Feedback Models of System Transition

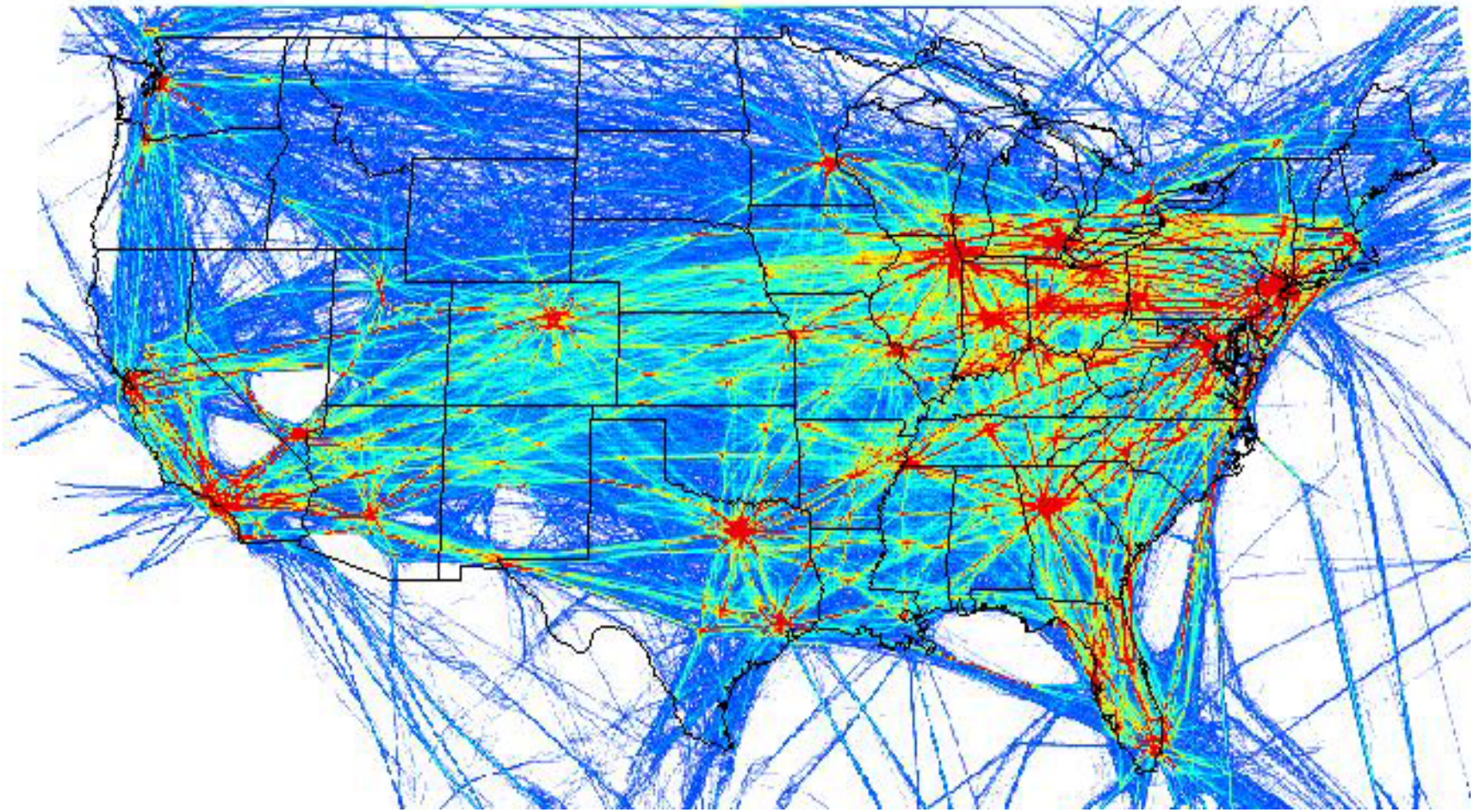
Prof. R. John Hansman

(in collaboration with, Aleksandra Mozdzanowska, Prof Annalisa Weigel, and Dr. Karen Marais)

MIT International Center for Air Transportation

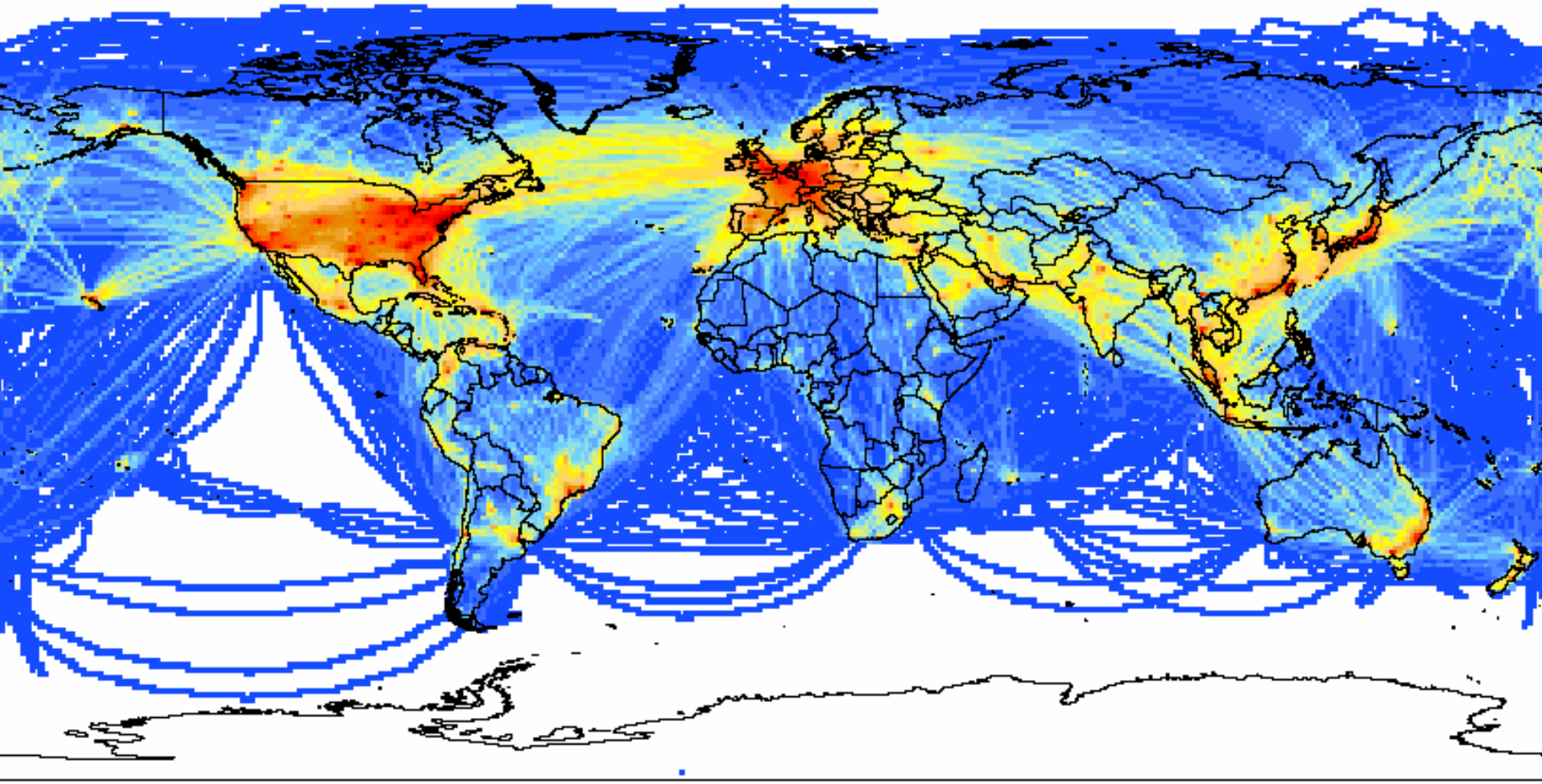
rjhans@mit.edu

National Air Transportation System (NAS)



