Improving Investment Analysis of Operational Improvements in the North Atlantic (NAT) via Stakeholder Interviews

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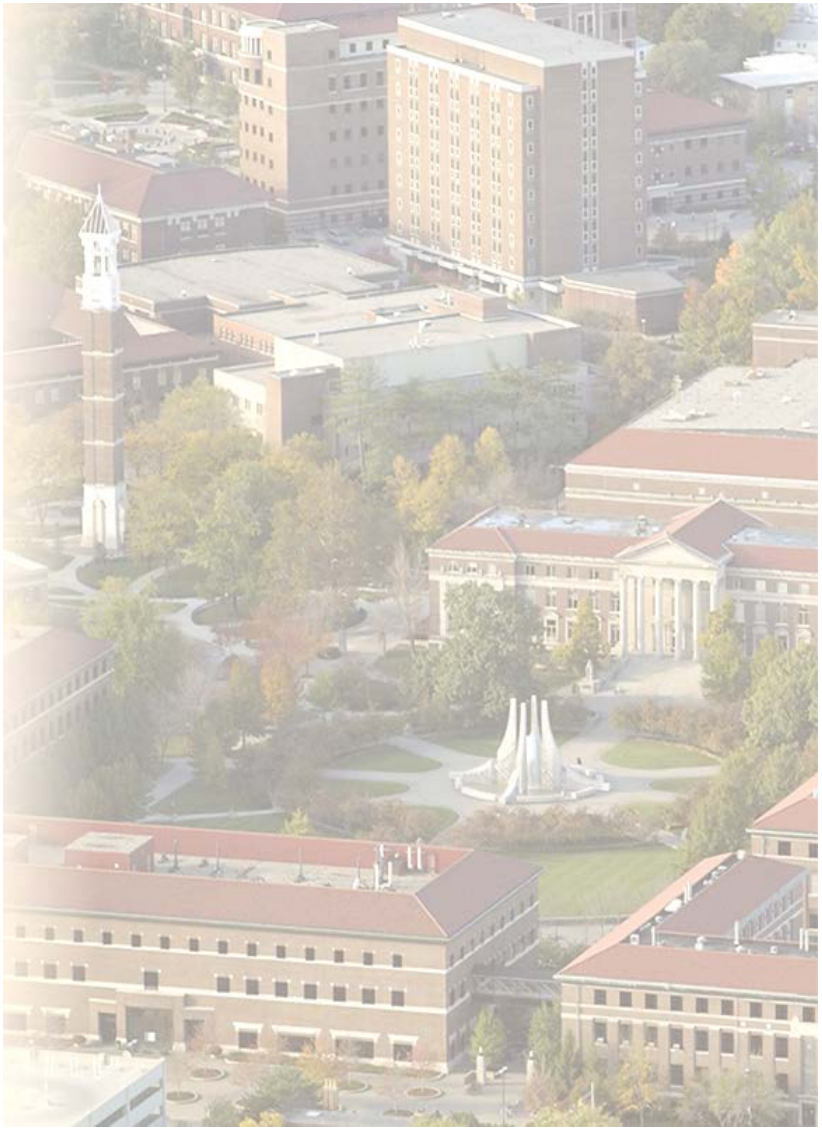


