Overview FAA's *NAS Strategy Simulator*

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Trends in Air Transportation Operations

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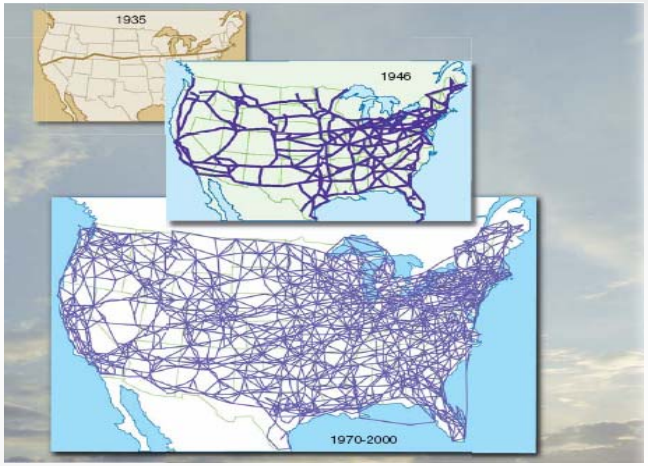
Complexity of Interactions in Network of Distributed Agents



Optimized Stochastic, Capacity-limited Networked Operations

Aircraft
- Basic Aero
- Propulsion

Barnstorming Operations

Air Transportation
- Air Transportation - Mail

Air Traffic Control
- Basic Airport Traffic Control

Point-to-Point Scheduled Operations

Air Transportation
- National Air Carriers
- Point-to-Point Service
- Inter-modal

Air Traffic Control
- En-route Air Traffic Control
- Terminal Area Traffic Control

Networked Scheduled Operation

Air Transportation
- National/International Network airlines
- Civil Aviation Board

Air Traffic Control
- Radar
- Precision Approach

Optimized Networked Operations

Air Transportation
- Deregulation
- Hub monopolies
- Schedule/Network optimization
- Overscheduling
- Yield Management
- Fuel Management airlines

Air Traffic Control
- Radar
- Precision Approach

Air Transportation
- Flexible Airline Business Models
- Low Cost Carriers/Regional Jet Airlines
- Network configurations (Hub, point-to-point)

Air Traffic Control
- Collaborative Decision Making
- Revenue/Cost Synchronization
- Aircraft Self-separation
- Facility Resizing
- Safety/Capacity Tradeoff

1920 1940 1960 1980 2000 **Years**

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Air Transportation System

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- Air Transportation System is …
  - Layers of networks
  - Networks composed of agents
    - Distributed, Autonomous
  - Agents operated by private and public entities
- Networks and agents:
  - capacity limited
  - exhibit stochastic behavior
  - operate in non-equilibrium state (both economics and system performance)
  - **operate with conflicting objective functions**
- Brining Networks and Agents into synchronicity
  - Collaborative Decision Making
  - Economic *and* Technology controls

Layers of Networks in ATS	Objective Functions
Air Traffic Control (Federal) •Command and Control (1) •Centers (20) •Terminal Radar Controllers (170+) •Towers (400+)	•Service all aircraft in the air •Safety (through Procedures and Certification) •Promote aviation
Airports (Municipal/State) •Terminals, Ramps, Taxiways, Runways •Access Roads, Parking, … •Security, Passenger processing …	•Revenue Neutral •Passenger flow, security •Passenger experience
Airline Operations (Private Sector) •Dispatch, Flightplanning, Weather •Maintenance, …	•On-time •Minimize costs
Airline Planning (Private Sector) •Fleet selection and purchase •Marketing, Scheduling, Pricing •Sales, Ticket Processing, …	•Marketshare in super-competitive marketplace •Profit (sometimes)
Aircraft Manufacturers •Design, Production •Training, Support, …	•Marketshare in duopoly •Profit (someplaces)