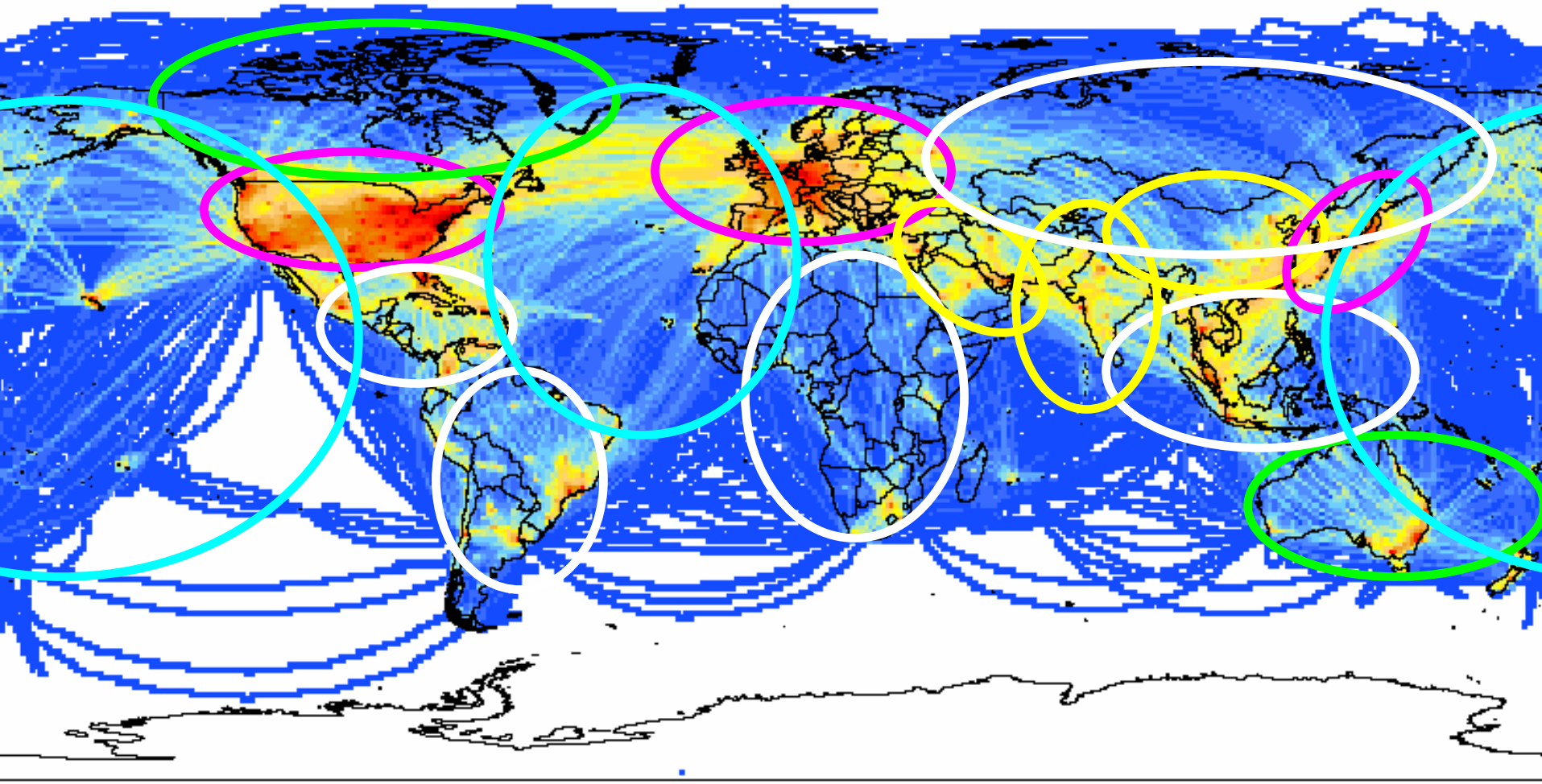
- Example of a complex adaptive system evolved over 70 years

Global Air Transportation System (GAS)



Traffic Source: Sage Analysis courtesy Prof Ian Waitz

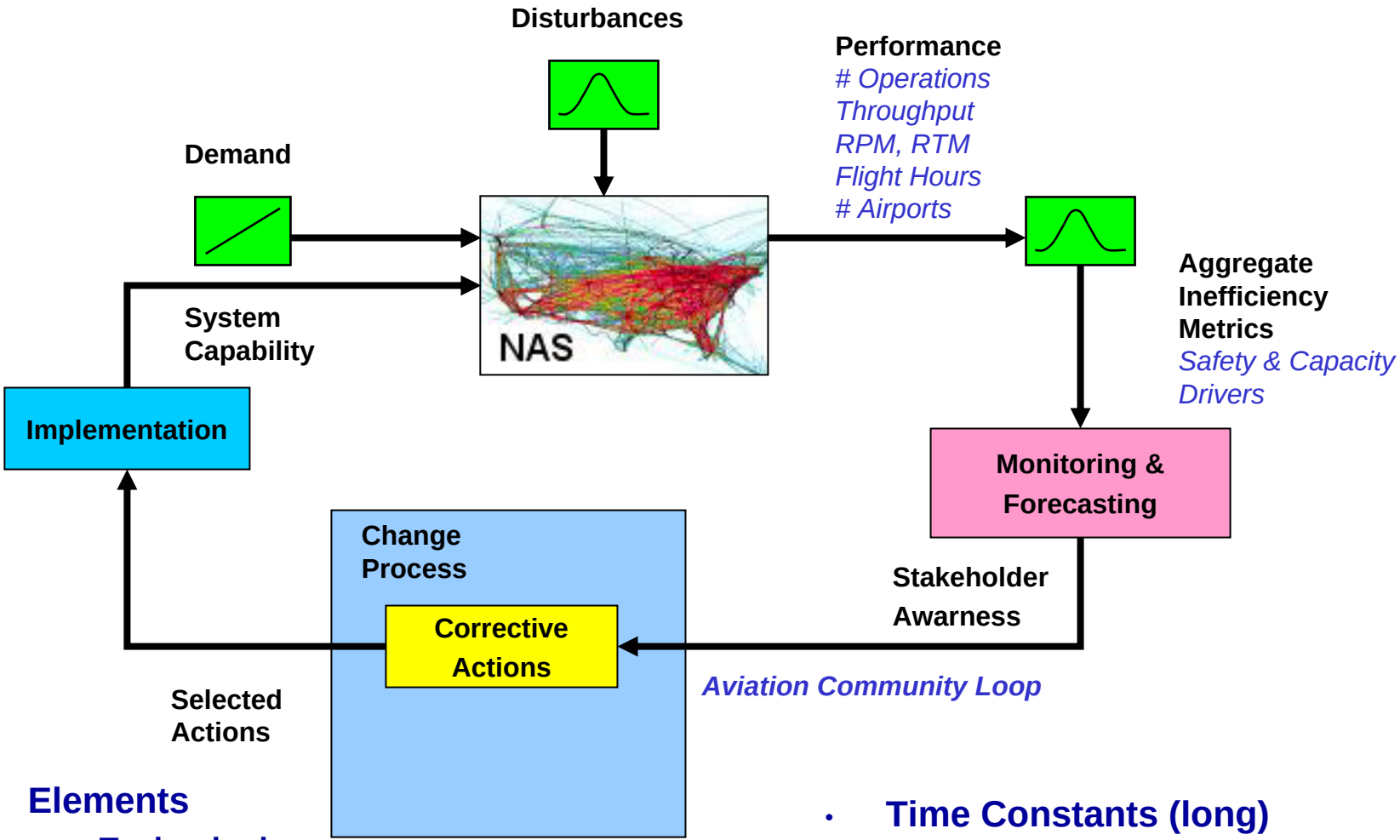
Global Air Transportation System (GAS)



- Multiple Interacting Subsystems
- Regional and Global Evolution Dynamics, Phasing, Harmonization

Traffic Source: Sage Analysis courtesy Prof Ian Waitz

Simple Feedback Model of System Adaptation



- **Elements**
  - Technologies
  - Procedures
  - Policies

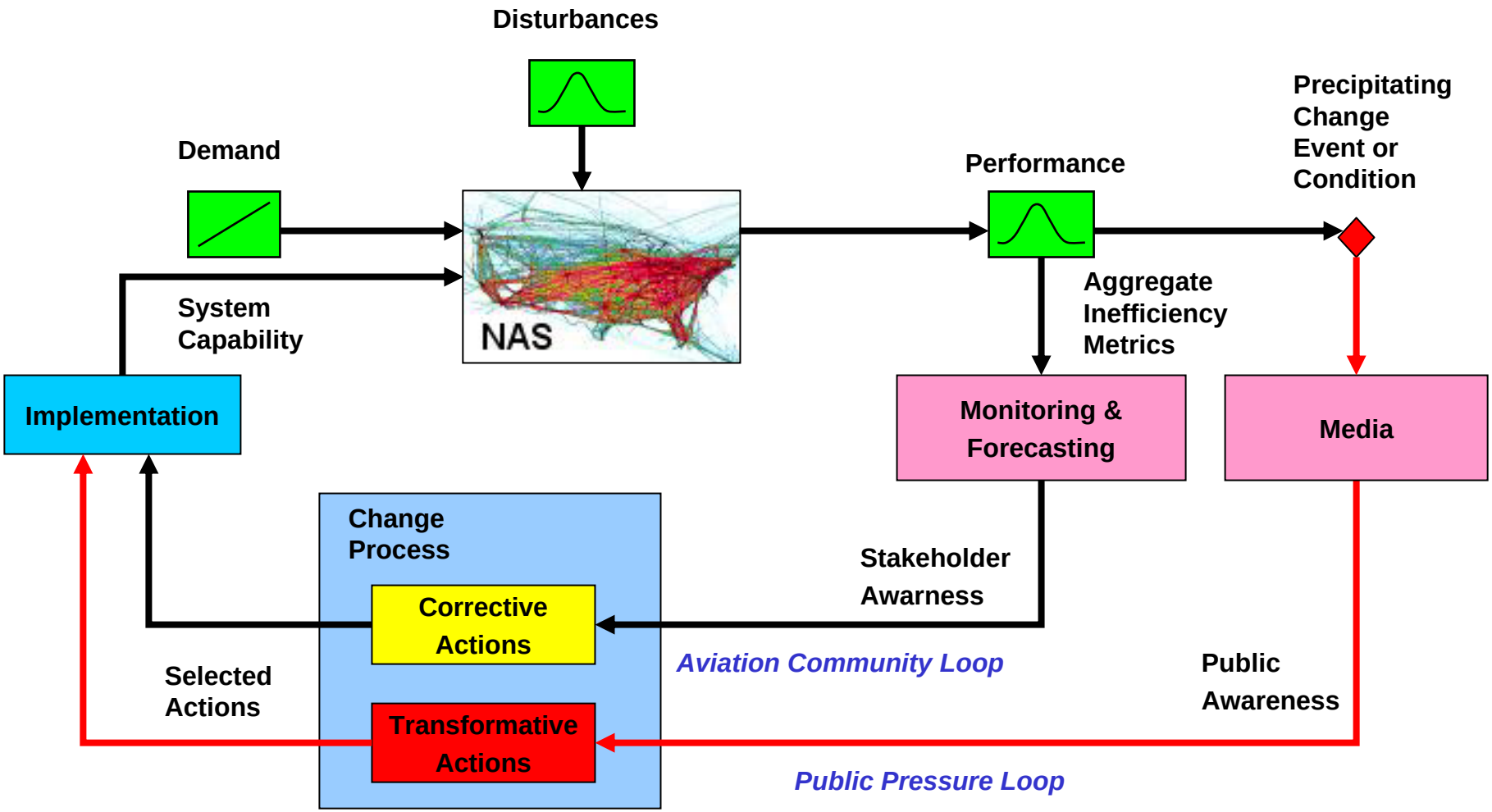
- **Time Constants (long)**
  - Awareness
  - Change Process
  - Implementation