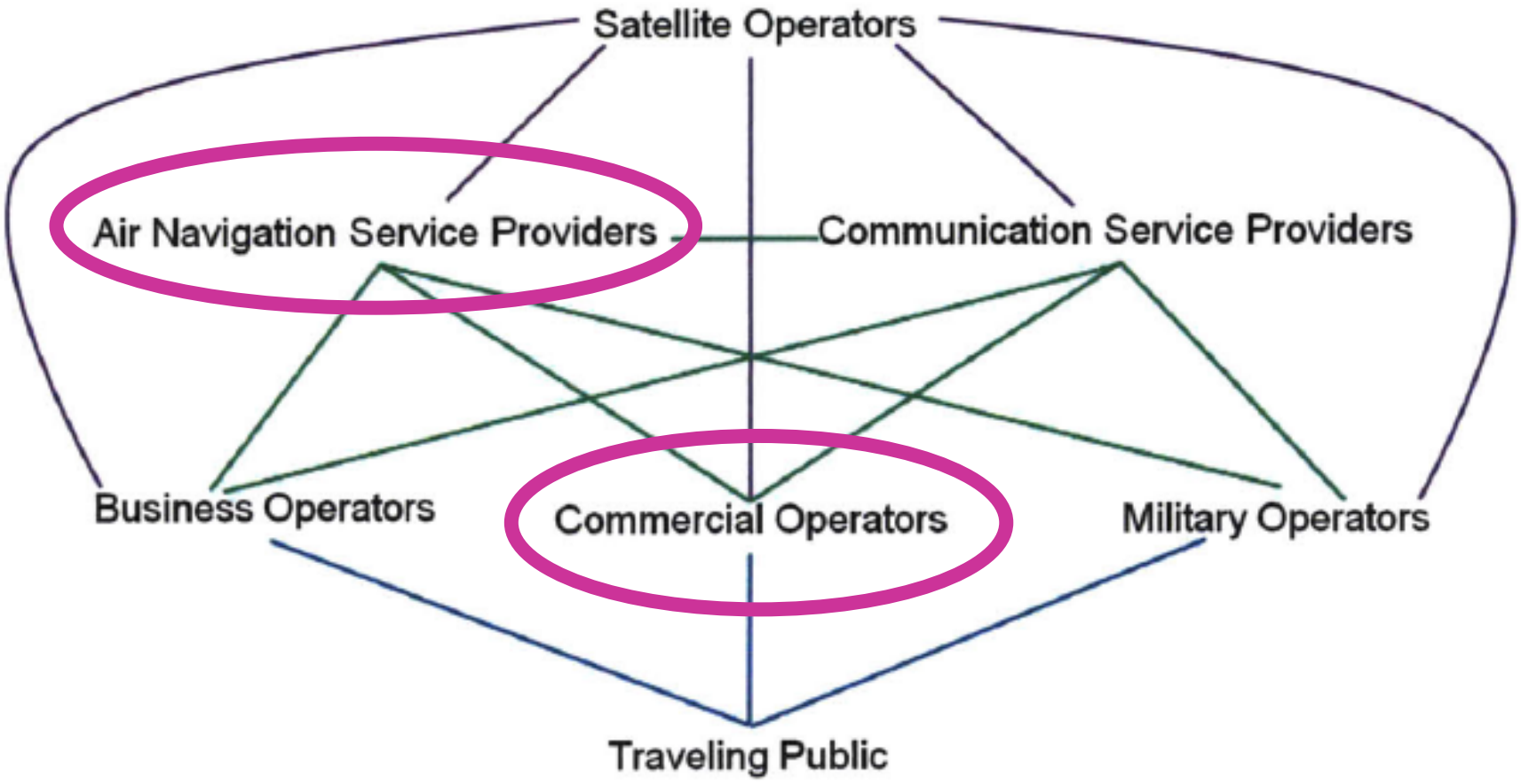
Summary

- Multiple perspectives on the Air Transport System
  - ***In reality a "system of systems"***
  - ***Each participant behaves according to semi-private system models***
- Economic Analysis of Investment
  - ***A form of systems analysis, but beset by uncertainty …***
  - ***Structure of each system model for adoption is uncertain***
- Our research goal: methods for improved investment analysis
  - Objective/Activity 1: ***Characterize uncertainty at different stages in the adoption process through focused interviews with stakeholders in the North Atlantic (NAT)***
  - Objective/Activity 2: ***Suggest a system-of-systems framework for cost-benefit analysis with reduced uncertainty***

Air Transportation as a System of Systems

		System of Systems Dimensions			
	Level	**Resources**	**Operations**	**Economics**	**Policy**
Base Level	α ($\vartheta\ 10^6$)	Vehicles & Infrastructure (e.g. aircraft, ATC facility) 	Operating a Resource (e.g., pilots, crew, maintenance) 	Economics of building/operating/buyin[illegible]/ selling/using a single reso[illegible] 	Policies relating to single resource use (e.g. type certification, flight procedures, etc.)
Network of Networks	β ($\vartheta\ 10^4$)	TRANSPORT  Collection of resources for a common function (e.g. airport, etc)	CREW  Operating resource networks for common function (e.g. airline)	MOBILITY  Economics of operating/buying/selling /leasing resource networks	Policies relating to multiple vehicle use (e.g. airport traffic mangt, noise policies, etc.)
	γ ($\vartheta\ 10^2$)	Resources in a Transport Sector (e.g. air transportation)	Operating collection of resource networks (e.g. ; commercial air Ops)	CAPACITY  Economics of a Business sector (e.g. Airline Industry)	Policies relating to sectors using multiple vehicles. (safety, accessibility, etc.)
	δ ($\vartheta\ 10^1$)	Multiple, interwoven sectors (resources for a national transportation system)	Operations of Multiple Business Sectors (i.e. Operators of total national transportation system)	Economics of total national transportation system (All Transportation Companies)	Policies relating national transportation policy
	ε ($\vartheta\ 10^0$)	Global transportation system	Global Operations in the world transportation system	Global Economics of the world transportation system	Policies relating to the global transportation system

Stakeholder Groups in the NAT*



*N. V. Campos, “Encouraging technology transition through value creation, capture and delivery strategies: the case of data link in the North Atlantic airspace,” Massachusetts Institute of Technology, 2009.

NAT ANSPs- Diversity!

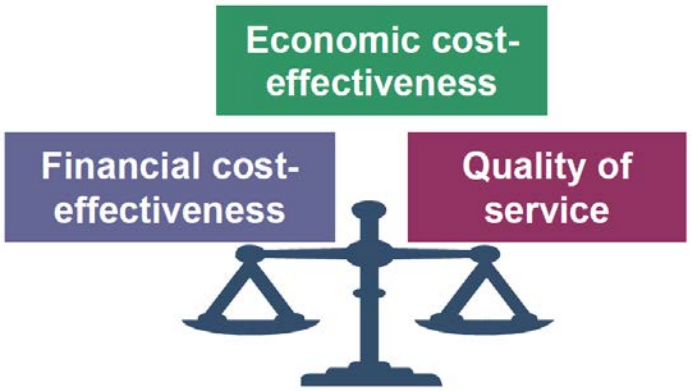
Name	Country	Type	Features
Avinor	Norway	State-owned company	
Federal Aviation Administration	United States	Government agency	
Irish Aviation Authority	Ireland	State-owned company	
Isavia	Iceland	State-owned company	
National Air Traffic Services	United Kingdom	Private-public partnership	UK government holds 49% share
NAV CANADA	Canada	Private corporation	Non-profit
NAV Portugal	Portugal	State-owned company	
Naviair	Denmark	State-owned company	
DSNA- Directorate of Air Navigation Services	France	Government agency	

NAT Commercial Operators- Many!

- Passenger (~40 airlines operating in NAT) (Campos 2009)
  - 536,309 passenger flights in North Atlantic in 2012 (FAA 2015)
  - Top 5 airlines by # PAX from US to Europe in 2013 (BTS T100):
    1. Lufthansa German Airlines
    2. United Air Lines Inc.
    3. British Airways Plc
    4. Delta Air Lines Inc.
    5. Compagnie Natl Air France

- Cargo
  - 11,598 cargo flights in North Atlantic in 2012 (FAA 2015)
  - Top 5 operators by lbs freight from US to Europe in 2013 (BTS T100):
    1. Federal Express Corporation
    2. British Airways Plc
    3. Lufthansa German Airlines
    4. United Parcel Service
    5. American Airlines Inc.

