Draft-
Outbrief from NIA Transportation Workshop

Workshop Conducted: May 20, 2003
National Institute of Aerospace (NIA), Hampton, VA

Draft Report Dated: June 2, 2003

Contents

- Attendees and Workshop Purpose
- Original Workshop Description Charts
- Workshop Deliverable Charts (Blue Titles)
- Related Briefing Material (under separate package)
  - Shockor (Pathfinder Project)
  - Holmes (Thoughts on the Future State: Scaleable Networks)
  - Trani (Transportation Modeling Methods)
  - Shortle (Safety Considerations in Future Transportation Archs.)
  - Dollyhigh (LaRC Transportation System Analysis Models)
  - DeLaurentis (Decision-Making Processes; Problem Boundary)

Attendees

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Workshop Purpose & Deliverable Description

- Purpose:
  - Concise: Begin a dialogue on analysis methods for trans. architectures
  - Verbose: Explore ideas and formulate a research plan targeted at the creation of a capability that enables the rapid analysis, exploration and evaluation of alternative transportation architectures (conceptual level). The capability must be able to model and exploit interconnections between aerospace vehicles, airspace systems, and infrastructure and address measures of merit defined by "Pathfinder" team.
  - (Added) Thinking towards a continual-use approach, structured
- Deliverable (to NIA and NASA/Pathfinder):
  - Near Term: Process guidance for Pathfinder Phase II
  - Far Term: Documentation of a research plan (roadmap and potential pitfalls/synergisms) outlining the important areas (and their association) required for the creation of the subject desired capability (including recommended intra-agency and inter-agency activities)
  - (Added) Generate research proposal

Agenda

8:10a	Arrival, Continental Breakfast
8:30a	**Introduction**: NIA, Workshop Purpose, and Attendees
9:00a	**Review**: NASA Pathfinder Baseline Architecture & Assumptions
9:45a	**Foundation**: Discussion Topics – Levels of Abstraction and Lexicon – Model Boundaries and Problem Scope – Value Objectives
10:00a	**Methods**: Primer Briefings – Current Work, Potential Modeling Approaches – Discussion: Benefits/Limitations/Robustness
12:00p	Working Lunch (provided)
12:15p	**Synthesis**: Recommended Method Research Plan – Near Term (NASA Pathfinder) – Far Term (NIA/NASA)
4:15p	**Summary** – Future Meetings
5:00p	Adjourn

Method Imperatives from "Pathfinder Workshop 2"

- Modeling must capture/exploit system concept (program) interactions…. isolated assessments may miss emergent dynamics (both positive and negative)
  - Provide a unified view across vehicle, airspace, safety programs
- Modeling must include interfaces to external world ("Externalities"), especially new business models/value stream
  - Leading indicators as metrics ?
- For Pathfinder, treat problem as investment portfolio prioritization (at the technology level)
- Process (and models) must evolve! ("living system")

