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Developing Far-Term Portfolio Cost Estimates for a System of Systems

2010 ISPA/ SCEA Joint Conference Presentation

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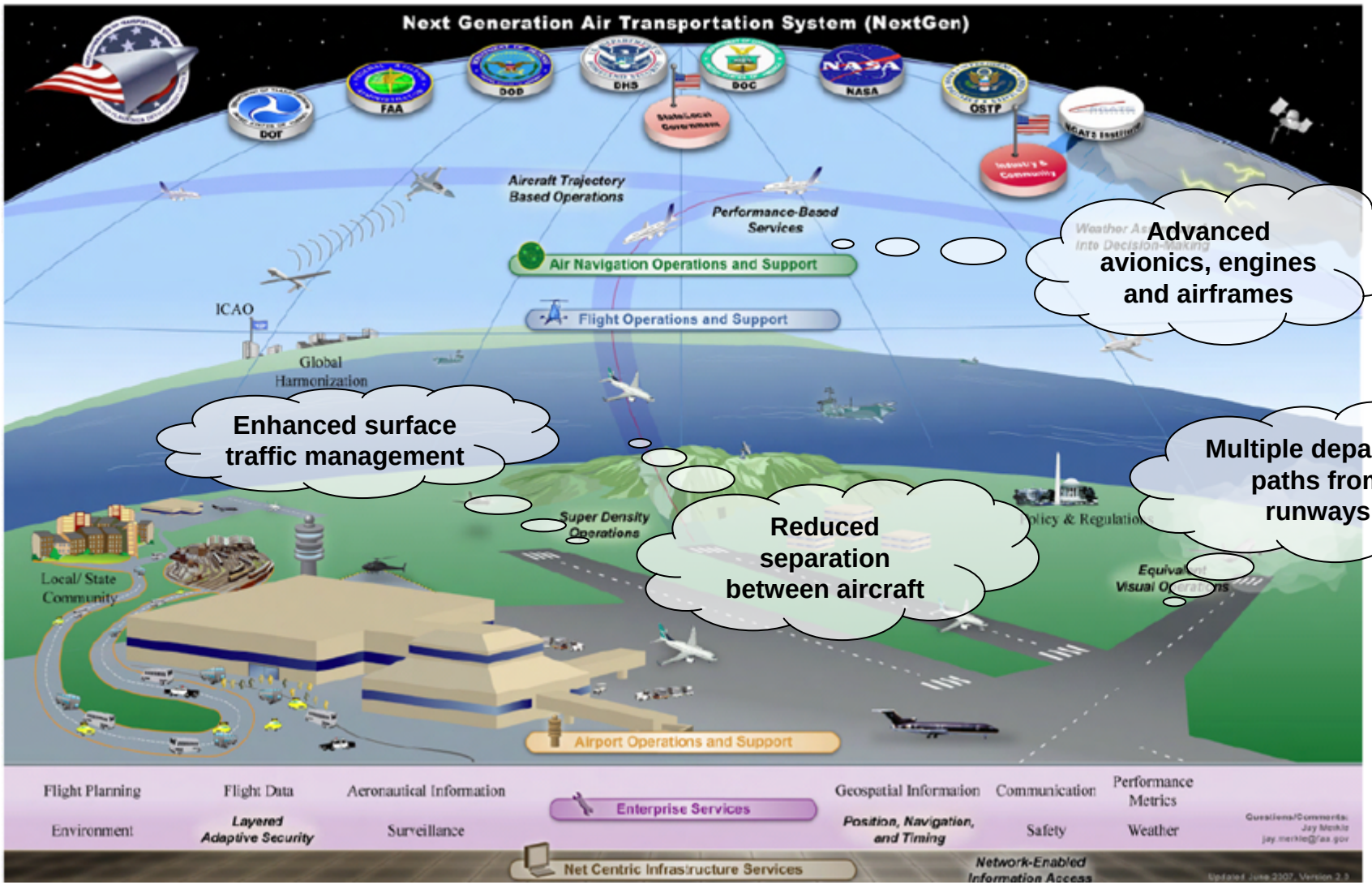
Abstract

- Traditional cost estimation relies upon data such as requirements, schedules, and relevant historical data
- Significant problems arise for information systems, equipment or technologies with far-term (>10 years) implementation dates, because far-term data may be unavailable and program offices may not exist
- Historically, many commercial and government agencies would either not attempt to estimate these future costs or develop simple Rough Order of Magnitude (ROM) estimates
- Additional complexities arise when these far-term programs interact with existing programs. In these complex "systems of systems," decision makers require greater accuracy than is traditionally provided by ROM estimates to enable more detailed trade-off analyses between programs within these systems
- This presentation will offer a method to provide decision makers more detailed levels of cost and schedule information for far-term assets, based upon a detailed understanding of the programmatic evolution from the current "As Is" state to the future "To Be" state
- The method is being developed in support of the Next Generation Air Transportation System (NextGen)