Components of Investment Analysis*



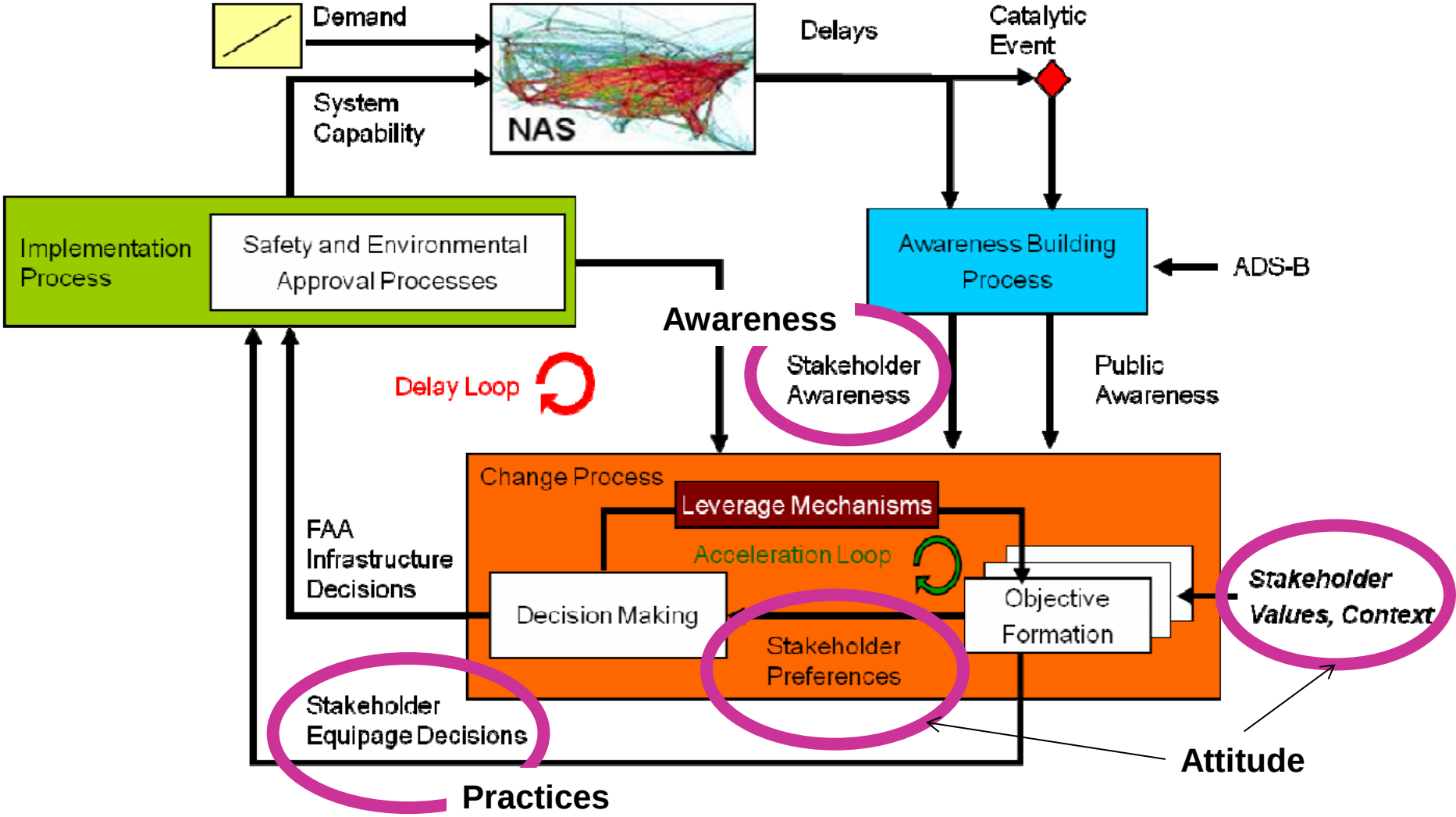
- To assess economic performance, ANSPs must consider both the **quality of service** and **financial cost-effectiveness** through economic investment analysis
- Tradeoff between the two
  - Expanding capacity, reducing delays may impose costs on users
  - Need to look at the 'system' picture: benefits of reduced delay may outweigh financial costs, depending on other factors

*"ATM Cost-Effectiveness (ACE) 2010 Benchmarking Report with 2011-2015 outlook," EUROCONTROL, Brussels, Belgium, May 2012.

Economic Analysis of Investment

- Economic analysis of investment decisions seeks to provide answers to two questions (Hoffer 1998):
  1. Is a particular objective worth achieving?
  2. Which of several alternative methods of achieving an objective is best?
- Benefit-cost analysis answers both questions
- Uncertainty in time and magnitude of benefits delivery reduce the attractiveness of new technology to stakeholders (Mozdzanowska 2007)
- Other sources of uncertainty affect investment analysis (Hu 2008)
  - Technology: How long will a certain technology be supported?
  - Regulatory: Will regulations be standardized in all countries and all airlines?
  - Human Factors: How will operators respond to new technology?
  - Information: Is the communication regarding the requirements adequate?

Transition Dynamics Process Model*



* A. Mozdzanowska, R. Weibel, E. Lester, R. Hansman, A. Weigel, and K. Marais, "Dynamics of Air Transportation System Transition and Implications for ADS-B Equipage," 2007.

Interview Content

- Categories: *Knowledge/Awareness, Attitude, Practices*

- Topics:
  1. Speed/Altitude changes in the NAT organized tracks
     - Determine whether and how ANSPs grant altitude, speed changes
     - Determine how and why airlines request/accept altitude, speed changes
  2. Future space-based ADS-B service in the NAT
     - Determine how ANSPs will choose to offer (or not) space-based ADS-B
     - Determine how airlines will decide to adopt and equip (or not)

- One open-ended topic at end on “Flexibility”
  - “How do you understand, value, and prioritize flexibility?”
  - Supports research efforts of MIT partners

Interview Status

- Ten (10) interviews have been conducted:
  - 5 individuals from NAT operators
    - 3 passenger airlines
    - 2 cargo carriers
  - 4 individuals from 2 NAT ANSPs
  - 1 individual from an airline trade association
- Will continue to recruit from pool of candidates and recommendations from interviewees
- Based on literature, 10-20 interviews would be appropriate
  - Interviews can also be stopped when “saturation” is reached, i.e. no new insights are found

SPEED/ALTITUDE QUESTIONS

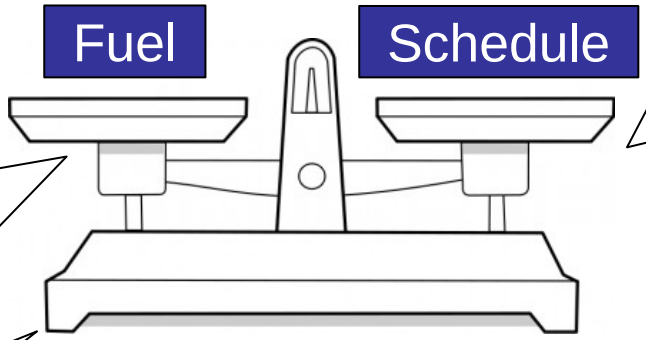
Main Factors

- Safety
  - From ANSP interviewee: "We cannot go forward with something unless it's more safe than today."
  - Clearly the number 1 consideration in technology adoption for both ANSPs and airlines
- Fuel Savings
  - ANSP perspective
    - Grant altitude and flight level changes for benefit of airlines
    - Fuel savings result in fewer emissions (societal benefit)
  - Airline perspective
    - Fuel savings most often reported as No. 1 consideration in seeking better altitude and speed...but not always (see next slide)
    - Two airlines (one cargo, one passenger) reported desire to fly fixed cost index

Key Differences: Operators

One **pax airline** says:

"Economy is number 1 (unless safety is an issue), meaning fuel."