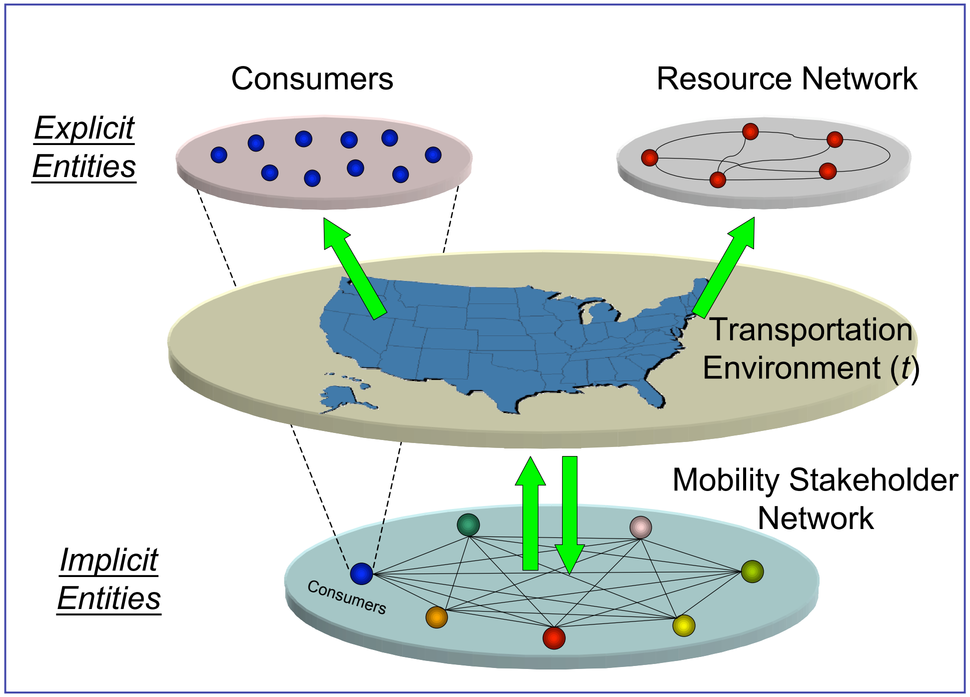
Abstraction

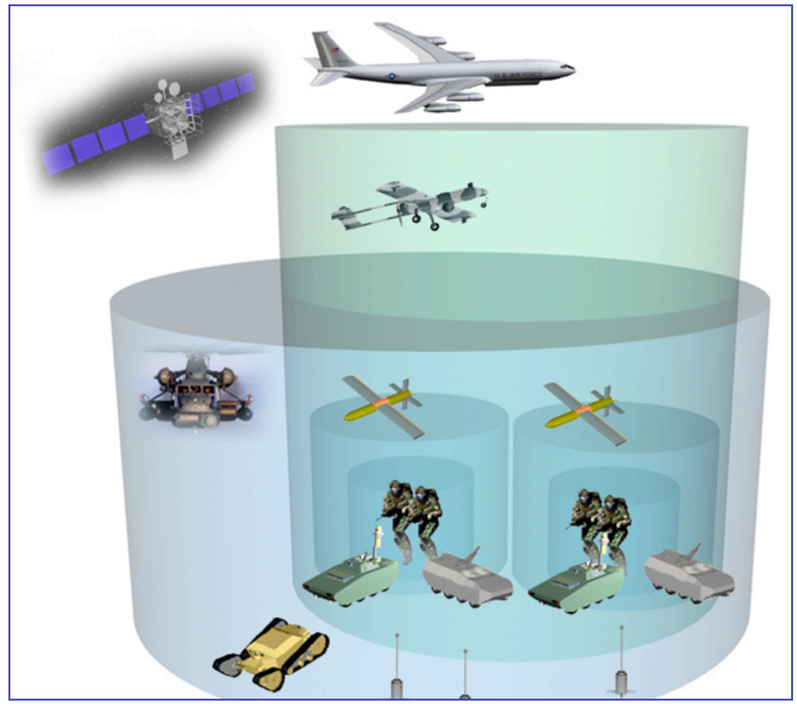
National Transportation System

"Stakeholders (including travelers) employ particular resources (both infrastructure and vehicles), organized in networks, in order to achieve a mobility objective."

Network Centric Warfare

"Every platform is a sensor; Every sensor is a node in the network that provides lethality, C4ISR, and survivability overmatch"