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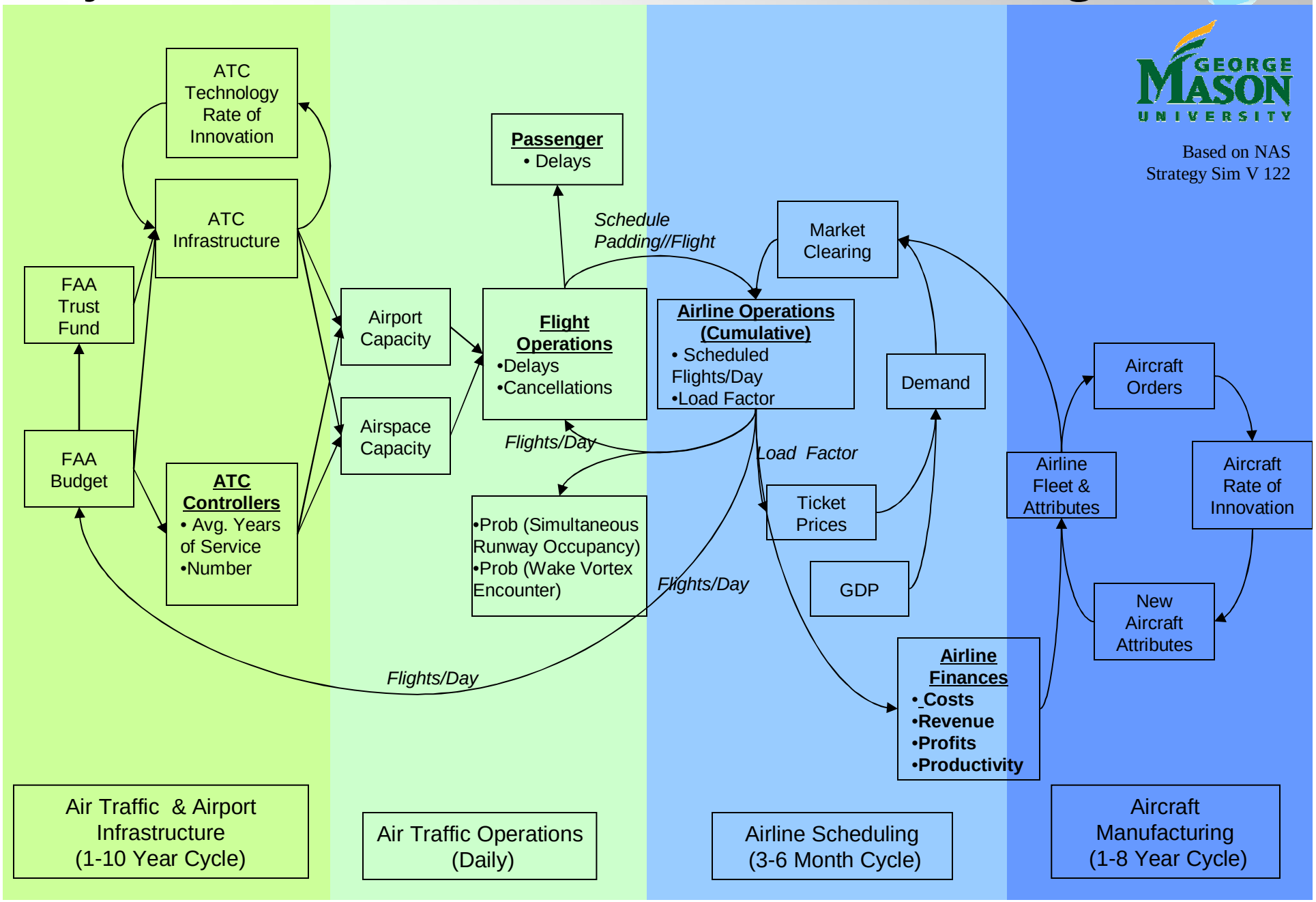
Objective Functions Reinforce/Undermine Agents



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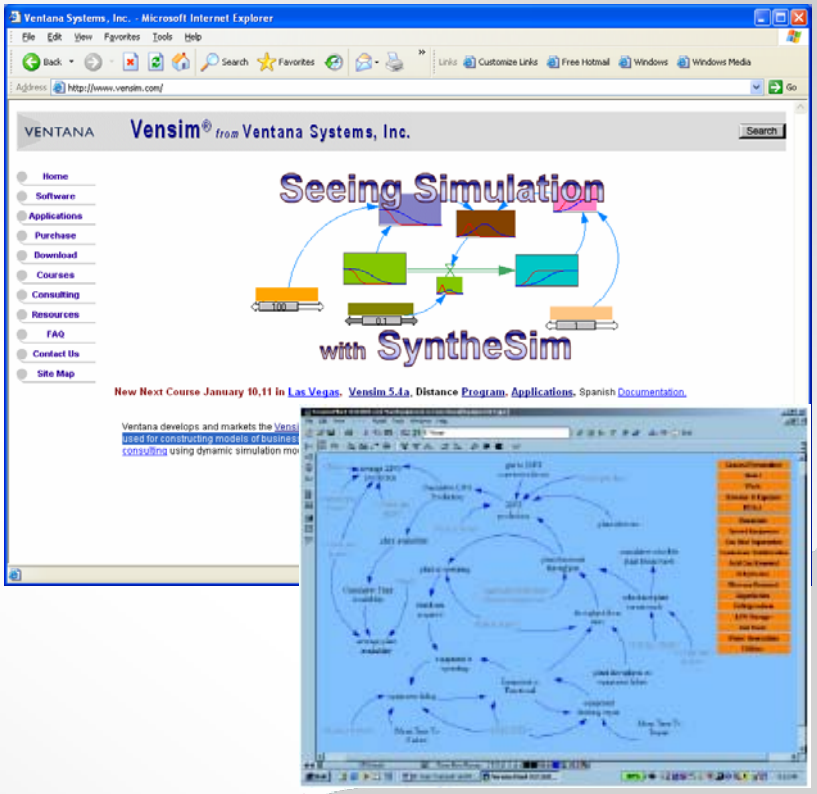
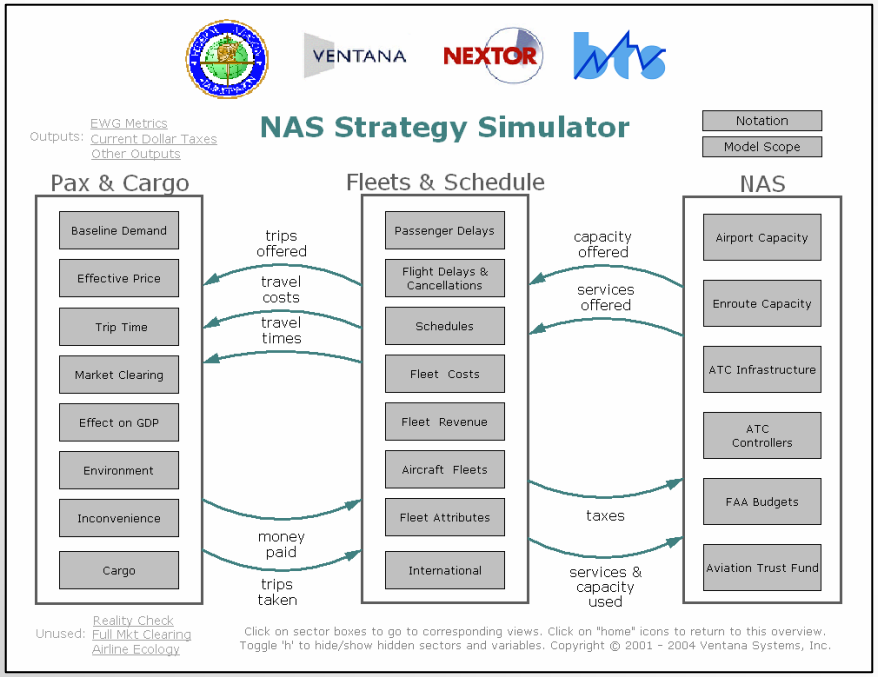
Based on NAS Strategy Sim V 122