Another **pax airline** says:

"[S]chedule reliability is most important factor…We want to get passengers on time…Schedule first, efficiency second."

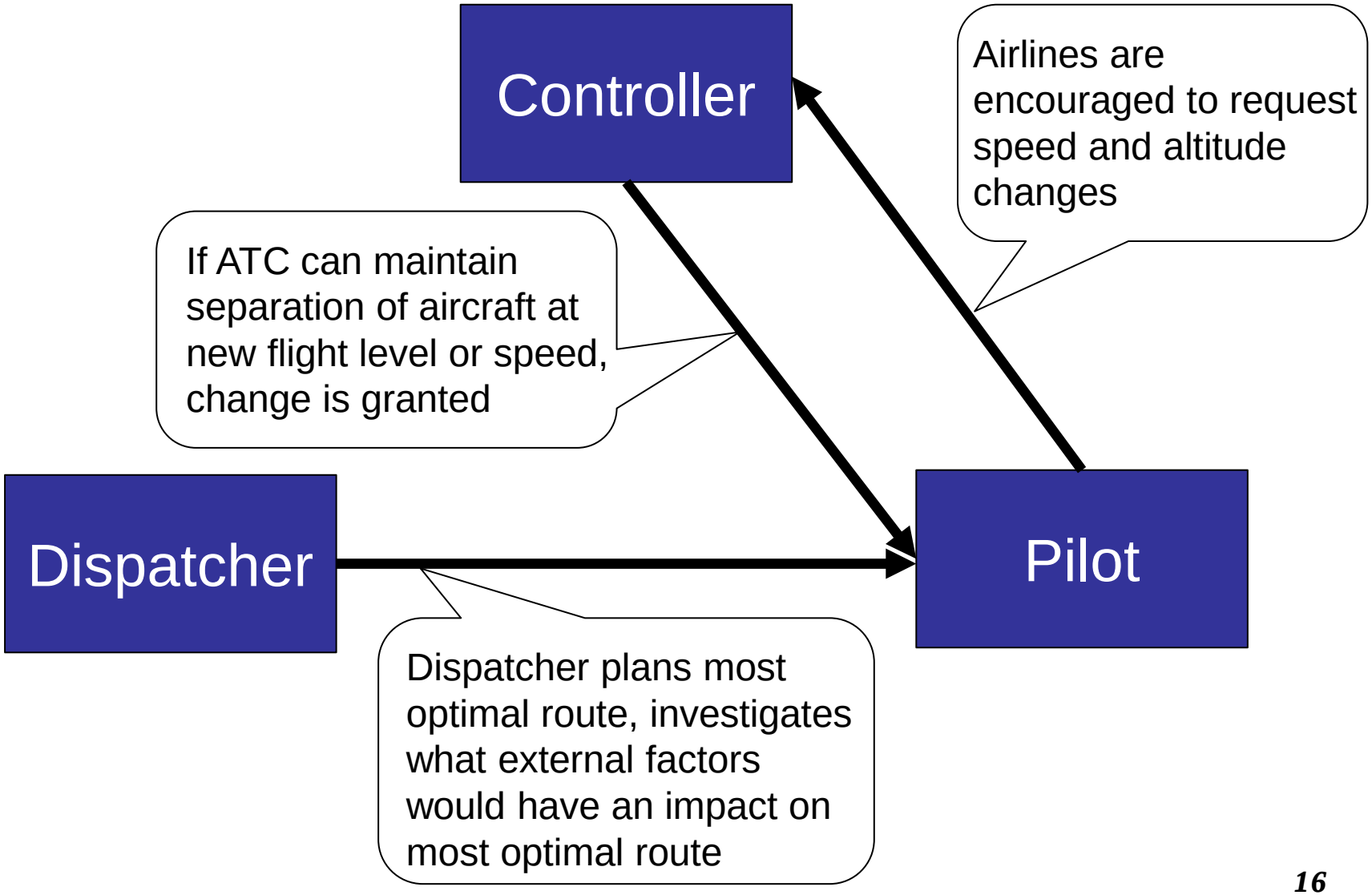
Cargo carriers say fuel is generally number one priority

One **cargo carrier** claimed that in some peak seasons (e.g. Christmas) schedule shifts to first priority