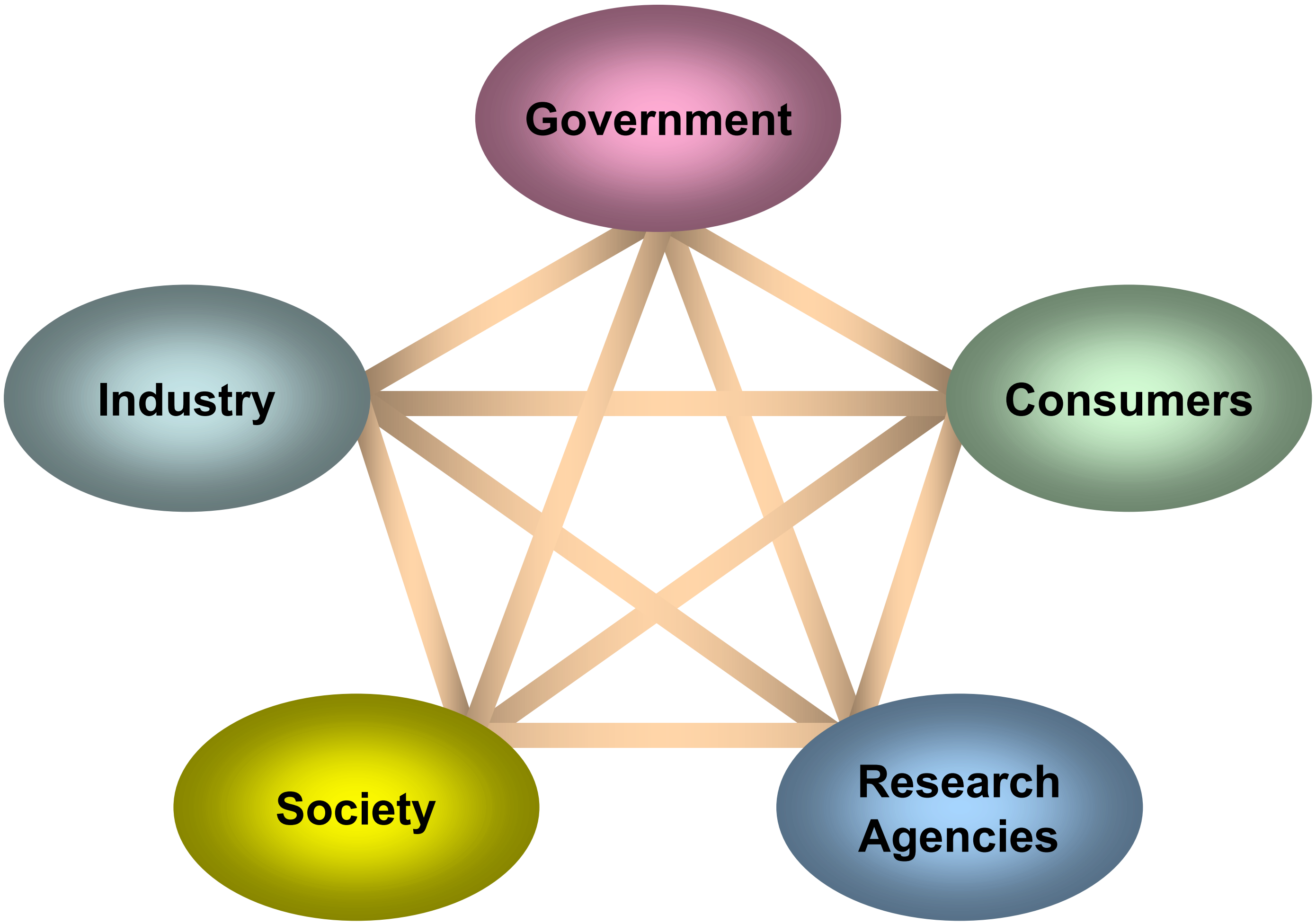


Power of Abstraction: Allows one to rise out of system (program) stove pipes, so that design studies are conducted at a level that supports inter-system innovation

Lexicon: "Transportation Architecture"

- Pathfinder Definition: "***Architectures*** are defined as an integrated set of functional building blocks that describe the method and style by which a set of activities are carried out to approach the system performance targets. *For our aeronautics planning, this is a system composed of the physical components and their rules of operation, that is, ground and airspace control, infrastructure, vehicles, operators, regulations, concepts of operation, business models, etc. The architecture is used to identify strategies (barriers and enablers), and thus, a framework within which various system concepts can be evaluated* ".
- Alternative Definitions: A system is considered to be any independent entity that has a specific functional purpose. An aircraft is a system. A system-of-systems is a collection of systems organized for a common purpose. An architecture is a particular collection of system-of-systems, including the connective relationships between them, that represents one view of the 'universe' for the particular problem under study. An architecture is a special form of the more generic system-of-systems type, one that spans the problem boundary.
- Other?