Transition Barriers

- 24/7 Operating System
- Competing Stakeholder Objectives
  - Reversion to the “Status Quo”
  - Labor Concerns
- Safety Considerations
  - Off Nominal Conditions Drive System Acceptability
  - Certification
  - Human-Automation Trades
  - Safety Veto
- Technical Maturity (TRL X)
- Equipage
  - Critical Mass
- Resource Limitations
  - Operating vs Modernization Investments
  - Competing National Objectives

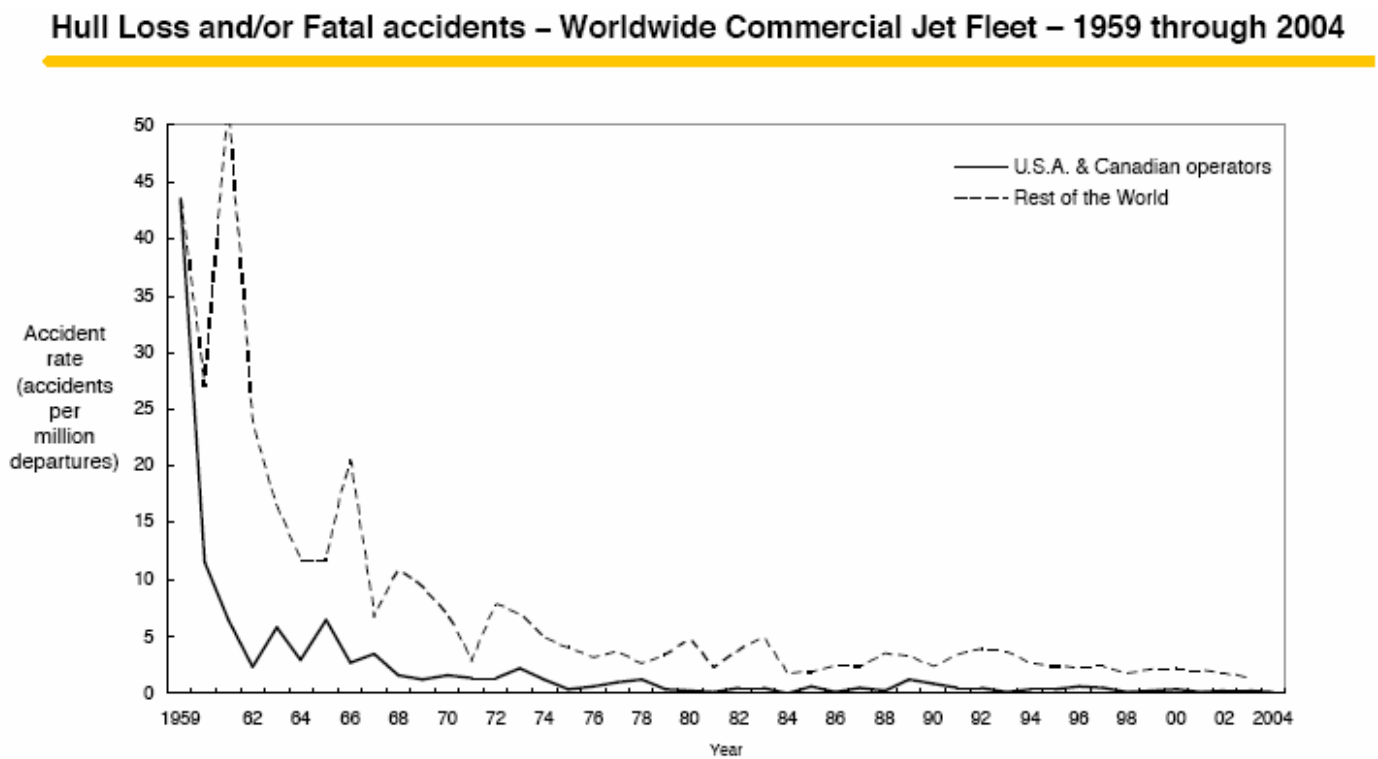
Predictive, Reactive, Catalytic Transitions

Safety vs Capacity Drivers



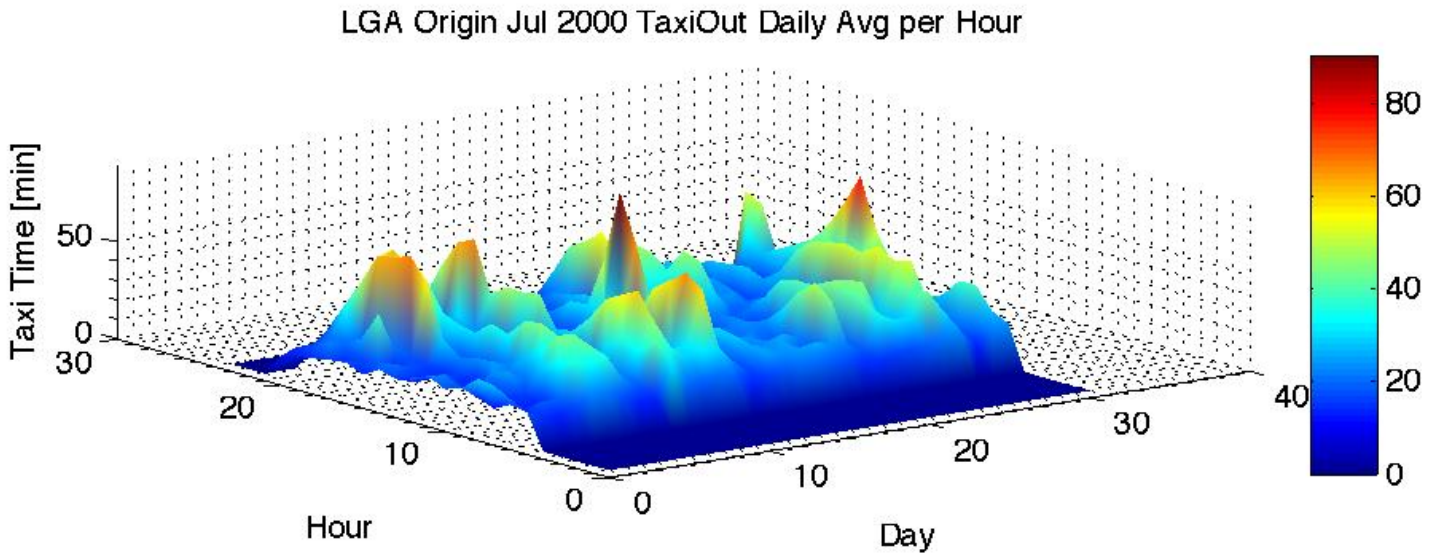
Event Driven Transitions

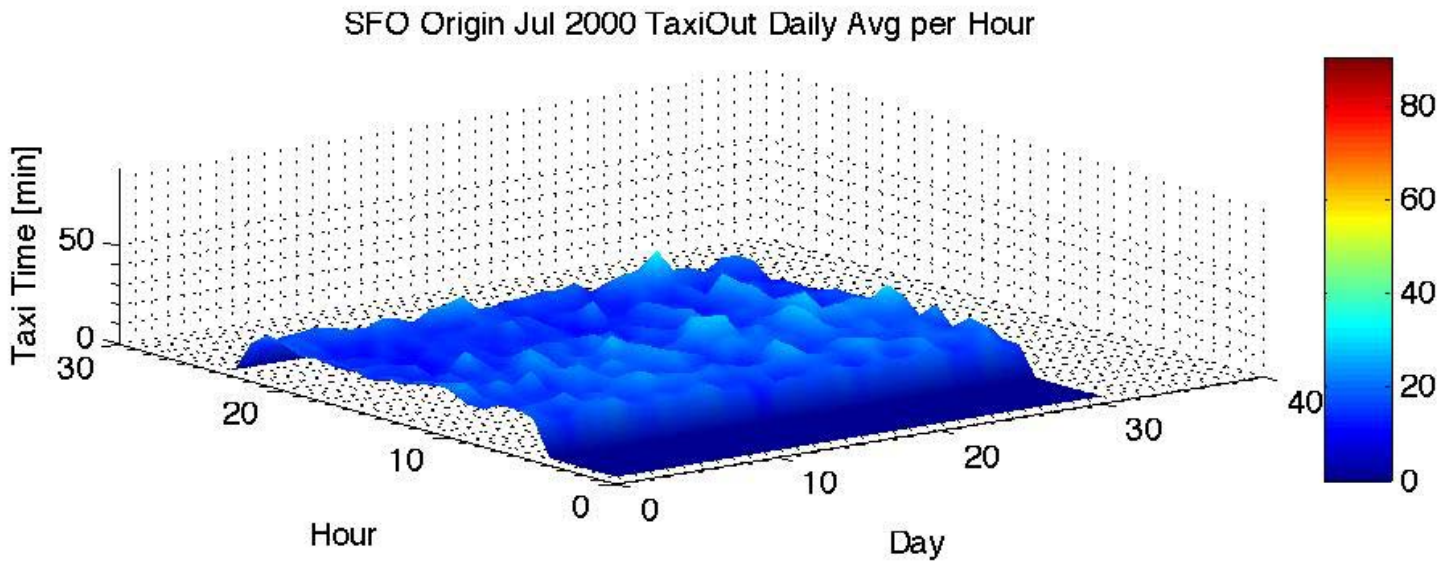
- **Safety Transition Examples**
  - **Grand Canyon (1955) > Positive Radar Control**
  - **Los Cerritos (1986) > TCAS**