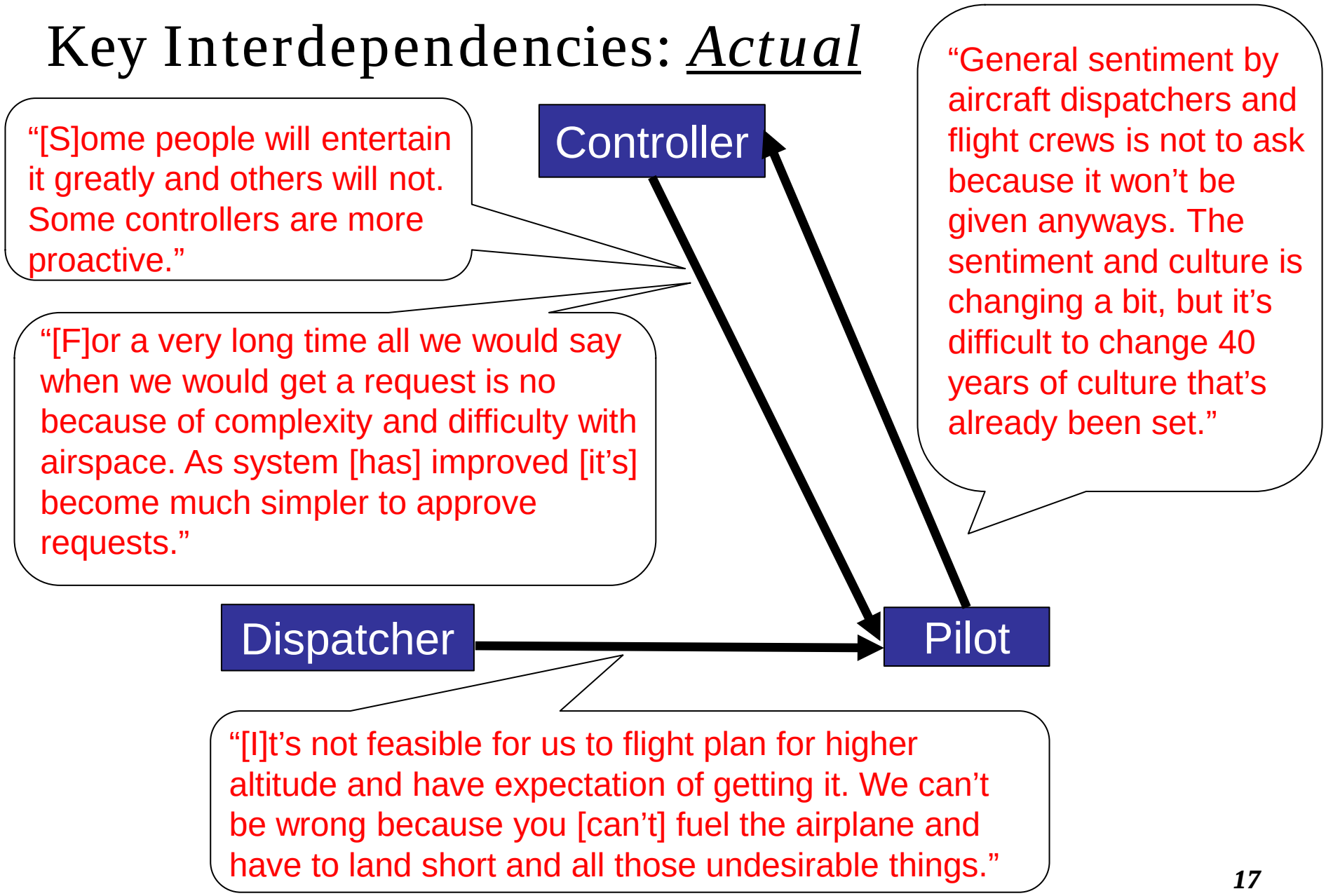
Key Differences: ANSPs

- Different tools for identifying open flight levels, e.g. Gander Oceanic Flight Level Initiative (Go-Fli) in Canada
  - Helping to automate the process of flight level changes
- Challenges caused by lack of harmonization
  - From airline trade association interviewee: "Part of the way we can change culture is through harmonization, and not having globally large areas of airspace that are drastically different in their operation specifications…If you align or harmonize specifications for airspace, you also harmonize training required for pilots to operate."
  - The ANSP interviewee explained how controllers are currently trained on separate streams for either procedural separation (e.g. in NAT) or surveillance (e.g. in domestic airspace)

Key Interdependencies: *Desired*



Key Interdependencies: *Actual*



SPACE-BASED ADS-B QUESTIONS

Main Factors

- The Benefits and Costs (of course)
  - Most interviewees see possible benefits in spaced-based ADS-B
  - Everyone (airlines and ANSPs) concerned about business case: will the benefits outweigh cost of equipage and use fees?
- Space-based ADS-B suggested by several interviewees as future surveillance tool to generate more options to get optimal route (speed and flight level)
- A desire to combat the “hype” was expressed by a couple interviewees
  - Malaysia 370 disappearance caused an interest in global surveillance, but adoption should not be a sudden reaction

Key Differences: Operators

- Weight-based charges
  - Over-fly charges have a weight component, so airlines that fly heavier aircraft have higher burden per flight
- Contra-flow
  - One cargo operator primarily flies contra-flow, or against the general flow of traffic in the NAT
  - In current environment, must be procedurally separated from general flow
  - "In [ADS-B] environment…[r]ules would be changed for ANSP that could allow us to fly between tracks or get vectored around to get on optimal altitude. Procedural separation goes away, creating a more dynamic environment that would allow some flexibility and near-time or real-time optimization of flight profile."