Stakeholders



Stakeholders' Value Objectives

- Stakeholder
  - Government
  - Consumer
  - Industry
    - Manufacturer
    - Service Provider
  - Society
  - Research Agencies

- Value Objectives
  - GDP (National Economy)
  - 'Mobility Credit', Safety
  - Market Share / Profit
    - Products
    - Services
  - Environment, Safety, Q.o.L.
  - Technologies, De-conflicting of Above Objectives

Resource Systems (Physical Entities)

- Vehicle Systems
- Infrastructure Systems
- Airspace Systems
- Networks
  - Topological
  - Implicit (between stakeholders)
  - Combined
- ?

Preliminary Observations & Implications

Observations

- Future transformational innovations are likely to be system-of-systems type
- They are interdisciplinary problems:
  - Across agencies
  - Across programs
  - Across systems
- They have unique characteristics:
  - Multiple, connected, heterogeneous systems
  - Uncertainties within & between systems
  - Dynamic (not static) behavior
  - Revolutionary technologies and operational concepts

Implications

- Current formal aerospace design methods are not complete for these problems
- No single agency, program, technology/vehicle alone can solve the problem
  - Interfaces needed at multiple levels
- New methods are needed to understand the problem and provide interdisciplinary interfaces such that interconnections can be exploited.
- The organization of systems is just as important as the nature of systems to be organized.

Research Plan Synthesis

Workshop Deliverables

Participant Interests/Expectations

- “Connect the dots”: Vehicles + Airspace
- Larger system: analysis → optimization
- Complexity
- Decision-making
- Modeling: definition of model?
- Assess research landscape (need)
- Seek collaboration
  - Pursue collaborations with external context- e.g. FAA
- Seek synergies

Lexicon

- Modeling
  - Two distinct definitions emerged:
    - Decision-making process methods
    - Methods for modeling particular transportation architecture scenarios
- Transportation architecture
  - *In general*, an architecture is a particular collection of system-of-systems, including the connective relationships between them, representing the 'universe' of study
  - *For our aeronautics planning,* this is a system composed of the physical components and their rules of operation, that is, ground and airspace control, infrastructure, vehicles, operators, regulations, concepts of operation, business models, etc. (Pathfinder definition)
  - (Added) Our intended transportation **architecture** model is a layered model in which tractable layers are connected with interfaces
    - Validated layers represent distinct decision levels
- Scale-free network
  - A basic feature common to complex networks whereby a microscopic structure and macroscopic structure appear the same; When small bits of the network are magnified, they resemble the whole

Model Boundaries (Scope)

- Rationale: Properly define the problem before solving it.
- "<u>Everything</u> on the <u>Table</u>"
  - What is Everything?
    - Aeronautics view (look at D-D speed w/o touching other modes)
      - Near and Far term concepts
    - Extra-than aeronautics view
      - Physical entities and infrastructure
      - Other modes (look at true D-D speed)
      - Economic, policy, stakeholders, States
      - Their networks
    - Near and Far term activities commence simultaneously, but use far term scenarios to "project backwards"
  - Time horizon (1 year, 10 years or 100 years)
    - Need for evolving system requirements generator to support multiple time horizons

Identified Crucial Issues

- What makes for scalable air transportation system?
  - Scalable at all layers, in the topology
- What is the value of mobility (time)?
  - Influence on transportation architecture
  - "Mobility Freedom Credit"
  - Research goal: remove barriers to freedom
- What of technology development models?
  - Traditional value web
  - Incubation network
    - Value emergent/unexpected benefits
    - Can we tolerate the uncertainty in outcome?
  - Dual path approach: Emergent research and decision-support
    - Proof → Research?
    - Additional troops are needed
- What of model validity – uncertainty?
  - In architecture model, dose combined uncertainty overshadow outputs?
  - Robustness: model assumptions, network
- Where are the "use cases"?
  - Design & assessment
  - Need to conceive and assess two architectures to establish a thought process