FAA NAS Strategy Simulator

- Dynamical System Modeling (Jay Forrester, circa 1950)
- Used for studying and managing complex feedback systems, such as one finds in business, scientific, environmental, social systems.
- Tool - Vensim
  - Ventana Sysytems product
  - http://www.vensim.com/



FAA NAS Strategy Simulator



Top-level View of NAS Strategy Simulator (V117c)

- Number of runways in NAS = 132
  - 35 major airports (US DOT Form 41 Airports)
- Number of Airports Gates = 10000
- Schedule
  - Number of Part-121 Ops per day = 24000
  - Price = $150/trip
- Fleet = 8500 aircraft
  - Average cruise speed = 330 knots
  - Aircraft size = 103 person/flight

FAA NAS Strategy Simulator

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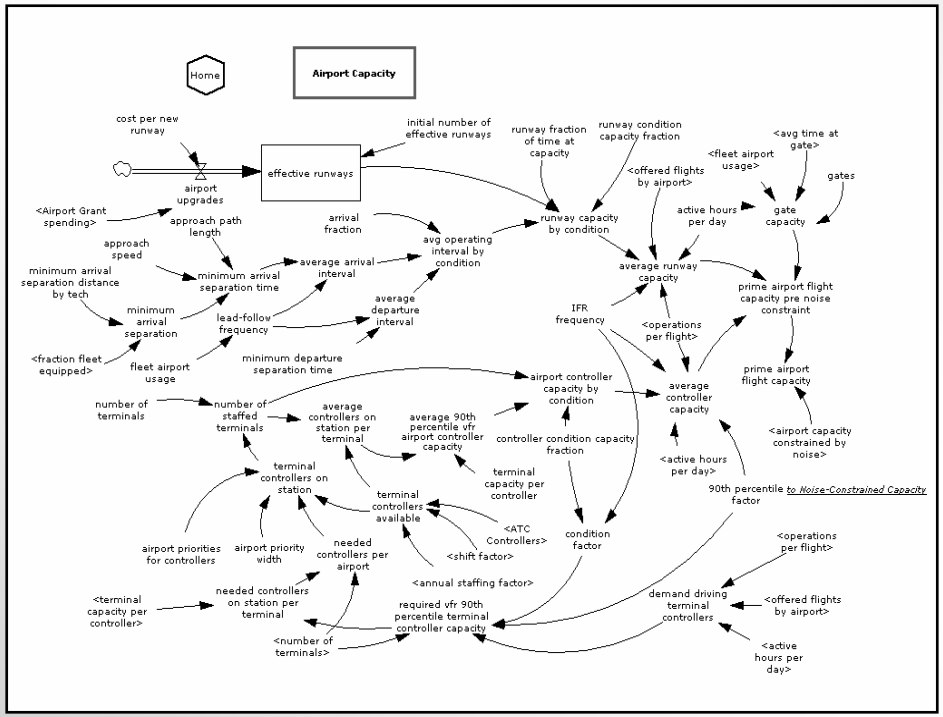