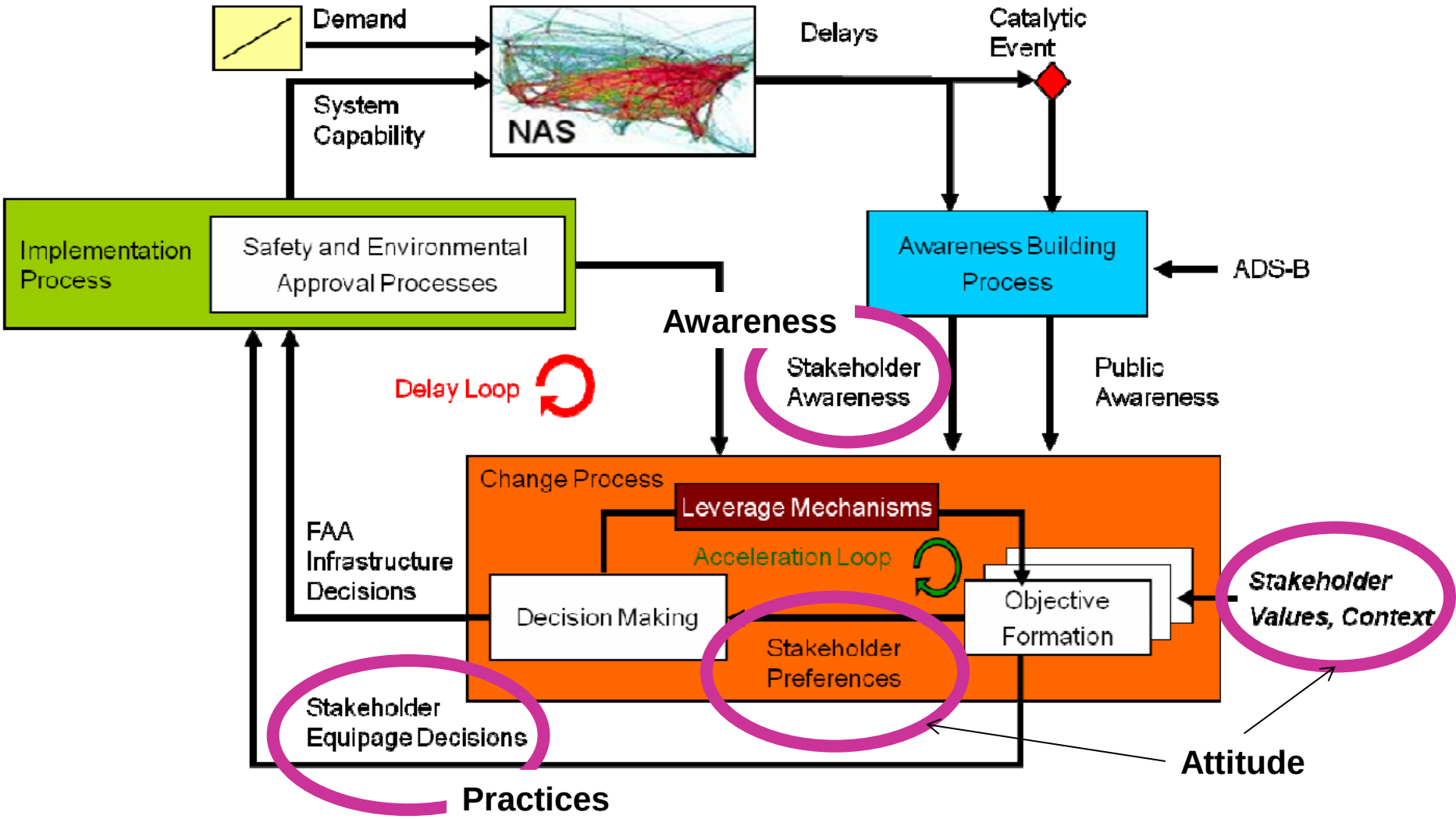
Key Differences: ANSPs

- Differences in organizational structures (state-owned company, private non-profit, government agency)
  - Lead to significant differences in cost-benefit analysis and future cost structure of space-based ADS-B service
- Assumptions made in cost-benefit analysis
  - Benefits and costs may change over time and with traffic levels in the NAT, difficult to predict
- Congestion
  - "How many times do you fly from Iceland to Anchorage and not get [the desired speed and altitude]? Almost never. So no business case for making it better."
- Cost structure for ADS-B
  - "[Aereon] can't have uniform cost/price structure; in uncongested airspace, [they] don't need [to] update every second. They have to look at what is benefit coming to user, tailor the business case to context."

Key Interdependencies

- Between ANSPs and airlines
  - Cost-benefit analysis is dependent on traffic levels
  - Changing traffic levels change constraints on system
- Between ANSPs and other ANSPs
  - Bottlenecks created if one ANSP does not adopt
  - "Necessary that NY is included or we'll have a bottleneck at FAA boundaries…If NY is not included, the flows across NAT are not going to look substantially different...In ATM we talk about bottlenecks. Fix one you get another one. You don't have systemic improvement until you correct all of them."
- Between airlines
  - Un-level playing field if some airlines are mandated to adopt and some are exempt or given extension
  - Airlines should not be disincentivized for adopting

Returning to the Transition Dynamics Process Model



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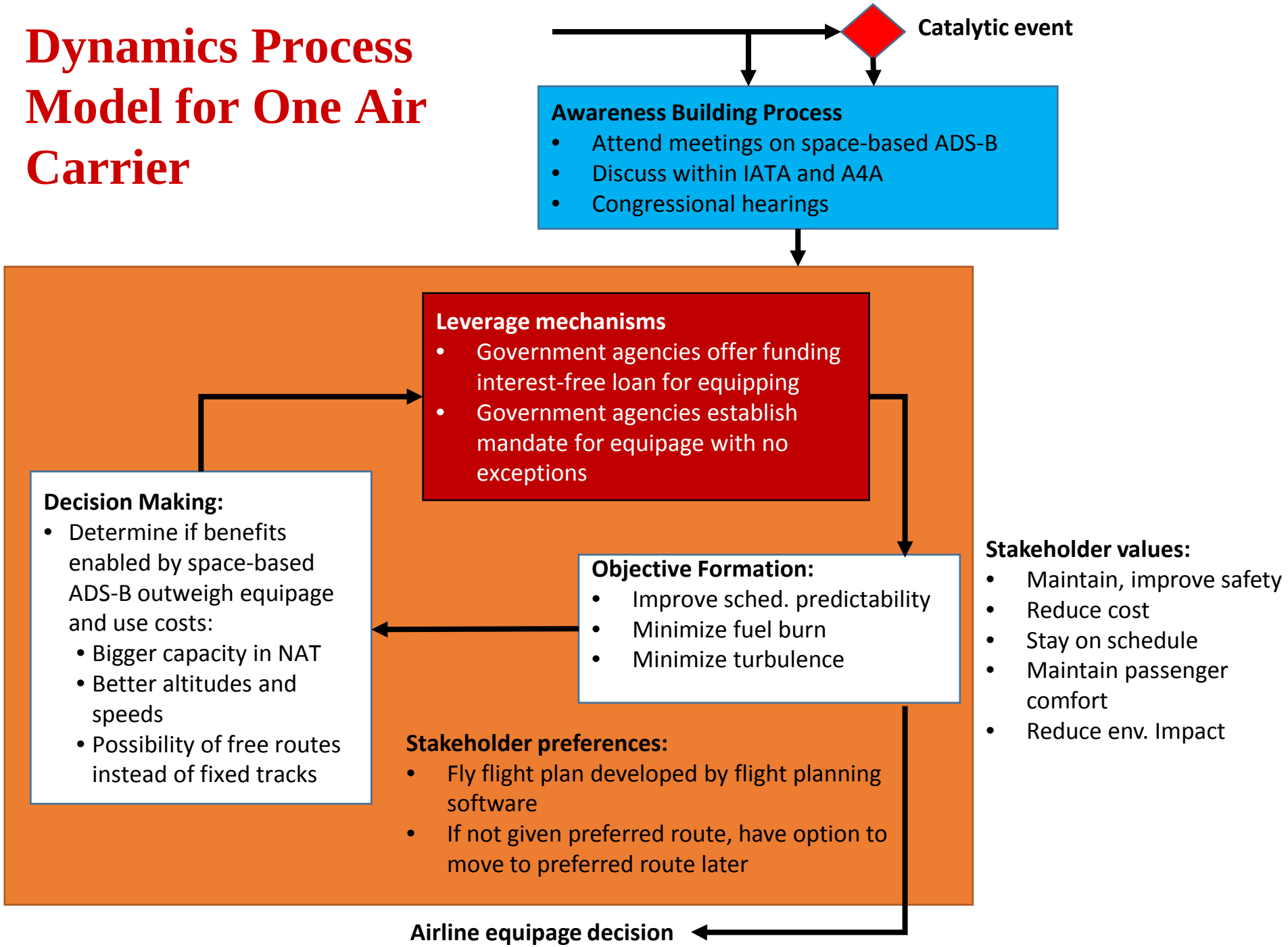
Dynamics Process Model for One Air Carrier



Summary ... and Thank You

Goals Accomplished

- Detected instances of *differentiation* in stakeholder decision-making structure and priorities to adopt ops improvements in the NAT
- Further identified similarities and interdependencies

