NATIONAL CENTER OF EXCELLENCE FOR

NEXTOR

AVIATION OPERATIONS RESEARCH

Reflections on the First Year of NEXTOR

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Outline

- **N**ational Center of **EX**cellence for Avia**T**ion **O**perations **R**esearch
- **First-year projects**
- **Some fundamental research issues for NEXTOR**
- **A brief assessment**

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NEXTOR Mission

A university-industry-government partnership aimed at developing capabilities for

- **modeling, designing and evaluating the performance and safety of**
- **partially decentralized, more flexible, advanced technology concepts**

for air traffic management and airports

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First Year Projects

- Applied basic research primarily at universities
  - Human factors support to FAA Office of System Safety
  - World aviation safety data analysis
  - Modeling for establishing separation standards and computing associated collision risk
  - Positive Passenger Baggage Matching
  - Advanced concepts for Collaborative Decision Making
  - Integration of Reusable Launch Vehicles into ATM system

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First Year Projects (2)

- Shorter term issues mostly addressed jointly with industry partners
  - SIMMOD improvements and maintenance
  - Impact of AATT technologies on ATM concept definition
  - Center Sector Tools Descent Advisor Research
  - Investigation of Integrated Alert Systems concepts
  - Analysis of critical portions of CTAS
  - Development of a Project Management Information system

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First Year Projects (3)

- Industry-sponsored joint projects in areas of specific mutual interest:
  - Distributed environment for simulating weather events (TASC)
  - SIMMOD-based airport gate planning (Massport)
  - Terminal area automation in partially decentralized ATM (Draper)
  - Macroscopic queueing model of NAS (airports and en route) (LMI)

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Success under Stress

Aviation infrastructure (ATM and airport system) in US:

- **Vital and extremely successful**
- **Excellent levels of safety**

BUT:

- **Approaching (selectively) its limits in terms of capacity and efficiency**
- **Becoming highly resistant to change**

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A complex system

- ATM system has become extremely complex
- Techological / technical, economic, institutional, legal and human factors
- Increasingly constrained operating environment deepens complexity
- “NAS as CAS” (complex adaptive system)

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Basic research issues

To cope with complexity and to change, fundamental research needed on:

- **Current system's characteristics**
- **Uncertainty, variability, nonlinearity**
- **Computer-based models**
- **Objectives, behavior and interactions of stakeholders ("agents")**
- **Safety and human factors/automation**

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Current system: Delays

- Magnitude of current delays
- Cause-and-effect relationships
- Average delay vs. delay variability vs. "system flexibility" in delay assignment
- Airline tactics (short-term) vis-a-vis delays
- Airline strategies (long-term) vis-a-vis delays

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Understand current system (2)

Need for systematic analysis and evaluation of existing system's performance:

- **gigabytes of data daily (ETMS, ACARS, airlines)**
- **completeness? adequate level of resolution?**
- **automated gathering and processing of data**
- **visual and statistical presentation of key selected metrics**

Potentially invaluable insights!

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UVN

- Uncertainty, variability, nonlinearity are pervasive in ATM system
  - Capacity and delays
  - Aircraft position predictability
  - Agent behavior and public perceptions
- Concepts and programs based on "deterministic and linear" assumptions are usually doomed to failure

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Models

- "Existing and Required Modeling Capabilities for Evaluating ATM Systems and Concepts"
- Reviews 27 fast-time models (2-6 pages)
- State-of-the-art assessments in 5 areas
- General and model-specific recom'dns
- http://web.mit.edu/aeroastro/www/labs/AATT/aatt.html

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General Findings: Existing Models

1. Flow, capacity and delay: Most advanced.
2. Conflicts: Scattered features/capabilities; no one model adequate for a complete analysis.
3. Humans and automation: Early stages; urgent attention / resources needed.
4. Cost-benefit: Formative stages; little knowledge of valuations; very hard to quantify some impacts of advanced ATM concepts.
5. Airline (AOC) and other user behavior: Major new area of basic research.

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"Agents"

- Studies of the behavior of NAS Agents
  - understand ("fuzzy") goals of users
  - responses to changes, e.g., capacity enhancements and decentralization
- Development of Modeling Tools
  - infer behavior of users
- Macroscopic Models of the NAS System Behavior and Performance
  - network competition
  - metrics

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Difficulties

- Funding constraints impose a short-term orientation on FAA R&D
- No FAA precedent for NEXTOR-like arrangements
- “Time constants” of university research are long
- Limited resources mean underutilization of affiliated universities and of some industry partners

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Fundamentally sound concept

- Enormous need for applied basic research on fundamental aspects of ATM and airport operations
- NEXTOR can complement in important ways the capabilities of other major loci of NAS R&D activity (Hughes Center, NASA, MITRE CAASD, MIT Lincoln Labs, et al.)
- A unique partnership of academic talent and industry expertise and resources