Source: Boeing Statistical Abstract

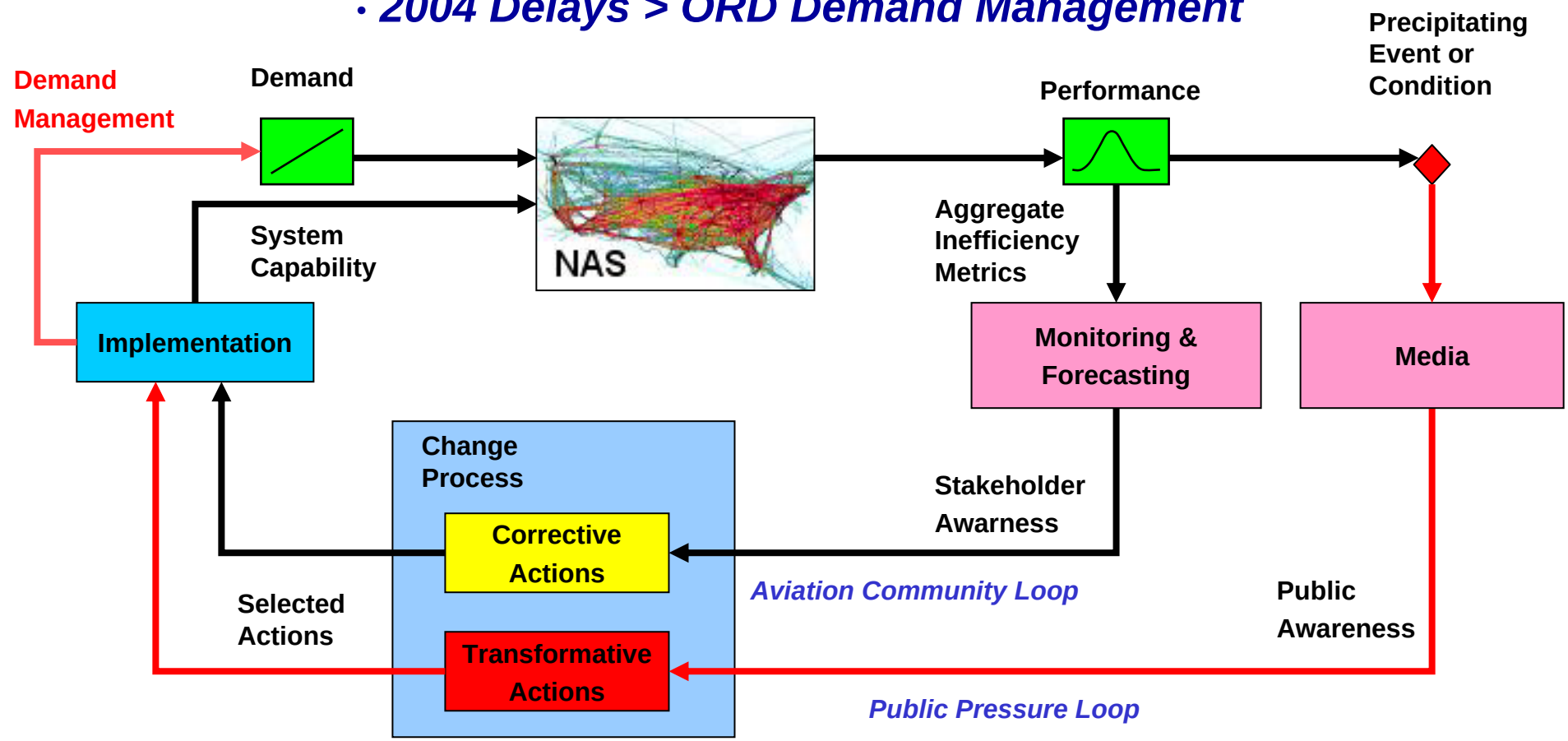
Capacity Driven Transitions
eg LGA 2000



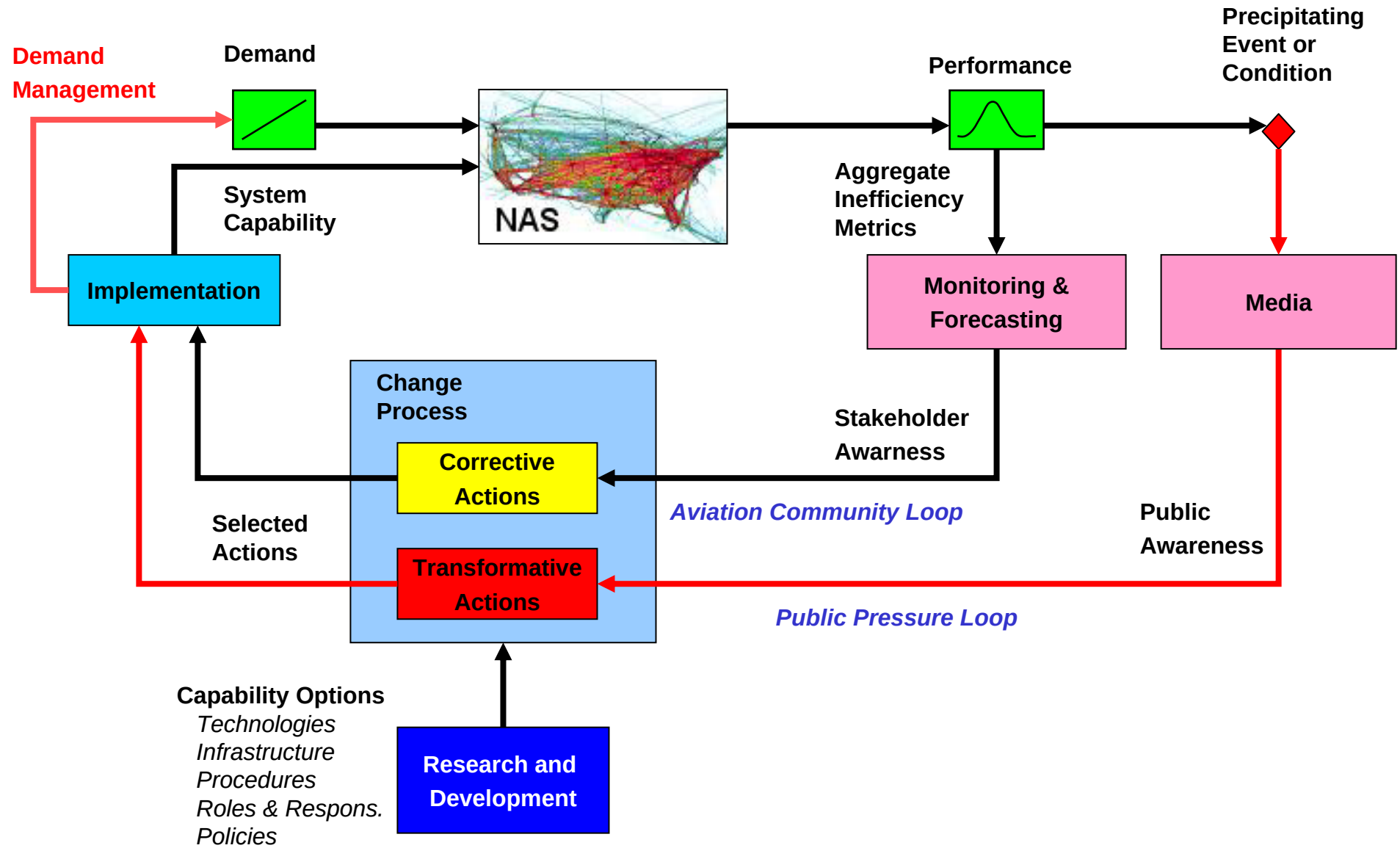


Increasing System Capacity vs Demand Management

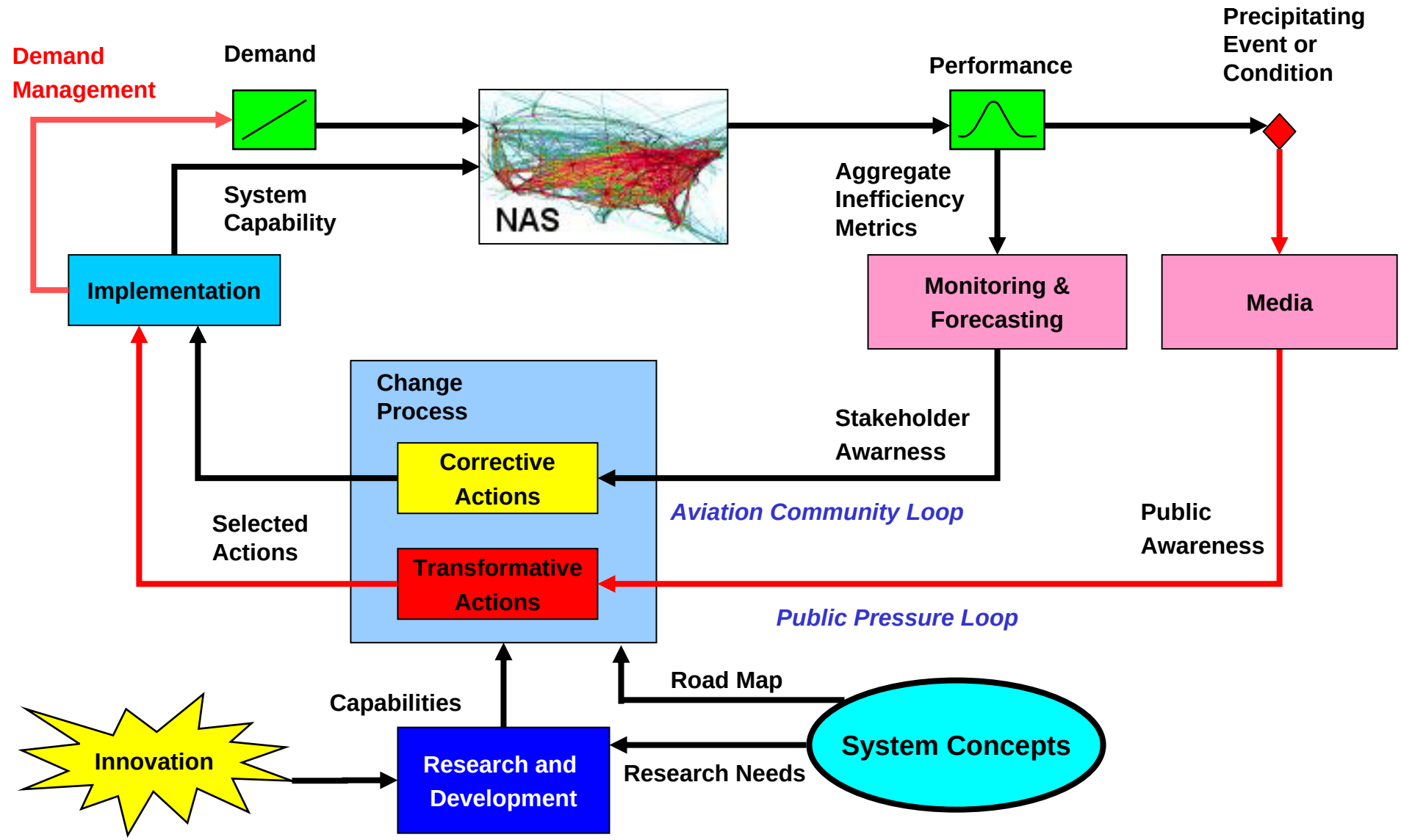
- *Demand Management Fast Implementation*
  - *2001 Delays > LGA Demand Management*
  - *2004 Delays > ORD Demand Management*