NextGen is an effort to improve the performance of the National Airspace System (NAS) – a complex system of systems



Source: Joint Planning and Development Office, NextGen Enterprise Architecture v2.0 for the Next Generation Air Transportation System

NextGen is supported by the Joint Planning and Development Office (JPDO)

- The Next Generation Air Transportation System (NextGen) is the evolution of the United States' national airspace system (NAS), and includes the transition from a ground-based system of air traffic control to a satellite-based system of air traffic management

  Key components include:

  - Space-based navigation and integrated surveillance
  - Digital communications
  - Weather integrated into decision-making
  - Advanced automation of air traffic management systems

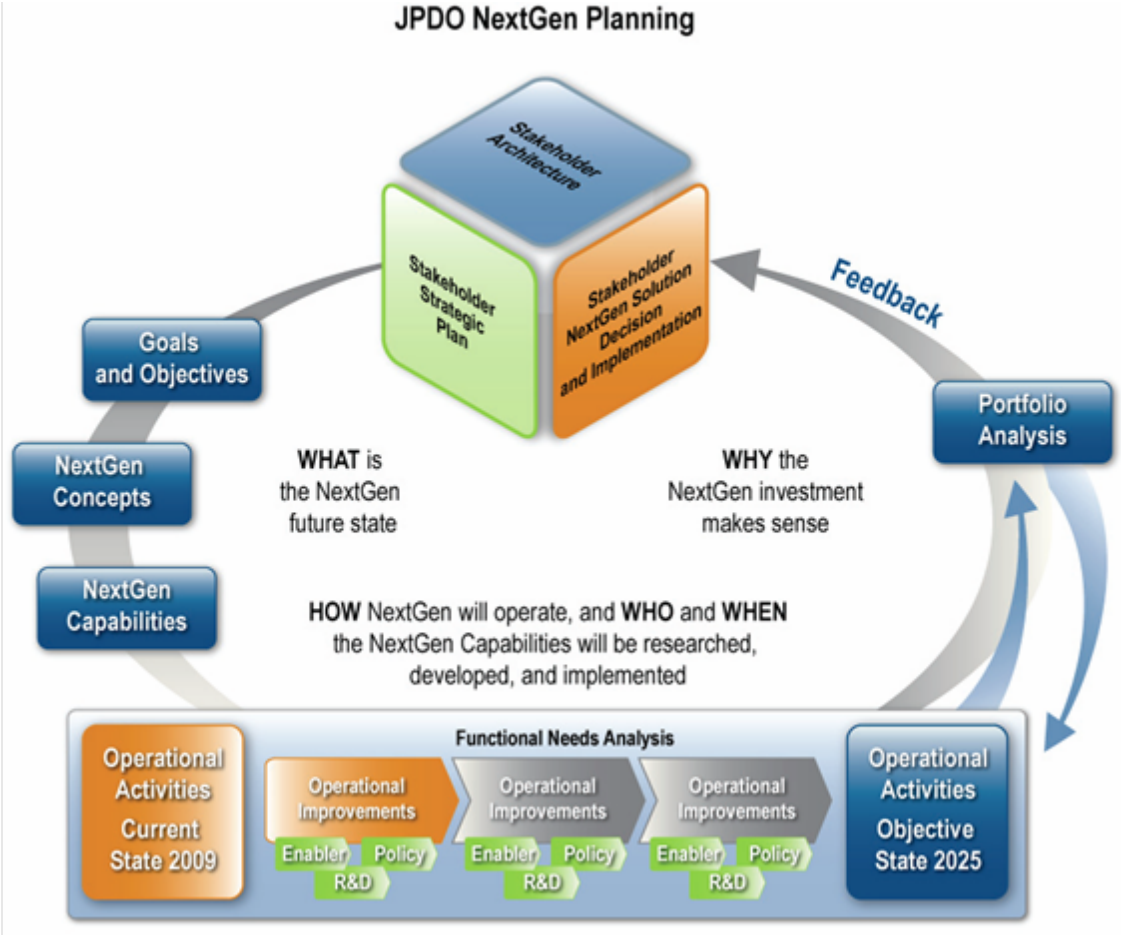
- The Joint Planning and Development Office (JPDO) is responsible for:
  - facilitating NextGen activities between the JPDO partner agencies – *the Federal Aviation Administration (FAA), National Aeronautics & Space Administration (NASA), Department of Defense (DoD), National Oceanic & Atmospheric Administration (NOAA), Department of Homeland Security (DHS), The White House Office of Science & Technology Policy (OSTP)* – and the private sector
  - developing a cost-benefit-risk analysis of the collection of programs, systems, and capabilities that, together, comprise NextGen

