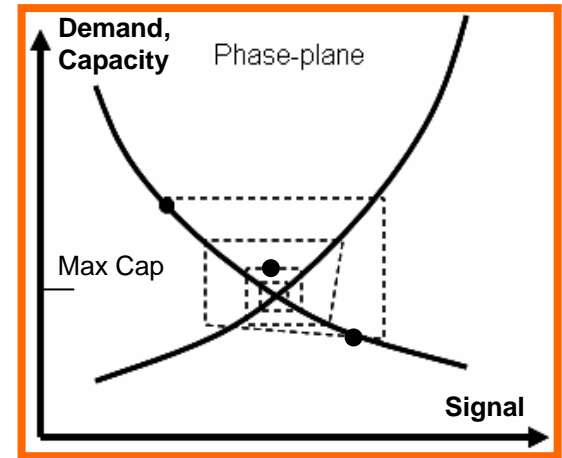
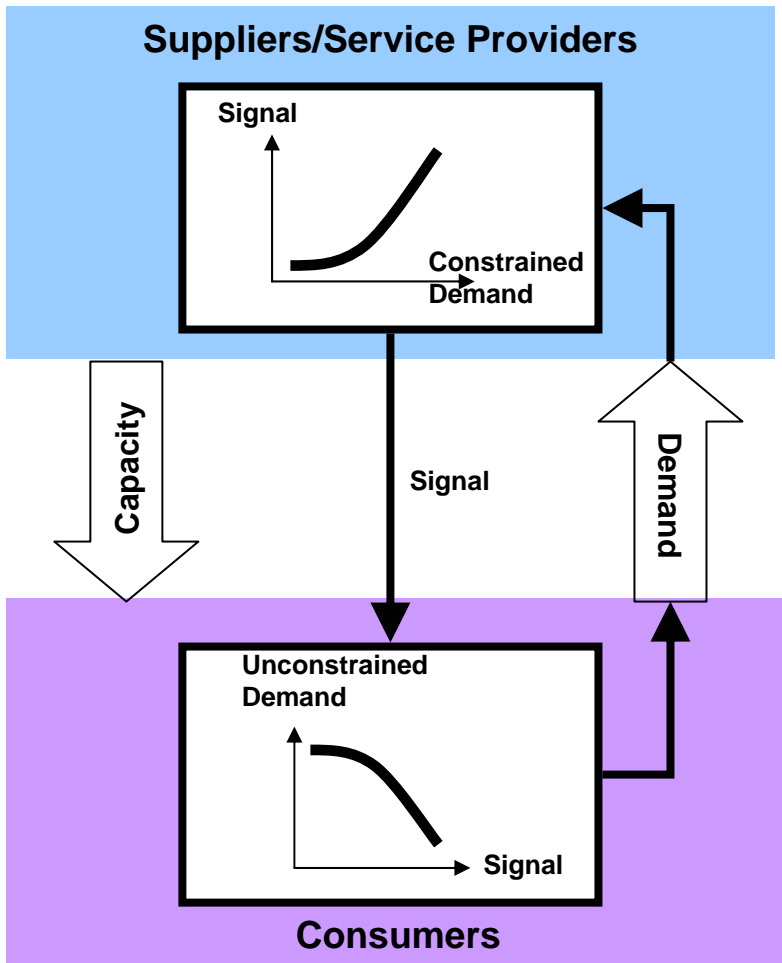
# Supply/Demand Relationships