Role of Research and Development to Provide Capability Options

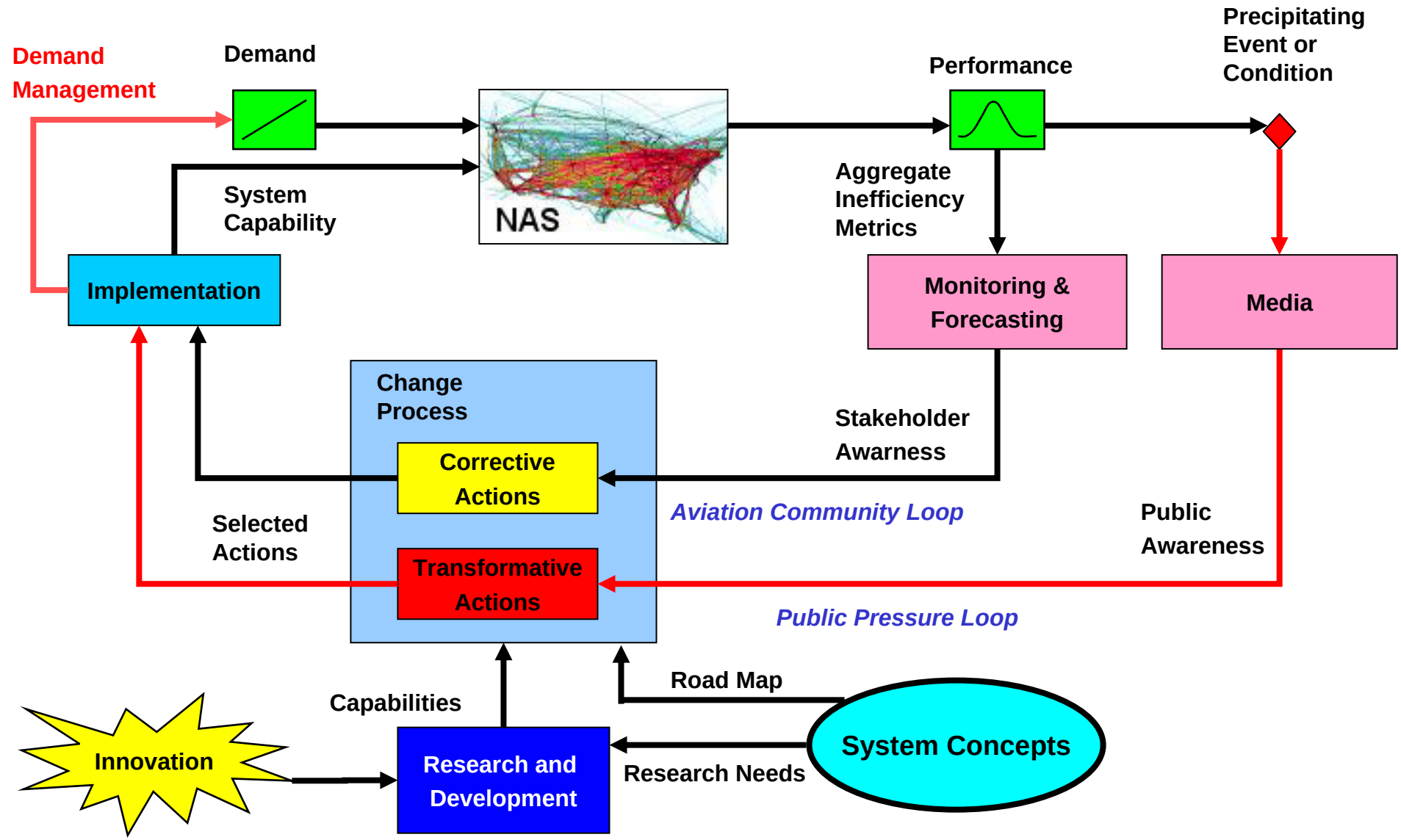


Role of Transformative System Concepts



Role of Transformative System Concepts

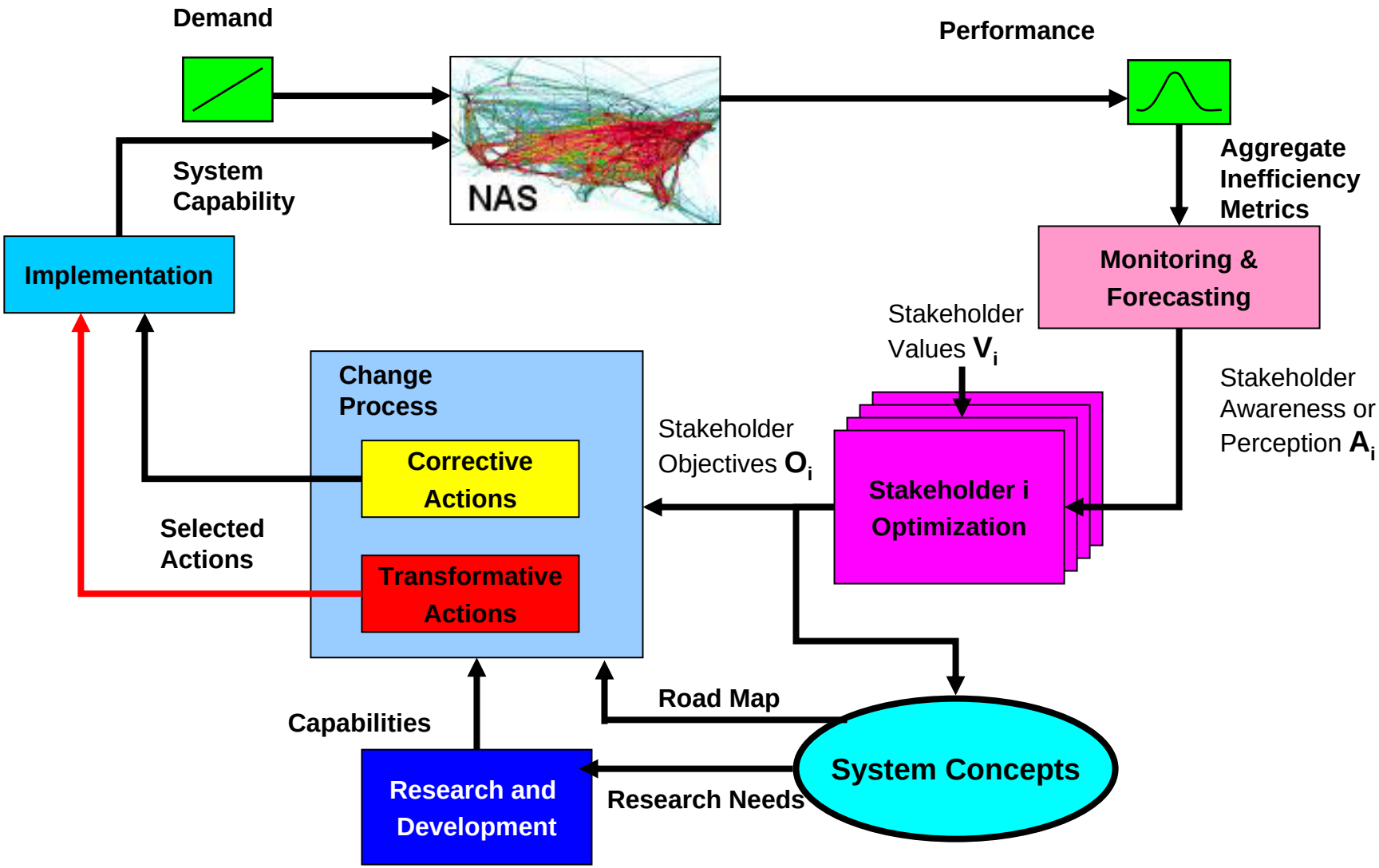
Stepwise Transitions and Configuration Control