Near-Term Work to Complete

- Conduct at least 5 more interviews, especially from different ANSPs
- Develop dynamics process model for each organization interviewed
- Recommend framework for system- of-system cost-benefit analysis, incorporating differences, similarities, interdependencies to reduce "structural" uncertainty

Future Possibilities

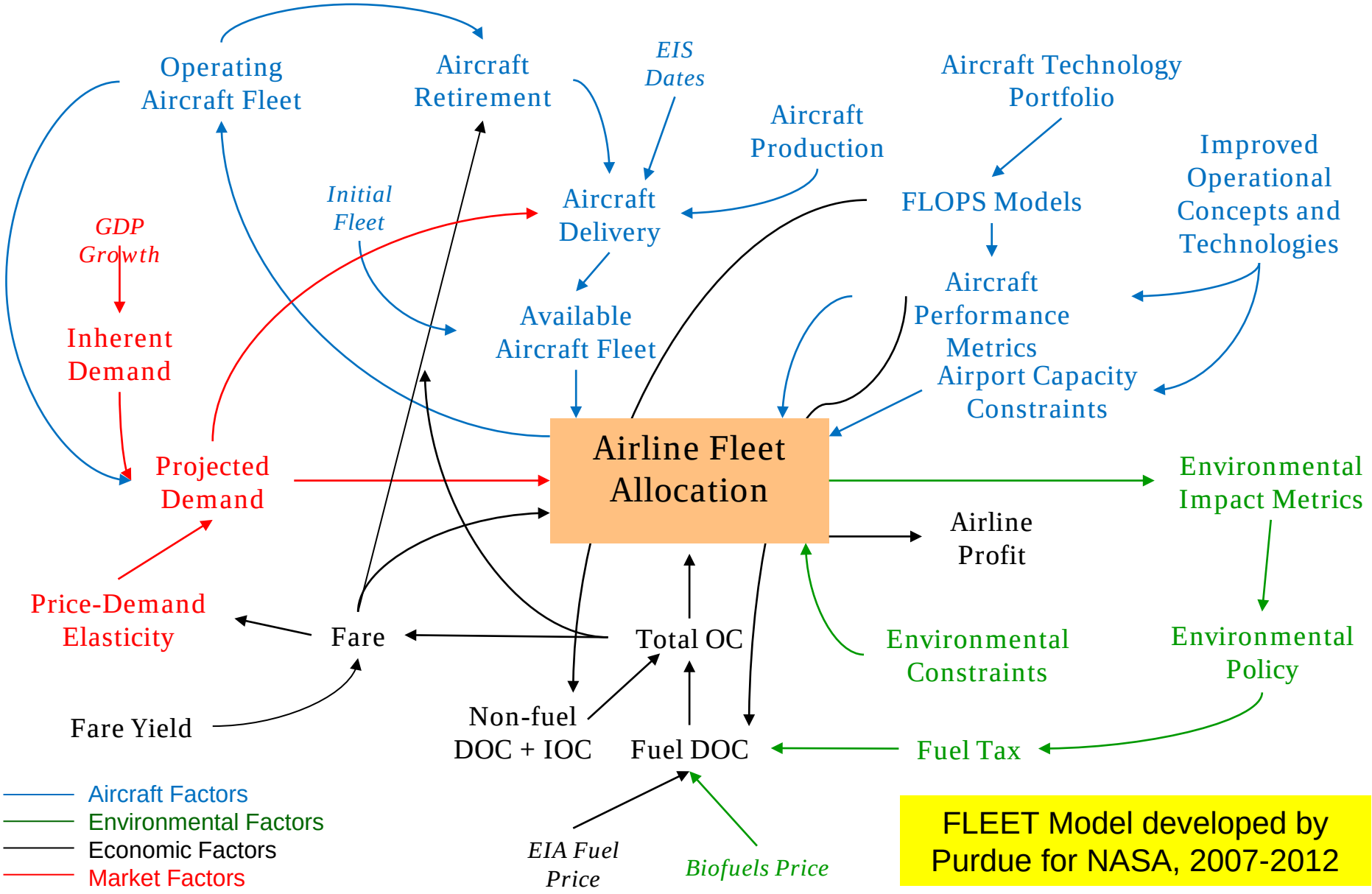
- Develop models to underpin framework and ID additional data for uncertainty reduction in sys-of-sys cost-benefit analysis
  - e.g., additional breadth or depth?

About Lauren Bowers

- Fourth-year PhD student
- Two FAA projects
  - Investment analysis
  - Air connectivity
- Dissertation focus: quantifying stakeholder perception of UAS through surveys and NAT ops

EXTRA

Representation of Airline Perspective from R&D Supplier View



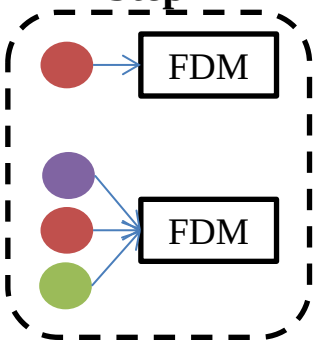
FLEET Model developed by Purdue for NASA, 2007-2012

Advanced research concepts can improve understanding of system costs/risks of near-term concepts

Step 1

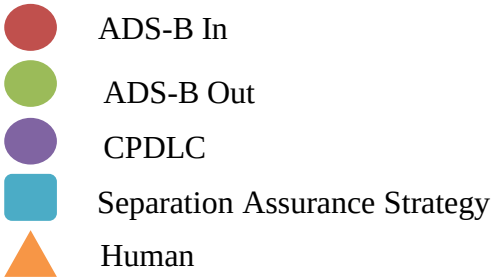
Fault Identification (LR)

Step 2



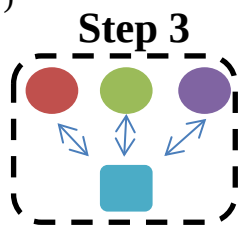
- FDM in individual CT (LR)
- FDM in joint space using RKCF (PW)

"Safety Assessment for Separation Assurance in a Distributed Environment"
NASA funded project at Purdue, started April 2014



CT: Communication Technologies
LR: Literature Review
PW: Proposed Work
DAF: Discrete Agent Framework
FDM: Fault Detection and Mitigation