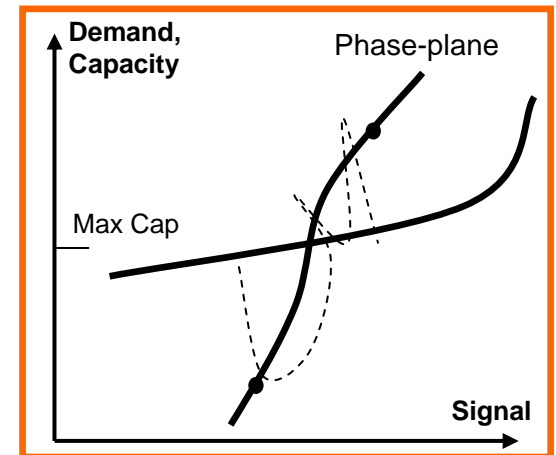
# Time Constants



# Signals



**Strong Signaling  
Equilibrium**



**Weak Signaling  
No Equilibrium**

# Signals

Supply/Demand Relationships	Signals	Signal Strength (Slope Supply/Demand)
<b>Air Navigation Service Providers</b> to <b>Airspace/Airports (Air-side)</b>	<ul style="list-style-type: none"> <li>• Delays (GS, GDPs, MIT)</li> </ul>	<p style="text-align: center;"><b>Strong</b></p> Air Traffic Flow capped by Airport Departure Rates and Arrival Rates
<b>Homeowners and Public Natural Resources</b> to <b>Airlines/Airports (Land-side)</b>	<ul style="list-style-type: none"> <li>• Emissions and Noise Penalties</li> <li>• Heath Costs</li> </ul>	<p style="text-align: center;"><b>Weak</b></p> Scheduled Operations impacted very little by Noise and Emissions penalties. Problem Ambiguous limits.
<b>Airspace/Airports (Air-side)</b> to <b>Airlines/Airports (Land-side)</b>	<ul style="list-style-type: none"> <li>• Ticket Tax, ...</li> <li>• Historic Delay Operating Costs</li> <li>• Noise/Emissions Procedural Costs</li> <li>• Marketshare Imperative Costs</li> </ul>	<p style="text-align: center;"><b>Weak</b></p> Scheduled Operations demand is regulated very little by fees set under assumption of infinite resources in presence of strong sustainable demand, delays ...etc.
<b>Airlines/Airports (Land-side)</b> to <b>Regional Markets</b>	<ul style="list-style-type: none"> <li>• Operating Costs</li> <li>• Landing Fees, Taxes, ...</li> <li>• Delays/Cancellations</li> <li>• Parking, Ground Transportation, Concessions, ...</li> </ul>	<p style="text-align: center;"><b>Strong</b></p> Passenger and Freight demand is strongly regulated to meet limit of Seats/Weight

# Market Forces on Signals

## Market Forces on Signals Between Service Provider & Consumer

- 1) Bargaining Power of Buyers
- 2) Bargaining Power of Suppliers
- 3) Threat of New Entrants
- 4) Rivalry between Existing Firms
- 5) Threat of Substitute Services
- 6) Regulation

# Market Forces on Signals

Market Forces Service Provider	1) Power of Buyers	2) Power of Service Provider	3) Threat of New Entrants	5) Threat of Substitute Services	6) Regulation
<b>Air Navigation Service Providers</b> [Very Profitable]	Low	High <ul style="list-style-type: none"> <li>• Labor market artificially controlled</li> <li>• Safety card</li> </ul>	Low. <ul style="list-style-type: none"> <li>• Class A vs. Class G</li> <li>• Canadian/Mexican Airspace vs. US</li> <li>• Super-high vs Class A</li> </ul>	Low	High (ADR, AAR)
<b>Homeowners and Public Natural Resources</b> [No profits]	High	Low <ul style="list-style-type: none"> <li>• distributed</li> </ul>	N/A	N/A	Low <ul style="list-style-type: none"> <li>• Capacity to regulate high</li> </ul>
<b>Airspace/Airports (Air-side)</b> [Potentially Very Profitable]	Low	High <ul style="list-style-type: none"> <li>• Maintenance of Equipment</li> </ul>	Low	High <ul style="list-style-type: none"> <li>• substitute technologies to Radar Surveillance</li> </ul>	Low (except for Slot Controlled Airports)
<b>Airlines</b> [ Low Profits due to Buyers and Competition]	High & Low <ul style="list-style-type: none"> <li>• subject to fluctuations</li> </ul>	High <ul style="list-style-type: none"> <li>• airlines seek best markets, leases</li> </ul>	High	High - other modes of transportation	Low
<b>Airports (Land-side)</b> [High Profits]	Low – long-range biz	Med	Low	Low <ul style="list-style-type: none"> <li>• High for short-range other modes of transportation</li> </ul>	Low
<b>Regional Markets</b>	Medium – Biz	Low	Medium <ul style="list-style-type: none"> <li>• competition from other cities</li> </ul>	N/A	N/A