Modeling Layers

- A useful approach for defining system-of-system problems
  - Identify self-contained layers that are tractable from a modeling perspective
  - Create interfaces that allow traceability between layers
- Supports management of customer and modeling hierarchy
  - Customer: Public →Agency →Program →Technology
  - Modeling: Mobility →Operator → Transport → Capacity
  - Implication: Need two branches of methods research
- Enables communication to other agencies at appropriate level

Use Cases

- Uses of desired analysis methods
  - Provide guidance at distinct layers (decision-making methods)
    - E.g. Agency level- visualization and insight to Code R Tech investment authority (Pathfinder)
    - E.g. Transport layer: identification of preferred networks for overall efficiency
  - Generate attractive future scenarios to elicit desired resource and stakeholder traits based on architecture level (transportation modeling methods)
    - Create better programs
    - Caveat- Tools must be developed with future state in mind
  - Linkage to "externalities"
  - Methodology implications
    - Good news- Many degrees of freedom (connections)
    - Bad news- Very high dimensionality

Unique System-of-Systems Characteristics vs. Modeling Philosophies/Approaches

Build methods credibility through validation

Synergy between Approaches

System-of-Systems Characteristics \ Philosophy / Approach	Agent-Based Modeling	System Dynamics	Mechanical Modeling	Network Theory	Object-oriented Approach	Mixed-type, High dimensional optimization
System Heterogeneity (Human & Machine)	✓				✓	✓
Scalability	✓			✓		
Connected-ness		✓				
Uncertainty						
Policy Feedback and Policy Resistance		✓				
Time Variance		✓				
Robustness/Vulnerability						