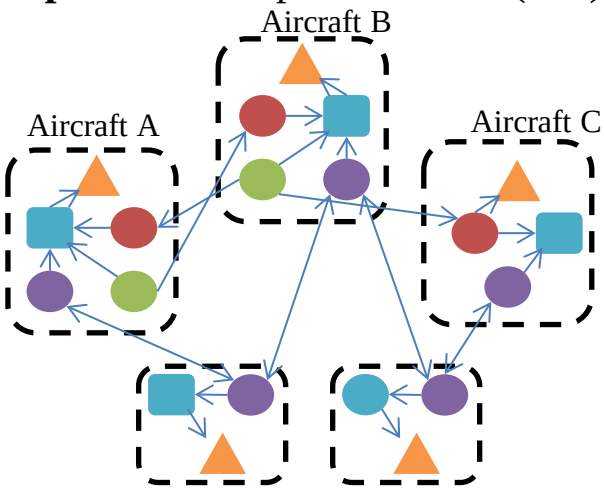
Step 3

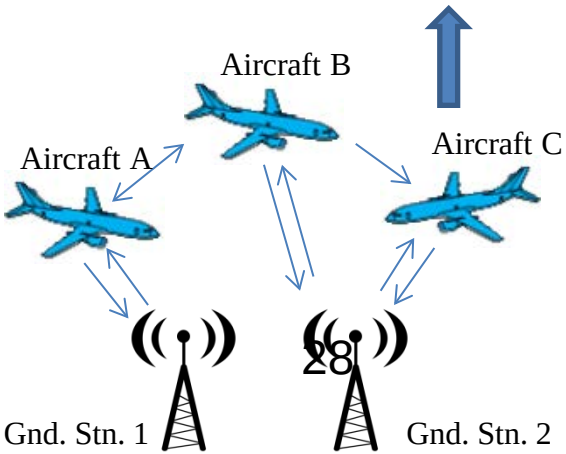


Dependencies study (LR)

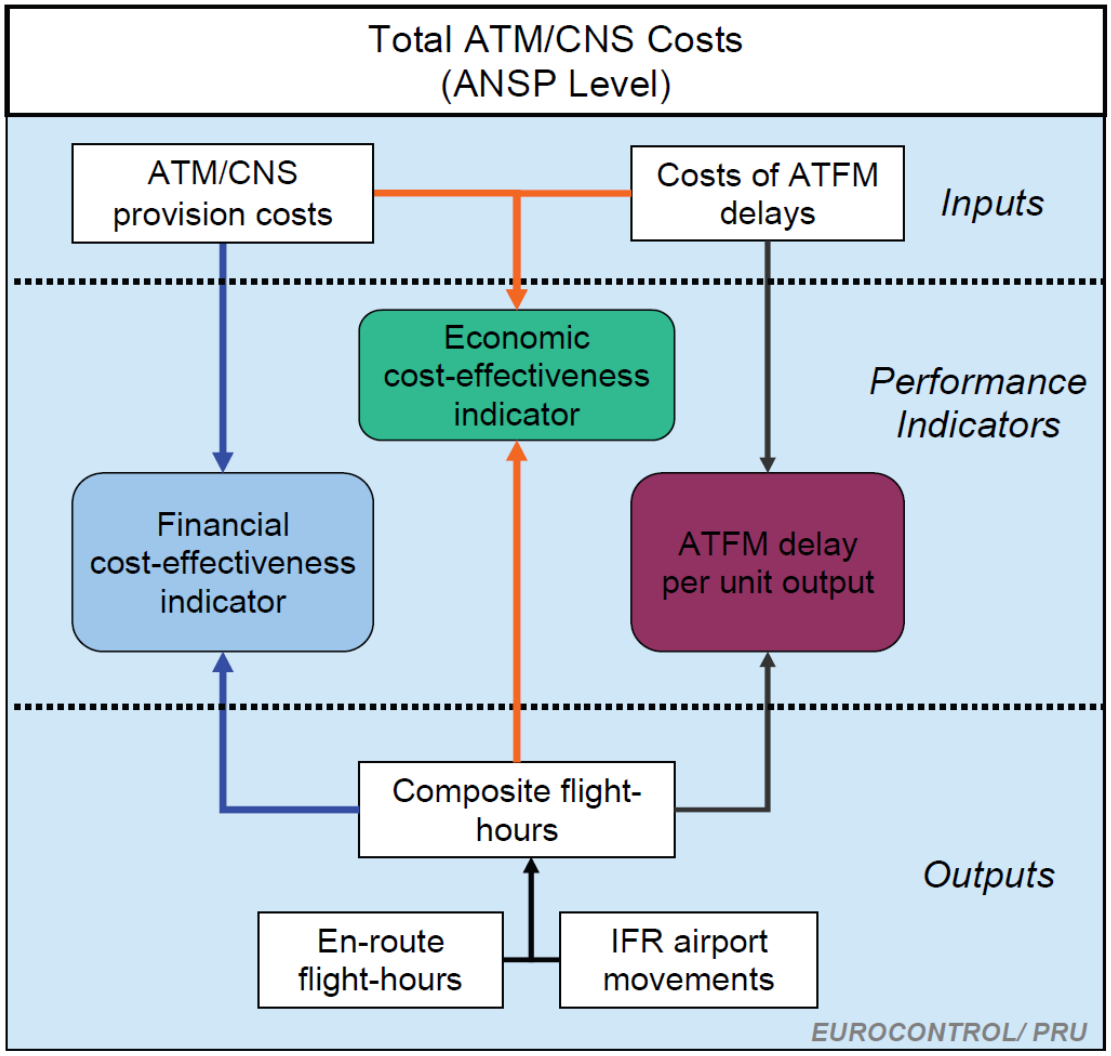
Step 4: Safety analysis using state-based models (PW)

Step 5: DAF implementation (PW)





An ANSP Perspective on Investment Analysis*



*"ATM Cost-Effectiveness (ACE) 2010 Benchmarking Report with 2011-2015 outlook," EUROCONTROL, Brussels, Belgium, May 2012.

Some Prior Research Will Help

- Marais 2006: Developed framework for identifying **strategies to persuade** stakeholders to adopt new technology
- Mozdzanowska 2007: Characterized the **barriers and uncertainty in adoption of ADS-B** using a stakeholder survey
- Hu 2008: Explored mechanisms that **impede and encourage technology adoption** using focused interviews of airline representatives
- Campos 2009: Proposed strategies to **encourage adoption of data link** in the North Atlantic airspace using a survey of commercial operators and ANSPs

FLEXIBILITY QUESTIONS

Flexibility

- ANSPs and airlines answered unanimously that flexibility was desired
  - Airlines want to fly their optimal routes, ANSPs want to grant them…but have to manage resources and constraints
- Increased surveillance may help to provide greater flexibility
- Future vision of “free flight” expressed by several interviewees