Airport Capacity Module

- Calculates variables from 1965 – 2025
  - Variables calculated annually (e.g. FAA operating costs in $B/year)
- Total Variables and Parameters = 634
  - Fixed Parameters - 122
  - Historical inputs – 44
    - Historical time series from industry data-bases
  - User Controls – 62
  - Input (Look-up) Tables – 25
  - Definitions and Conversion factors - 36
  - Internal Equations - 345

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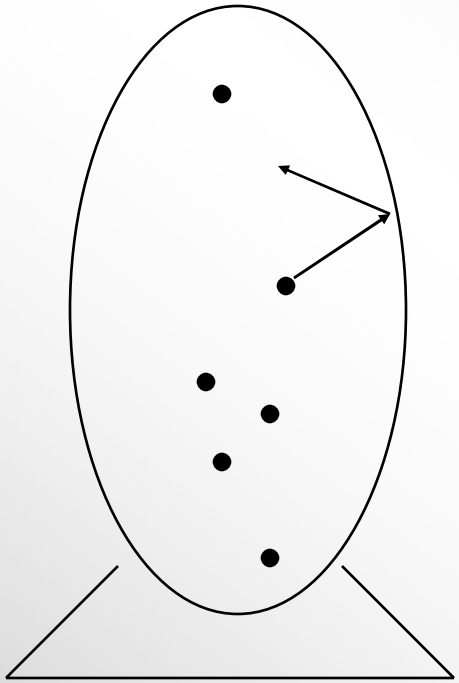
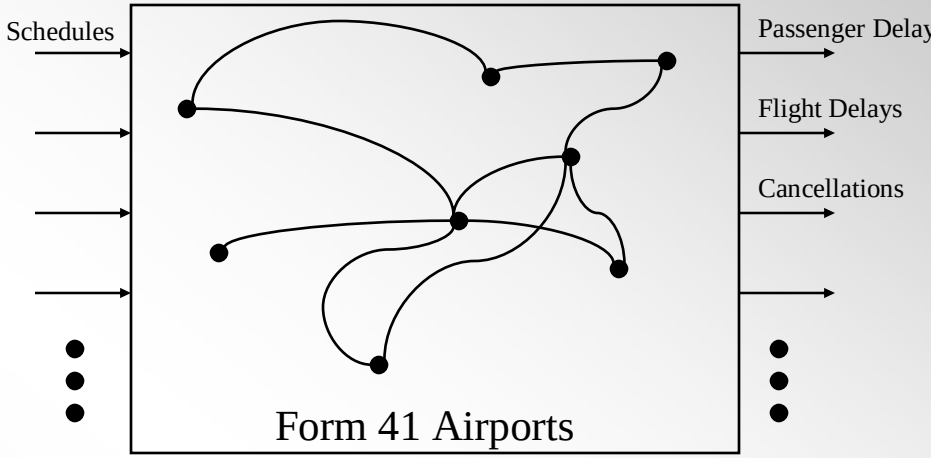
Way to Think About Strat Sim