# Economics of ATS

<b>Economic Properties</b>	<b>Impact of Signals from Suppliers Under Current System</b>	<b>Profits &amp; Incentive to Innovate Under Current System</b>	<b>Maturity Level</b>
<b>Service Provider</b>			
<b>Air Navigation Service Providers</b>	Strong – Capacity limits lost in noise of weather and schedule variability	Very High – No competition, no price pressures Low	4-Robust
<b>Homeowners and Public Natural Resources</b>	Weak –distributed, media and ambiguous data	None – No property rights, just costs	?
<b>Airspace/Airports (Air-side)</b>	Weak – fees set for infinite resources (except slot controlled airports)	Low – ATNS supplier power, threat of sub technology Low	4-Robust
<b>Airlines</b>	Strong – airfares regulate demand	Low - Competition, supply chain costs (e.g. fuel) High – pressure from all sides	5-Innovative
<b>Airports (Land-side)</b>	Weak – revenue neutrality allows cross-subsidization	Medium – no sub, no comp, but supplier pressure Low – competing based on cost, subsidized by parking, ...	3-Deterministic
<b>Regional Markets</b>		?	?



# *Impact of Modernization Initiatives & Benefits/Costs*

<b>Service Provider</b>	<b>Modernization Initiatives</b>	<b>Impact on ATS (Signals and Industry Structure)</b>	<b>Benefits/Costs</b>
<b>Air Navigation Service Providers</b>	<ul style="list-style-type: none"> <li>• Automate “Sequencing” &amp; Conflict Resolution tasks (e.g. Evaluator)</li> <li>• Transfer “Separation” to aircraft</li> </ul>	None	<ul style="list-style-type: none"> <li>• Reduced Ops Cost (Breakeven point when savings in Ops Costs &gt; Development Costs ?)</li> </ul>
<b>Homeowners and Public Natural Resources</b>	<ul style="list-style-type: none"> <li>• Reduced Noise footprint off RNP routes</li> <li>• Increased Noise/Emissions on RNP Routes</li> </ul>	None	None
<b>Airspace/Airports (Air-side)</b>	<ul style="list-style-type: none"> <li>• Potentially reduce F&amp;E Costs</li> <li>• Increase Capacity on RNP Routes</li> </ul>	None	<ul style="list-style-type: none"> <li>• Reduced F&amp;E costs</li> <li>• Increase capacity on RNP routes</li> </ul>
<b>Airlines</b>	<ul style="list-style-type: none"> <li>• Perform “Separation” tasks</li> </ul>	None	<ul style="list-style-type: none"> <li>• Potential benefits from differentiated service</li> <li>• Additional costs</li> </ul>
<b>Airports (Land-side)</b>	None	None	None
<b>Regional Markets</b>	<ul style="list-style-type: none"> <li>• Enhanced capacity</li> </ul>	None	<ul style="list-style-type: none"> <li>• Additional costs (passed on from Airlines)</li> </ul>

# Investment Incentives – “Modernization”

- “Modernization Plans”
  - No change in industry structure
  - No change in signaling
  - No change in incentives for investment
- Reduced Ops Costs: ANSP (Ops), Airspace (F&E)
- “Separation task” transferred to airlines without transfer of costs
  - Airlines remain not incentivized to equip
- Investment incentives for ANSPs, Airspace, and Airport (Airside) Supply Chain for Government Contracts
- Strategy to be investigated: Differentiated Service

# Investment Incentives – Strong Signals

## Preliminary Findings

- “Strong Signals” ATS:
  - Airports (Landside)
    - Make gates available to all carriers, User fees priced at marginal costs
  - Airports (Airside) & Airspace
    - Set efficient (marginal cost) takeoff and landing congestion tolls, Improve productivity to supply/demand equilib.
  - ANSP
    - Charge users marginal costs of services, Improve productivity to supply/demand equilib.
- Long-term (20+ years) sustainable:
  - high rates of innovation (continuous capacity increase)
  - more robust, response to perturbations (e.g. fuel)
  - Airfares slightly higher
  - Social/External Costs reduced
- Pathway: Cost Transparency → User Fees → (Congestion) Tolls → Auction Pricing

# Future Work

- Design and compute “Sustainability” Metric(s) for ATO
- Derive Strategy to migrate from 4-Robust to 5-Innovative
- Derive Investment Incentive Strategies
  - Understand impact of differentiated service
    - Signals
    - Industry structure
      - Profits
      - Innovation Incentives
  - Understand impact on Equal Access, Appropriations Process
- Create awareness and educate (non-domain) decision-makers on behavior of ATS