Transition Barriers

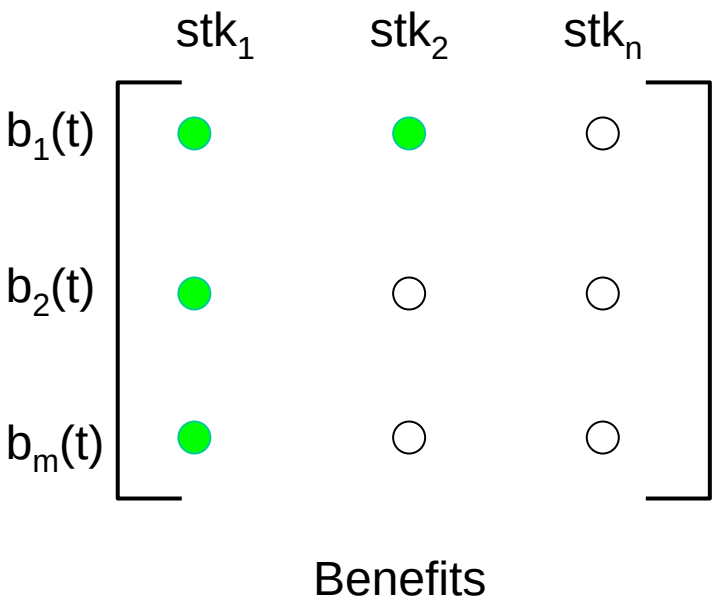
- 24/7 Operating System
- Competing Stakeholder Objectives
  - Reversion to the “Status Quo”
  - Labor Concerns
- Safety Considerations
  - Off Nominal Conditions Drive System Acceptability
  - Certification
  - Human-Automation Trades
  - Safety Veto
- Technical Maturity (TRL X)
- Equipage
  - Critical Mass
- Resource Limitations
  - Operating vs Modernization Investments
  - Competing National Objectives

Multi-Stakeholder Considerations

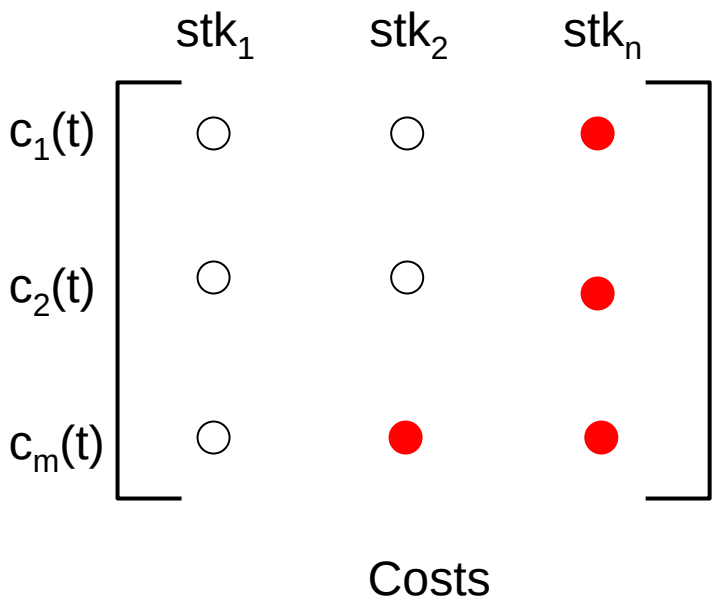


Value Distribution

- **How are costs and benefits distributed between stakeholders?**



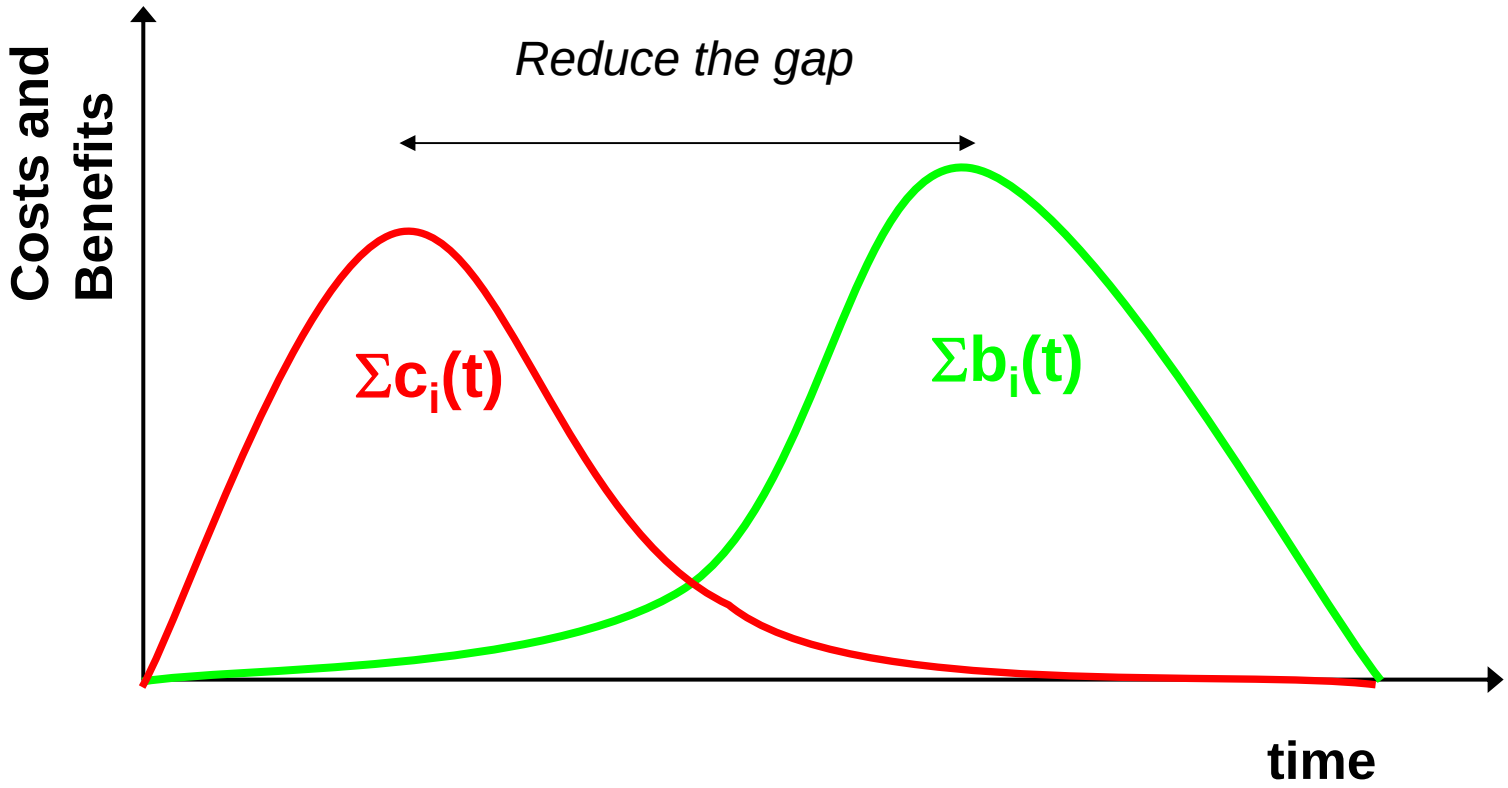
Benefits



Costs

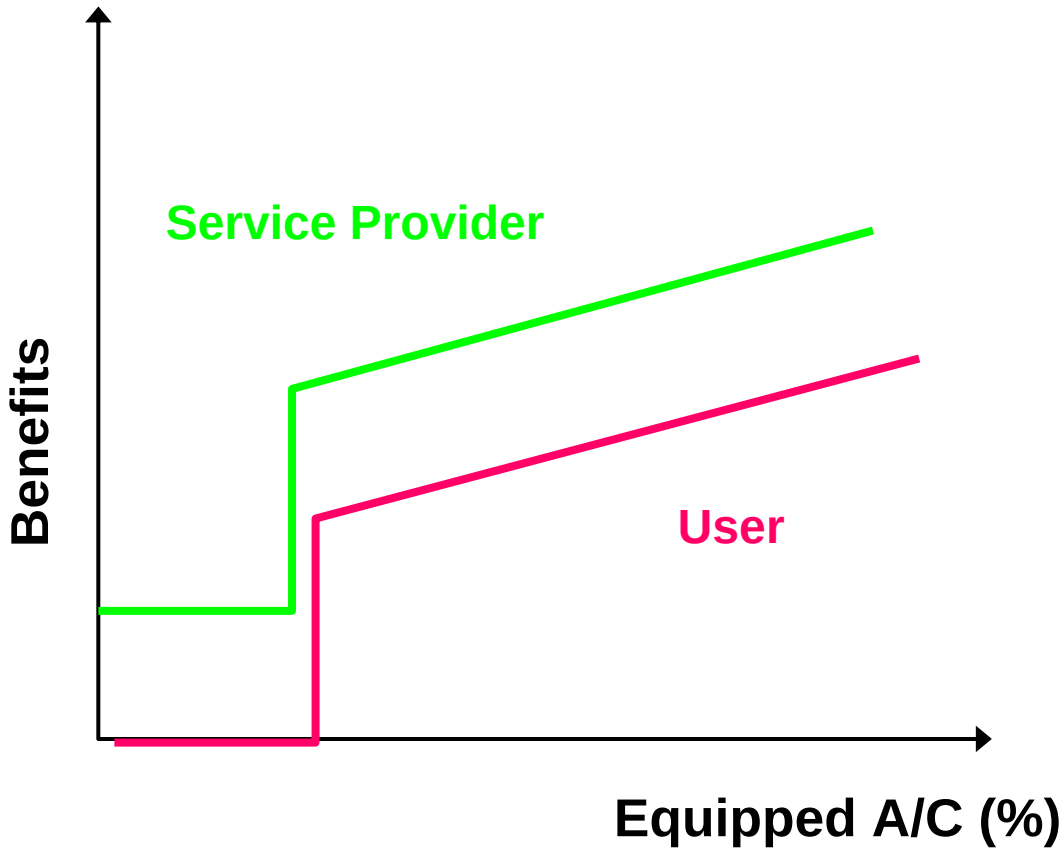
Adapted from: (Dr. Karen Marais & Prof. Annalisa Weigel (MIT) " Encouraging and Ensuring Successful Technology Transition in Civil Aviation"