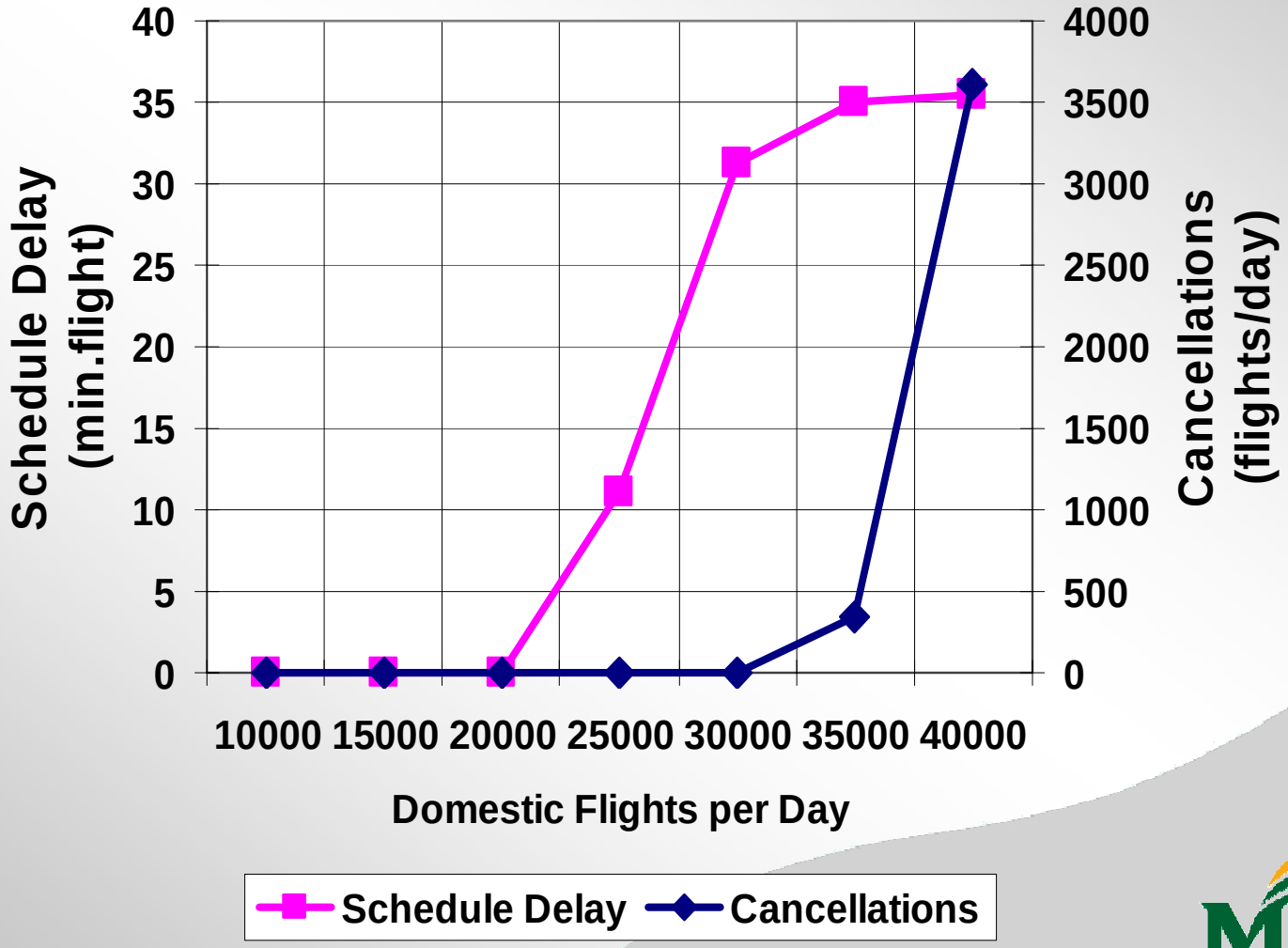


Measure Pressure of gas on vessel by PV=nRT (not by solving equations of motion for all molecules)



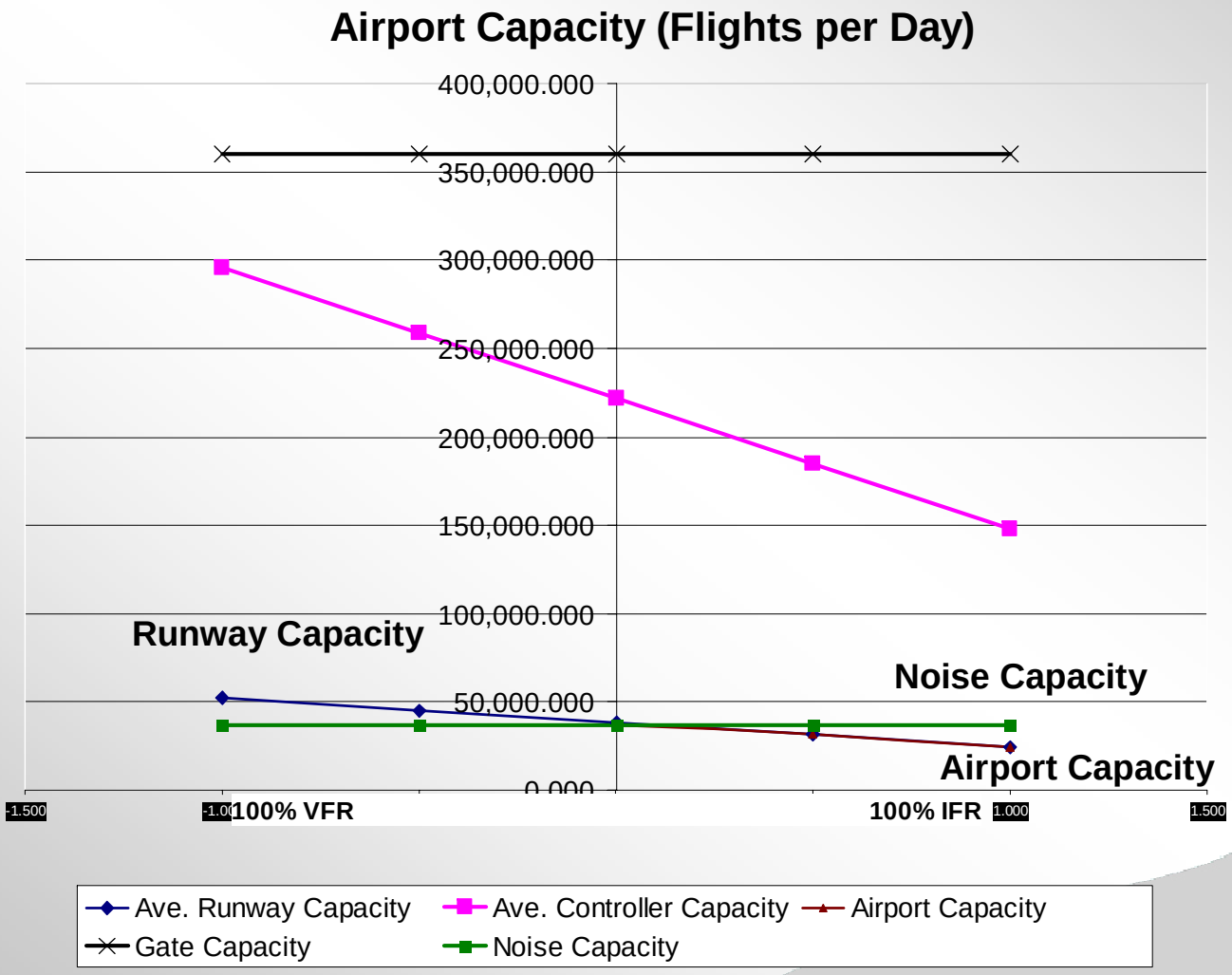
Understand behavior of NAS through macro-model (not by solving equations for network)