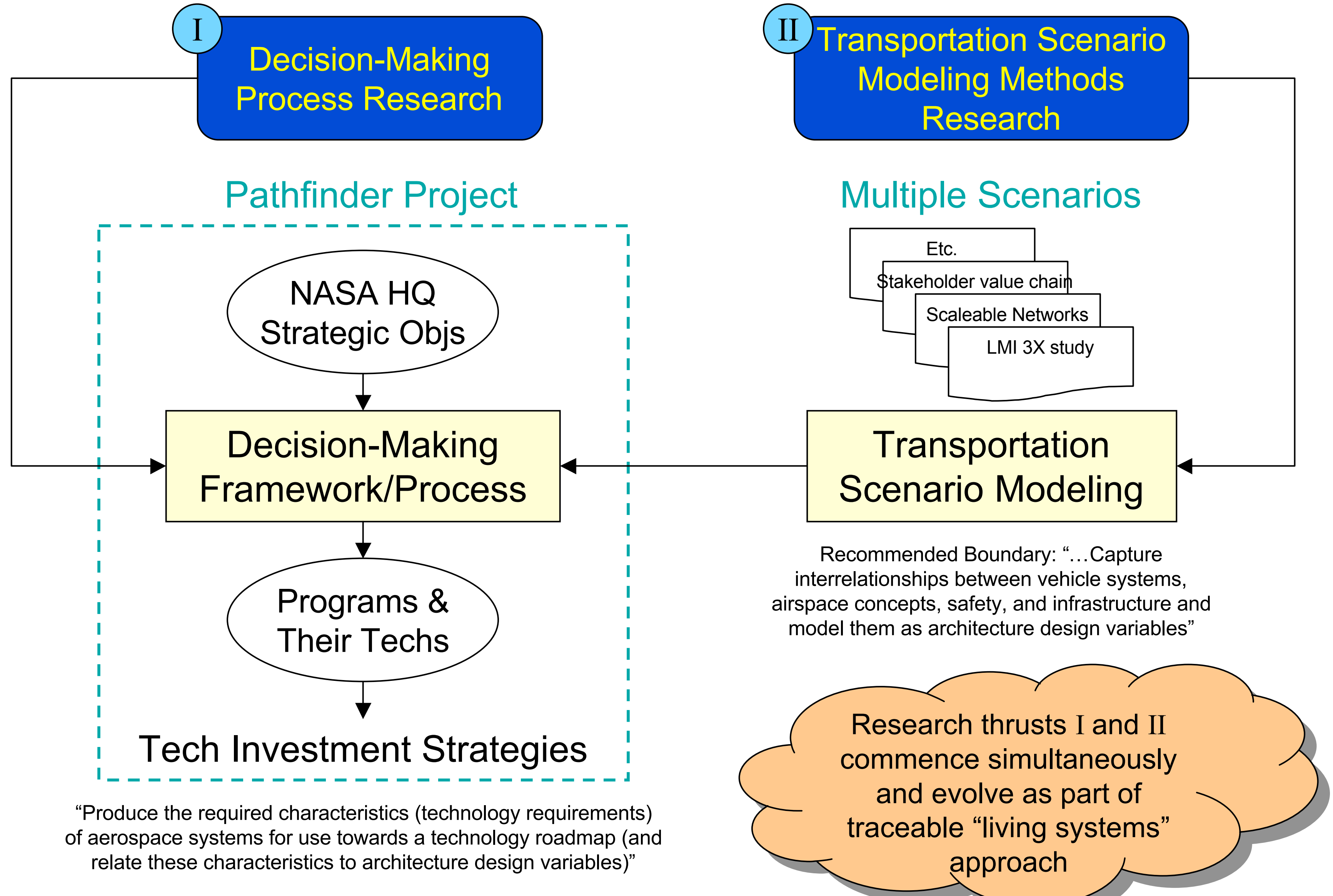
<u>Next Steps</u>

- Identify gaps in the matrix
- Identify synergies between approaches
- Identify different characteristics at different layers
- . . . . leading to required investment in transportation methods research

Caution!: Relevant Lessons Learned from the Past

- Old/current technology development constructs may not be sufficient for future transportation architecture exploration
- Be cognizant of the value of unintended consequences
- We tend to model what we can model, do what we can do
- NASA product is technology, not vehicles, nor systems
- Be aware of organizational barriers
  – Stove-piping, anti-thesis of interconnected approach
  – Lack of problem definition
  – Must understand how to help Code R Programs
- Who is “the customer”:
  – Public, OMB, “Terry/Bob” ?
- Be ready to create processes and tools that assist programs, not create or catalyze barriers to them

Proposed Dual Path Methods Development



Proposed Research Questions

I. Decision-making process research

- Can rapidly assembled, “on-demand” architecture analysis suite be created? Object oriented? Manageable complexity? “Living system”? Traceable decisions?
- Can variable intensity/type of information requirements be handled at different levels?
- How shall handle policy issues be addressed? Authorizing steps?

II. Transportation architecture scenario research

- What are scalable transportation architectures?
  - What metrics? Mobility “freedom” characterization?
  - What models are needed?
  - Is robustness / vulnerability understood? What are the effects?
- Can comparative assessment of transportation architectures be conducted?
  - Can the global optimum be identified?
  - Can we handle un-modeled dynamics?
- How to handle infrastructure: as constraints or design variables?
- Can a flexible “control volume” approach be adopted?
  - What granularity of modeling elements is appropriate for technology development at all levels?
- How is validity of modeling/assumptions assured?

Recommended Next Steps

1) Deliverable preparation and next-step coordination
   - NIA (Dan D. + Research Leadership, e.g. Liaison Professors)
     - Solicit feedback from Workshop participants
   - NASA Pathfinder, Bruce Holmes (coordination)

2) Further develop research questions; translate into proto-research proposal for living system methods

3) Engage external, related efforts (FAA, etc.)
   - Who is doing what? Get better connected to context.

4) Explore the idea of forming a "research community"
   - What program development approaches seem appealing going forward? Traditional, Incubation, both?

5) Future Meetings? Resources for proposal preparation?

Contents of Support Material

- Shockor
  - Overview of the NASA Pathfinder Project
- Holmes
  - Transportation innovation strategies, network theory considerations, NIA strategies, key characteristics of alternative architectures
- Trani
  - Framework for Modeling Impacts of Air Transportation Systems (SATS System Analysis)
- Shortle
  - Issues in Safety Modeling of Future Air Transportation Systems
- Dollyhigh
  - NASA LaRC Systems Analysis Branch Transportation Architecture Modeling & Simulation
- DeLaurentis
  - Decision-making Methods
  - Mobility Freedom Credit Modeling