Time-phased Value Distribution



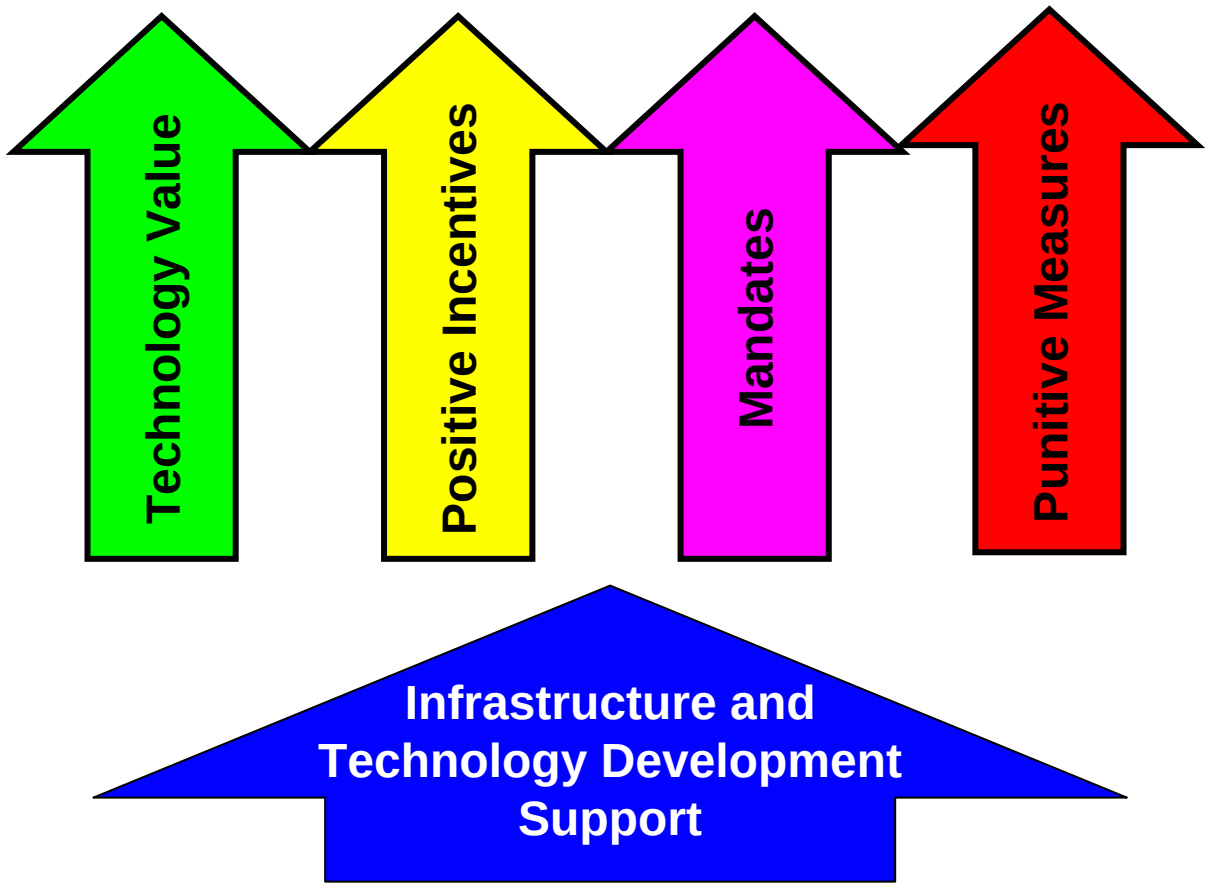
Adapted from: (Dr. Karen Marais & Prof. Annalisa Weigel (MIT) " Encouraging and Ensuring Successful Technology Transition in Civil Aviation"

Critical Mass for User Equipage



Adapted from: (Dr. Karen Marais & Prof. Annalisa Weigel (MIT) " Encouraging and Ensuring Successful Technology Transition in Civil Aviation"

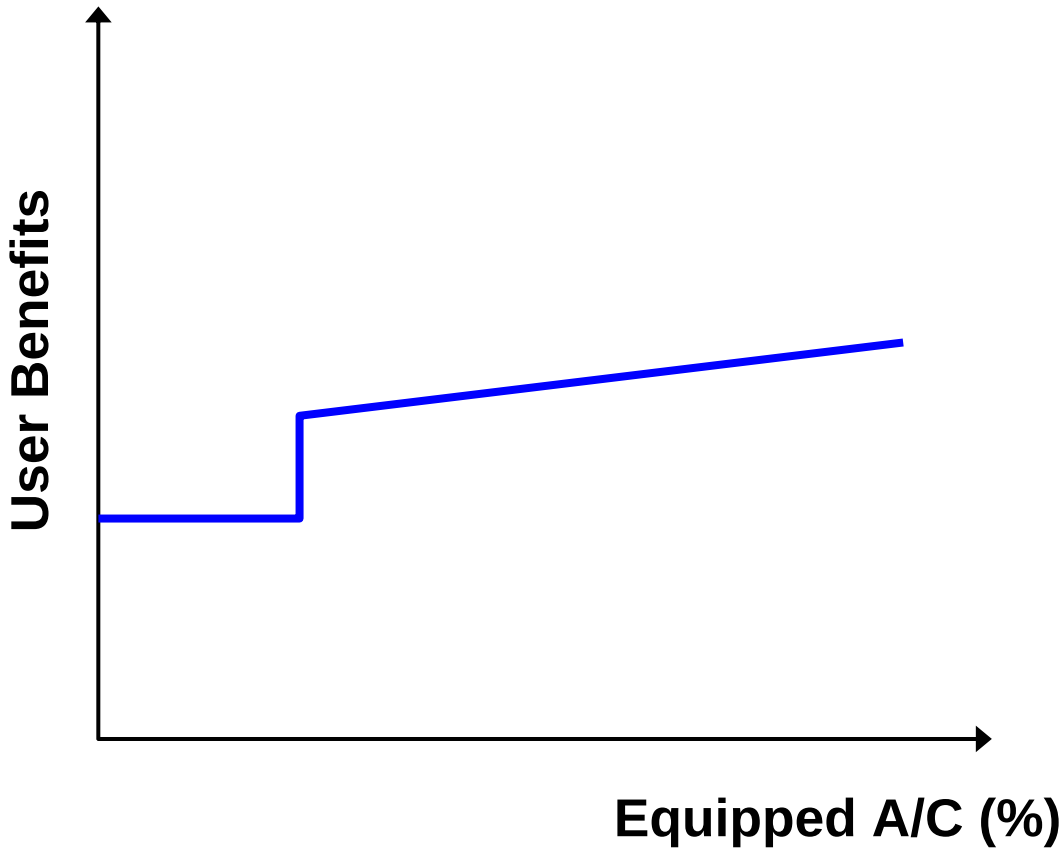
Incentivization or Leveraging Approaches



Adapted from: (Dr. Karen Marais & Prof. Annalisa Weigel (MIT) " Encouraging and Ensuring Successful Technology Transition in Civil Aviation"