Delays and Cancellations Function



Strategy Sim v117c – based on Ball (2003) Rho-50 model

Airport Capacity



Case Study –Revenue/Costs of Air Traffic Operation

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- FAA – Air Traffic Operations funded through Excise Tax (also known as User or Benefit Tax)
- 1990s- 10% tax on ticket price
  - generated $4 - $5 billion in tax revenue annually
  - airlines with lower ticket prices carried lower tax burden
- 1996 legislative authorization expired - Congress passed the Tax Relief Act of 1997
  - lowered ticket tax from 10% to **7.5%** of the ticket price
  - added **$3** fee for each leg of travel
- Problem with Tax scheme
  - FAA Revenue based on ***cost of travel*** (i.e. ticket price)
  - FAA Costs still based on ***cost of operations*** (i.e. number of flights per day)
- Not *robust* to changes in demand for travel, airline business models

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Assumptions

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- Existing (major) airport and ATC infrastructure
  - No new airports
- Existing route structure
  - No new origin/destinations, routes
- Airlines can change frequency and fleet mix (seats per aircraft)
- Fixed ticket prices
- Fixed costs of ATC operations
- Fixed costs of airline operations

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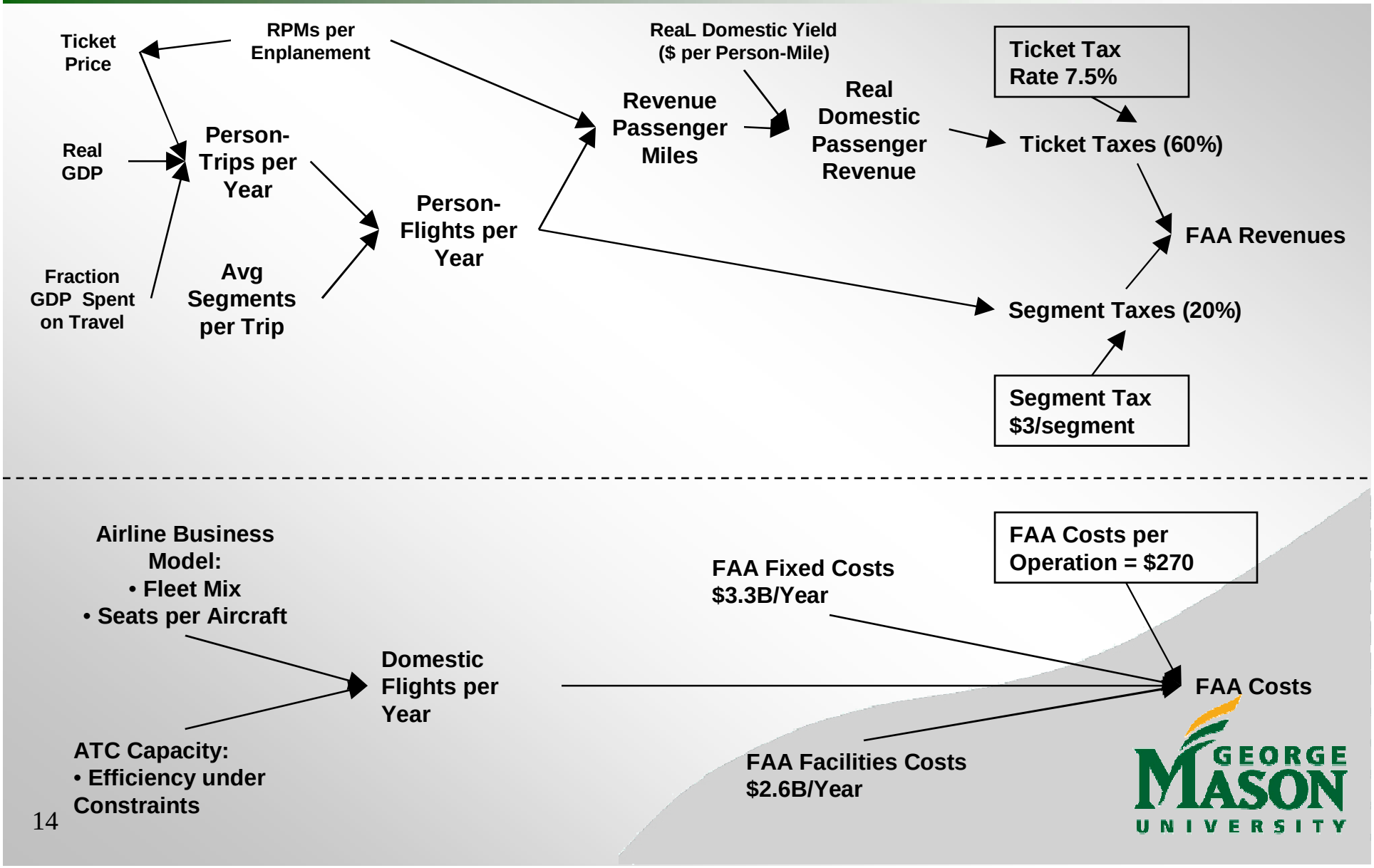
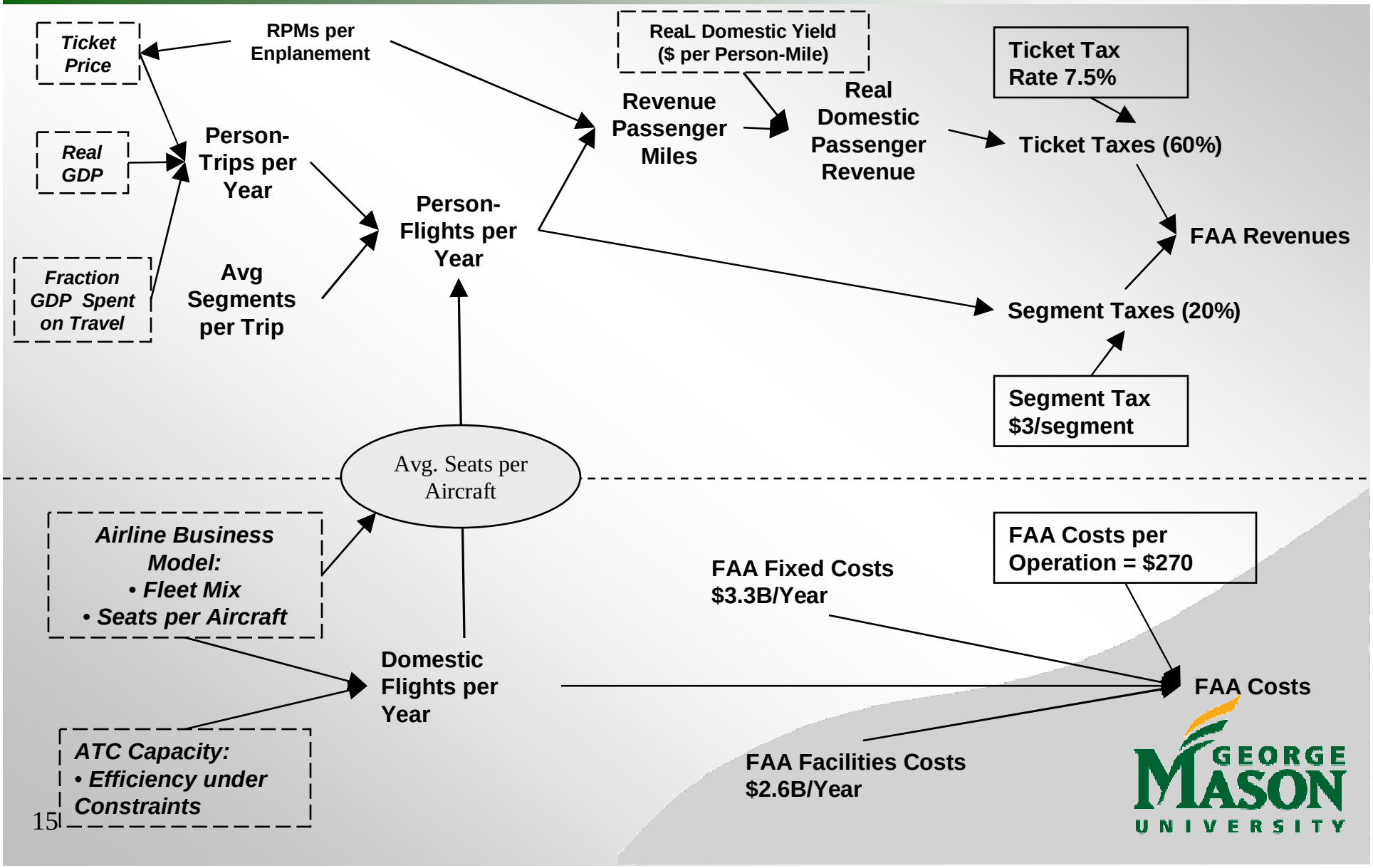
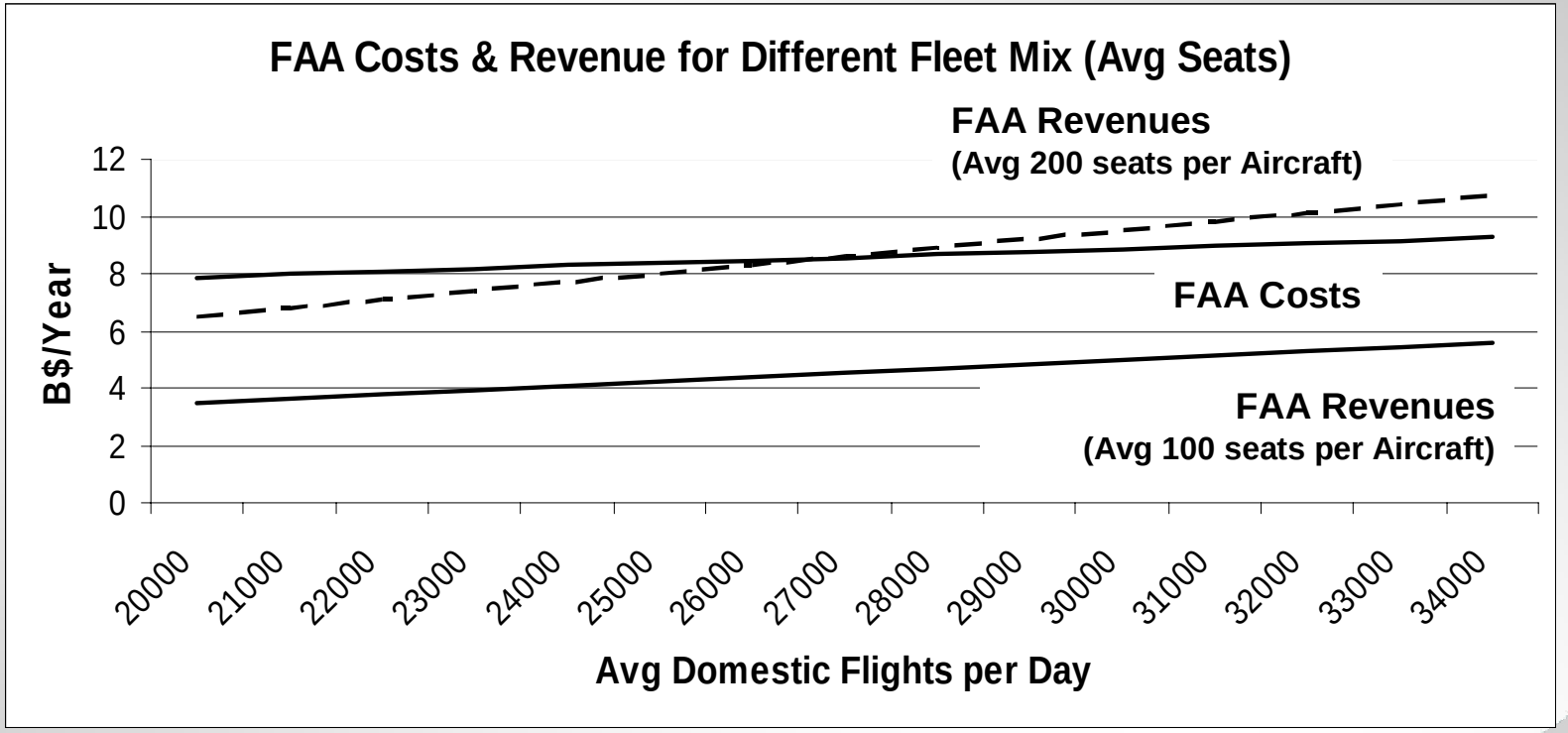
FAA Revenues and Costs



FAA Revenue/Cost Drivers



Impact of Fleet Mix on FAA Revenue



- Motivations under existing tax scheme:
  - Airlines
    - Compete for marketshare
    - Use frequency of service as competitive advantage
    - drive down ticket prices (and operating costs)
  - ATO
    - Set policies to drive airlines to up-guage to increase passengers per operation
    - only fund capacity upgrades when economically solvent

Conclusions

- FAA policy, procedure and technology decisions must take dynamical behavior of system into account
  - Robust to perturbations
  - Robust to changes in economy, business models
- NAS Strategy Simulator provides the basis for the analysis
- Business Opportunities:
  - Under existing capacity constraint:
    - Reduce variance in process (delays, cancellations, …etc.)
    - Maximize use of resources (e.g. up-guage in profitable manner)
  - Increase capacity
  - Modify taxation scheme to be more robust to perturbations and plausible future airline business models

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