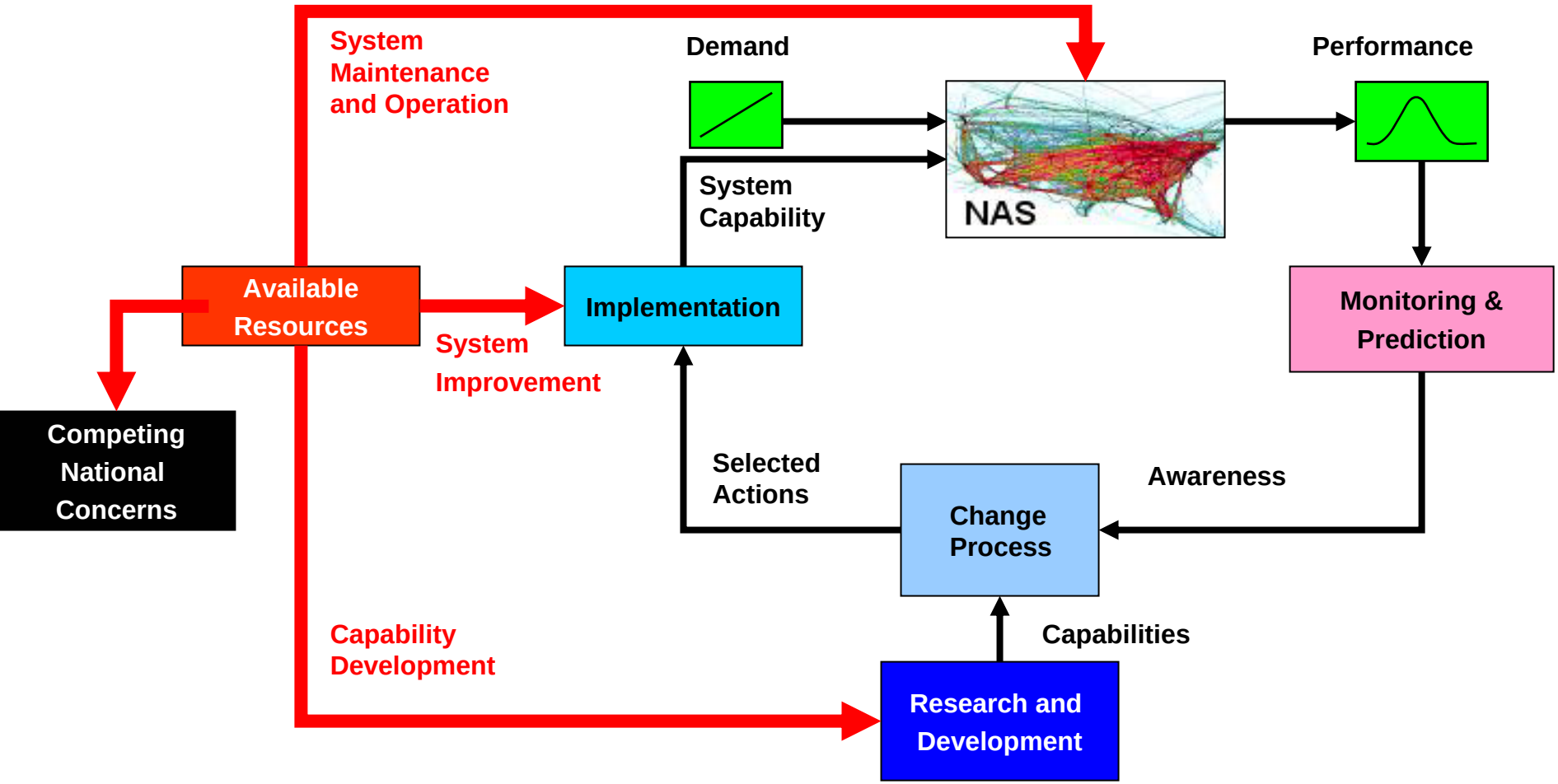
Early Benefit Incentivization

eg Airspace Access, RVSM



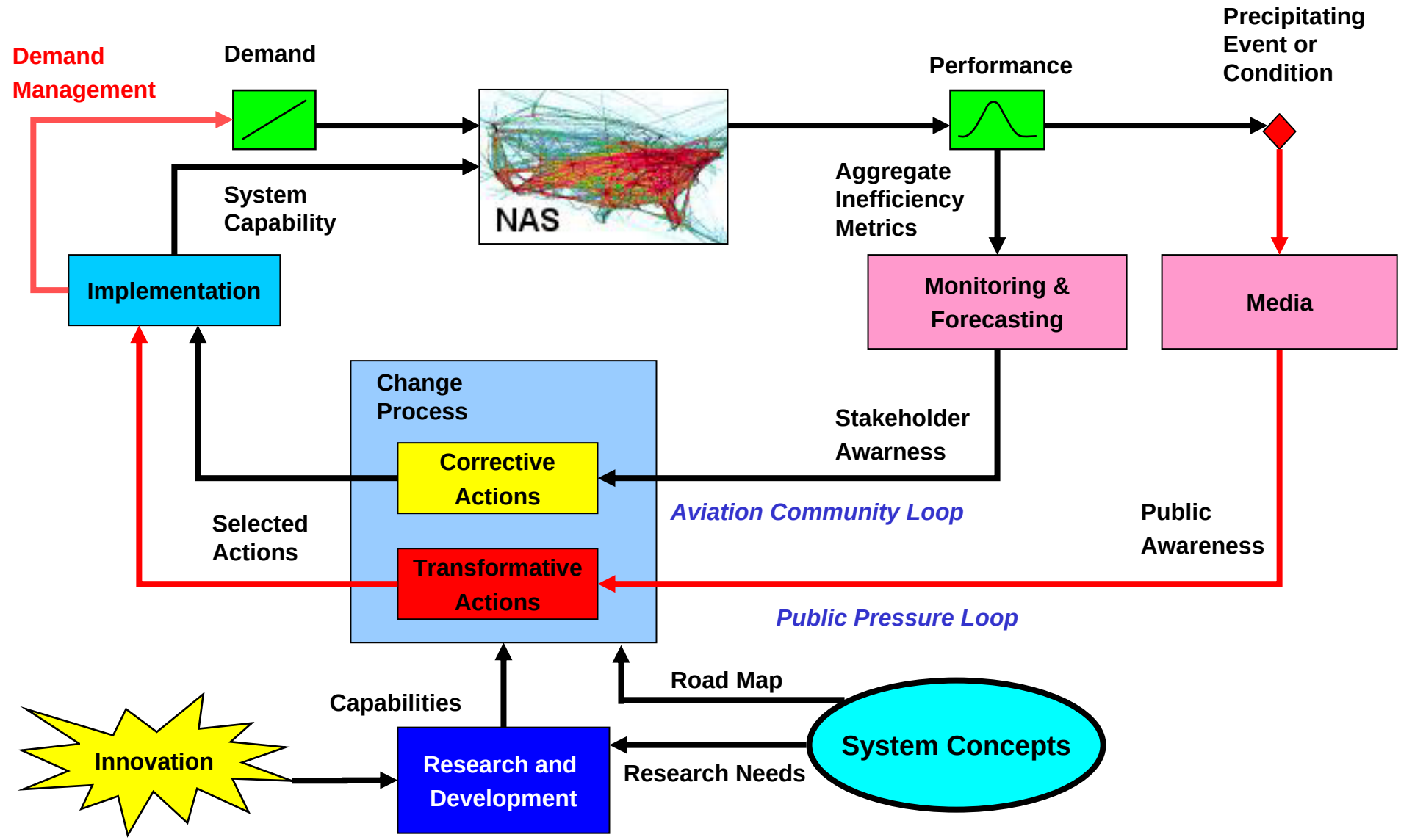
Adapted from: (Dr. Karen Marais & Prof. Annalisa Weigel (MIT) " Encouraging and Ensuring Successful Technology Transition in Civil Aviation"

Resource Issues

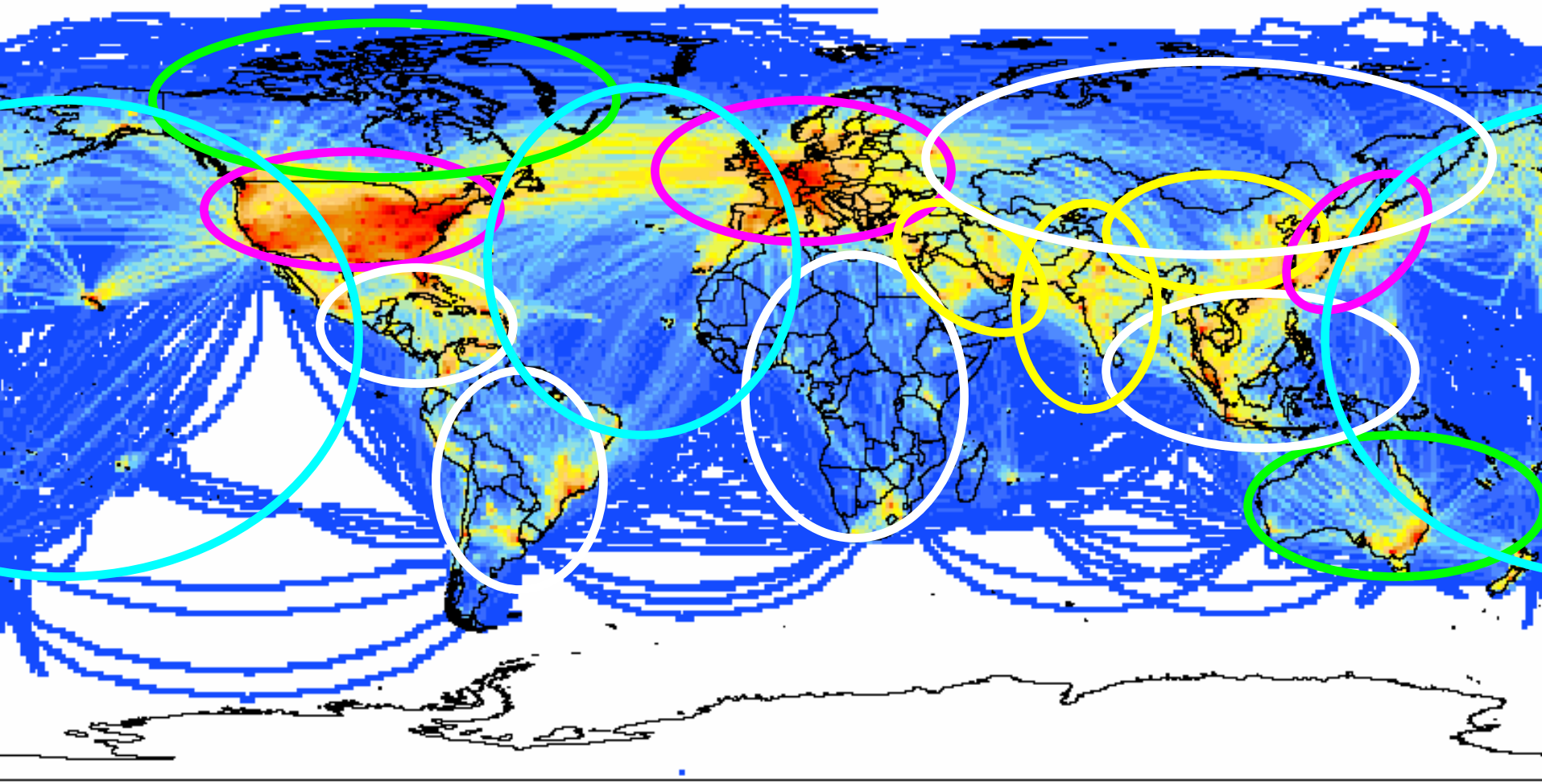


MIT ICAT

Aviation community responsible for adaptive change. We must also anticipate catalytic events and be prepared when the public awareness force transformative change.



Must collaborate and consider the Global Air Transportation System in System Transitions



Traffic Source: Sage Analysis courtesy Prof Ian Waitz