Developing cost estimates for a complex, heterogeneous system of systems such as NextGen is challenging…

- JPDO is developing an analysis of the costs, benefits, and risks that will impact the "system of systems" that define NextGen
- With many traditional cost estimates, detailed system, program and technical requirements are often available. Even programs in their early phases frequently have some clear definition of the operating environment of the project in question
- However, when programs are not slated to begin operation for over 10 years, and initial research and development activities are only beginning, it is difficult to develop meaningful cost estimates
- This presentation will document how JPDO is undertaking the process of translating broad requirements statements into 'Proxy Programs' that enable cost estimates to be developed

… particularly given that significant implementation activities will not take place for at least 10 years into the future

The analysis of NextGen costs is based upon an understanding of the functional needs of NextGen, as defined in planning documents



Source: FY 2012 JPDO Integrated Work Plan for the Next Generation Air Transportation System

To capture the possible end-states for NextGen, the JPDO developed an Integrated Work Plan

- The Integrated Work Plan (IWP) describes a long-term transition from the current "as-is" national airspace system to the “to-be” NextGen environment

- Within the IWP there are five basic planning elements:
  - Enablers: Material components, such as communication, navigation, and surveillance systems, as well as non-material components, such as procedures and standards
  - Operational Improvements: Specific stages in the transformation of operations and the expected performance improvements
  - Policy Issues: Summary issues for decision-maker consideration of viable solution options, ranging from further analysis and open discussion for less mature issues to specific policy recommendations for more mature issues
  - Research: Basic or applied research programs and the results needed to support other NextGen planning elements
  - Development: Results needed from ongoing development or demonstration programs to support other NextGen planning efforts

- The IWP documents the dates and the inter-relationships of these elements

Enablers represent high-level requirements of NextGen systems and capabilities

AVAILABLE INFORMATION: Each enabler includes an ID number, name, short description and date of planned availability

CHALLENGE # 1: Some capabilities are planned to be implemented beyond the short-term budget cycle and are not defined in detail

Name	Initial Availability
Deployable Incident Data Recorder Regulation	2011
Aircraft Systems - Deployable Incident Data Recorder	2012
Airport Advocacy Program	2013
Airport-Compatible Land Use	2013
Obstruction Measurement and Evaluation Process	2014
Airport GSE Surface Management System	2013
Zero or Low-Emissions Ground Support Equipment	2010
Ground Congestion Data Feed to Airport Acceptance Rate	2015
Airside Resource Management System - Level 1	2013
Landside Resource Management System - Level 1	2013
Airport Resource Management System - Level 1	2014
Airport Rescue Fire Fighting	2012
Runway Friction - Integrated Condition Reporting	2015
Runway Friction - Ground-Based Sensors and Technology	2013
Aircraft Systems - Runway Friction Sensors and Technology	2014
Ice-Resistant Pavement Surfaces	2018
Airport Winter Operations Resource Management System - Level 1	2013
Aircraft Systems - De-Ice/Anti-Ice Technology	2024
Aircraft Systems - Ground Icing Detection	2020
Advanced De-Icing/Anti-Ice Fluids	2018
Ground Based Non-Fluid De-Icing Technology	2015
Deicing/Anti-Icing Holdover Time Input to Flight Object	2015
Advanced De-Icing/Anti-Icing Fluid Recovery	2016
Water Quality Management	2016

CHALLENGE # 2: Enablers are updated each year

CHALLENGE # 3: There are over 400 enablers needing cost estimates

over 400 enablers

The elements within the IWP often cannot be readily cost-estimated

- One of the challenges to developing a cost estimate directly from the IWP is that there is no single, established, and structured way to estimate the costs of an individual Enabler:

> **EN-1214**: This enabler provides Terminal Radar Approach Control (TRACON) air /ground data exchange service for clearance and instructions services consisting of the following types of data exchanges: Common Trajectory Coordination - Widespread use of Four-Dimensional Trajectory (4DT) agreements down to paired approach consisting of trajectory constraints, trajectory requests, trajectory clearances, and trajectory non-conformance reports.

Sample ENABLER from NextGen Integrated Work Plan

- A cost of this Enabler cannot be directly estimated because the Enabler does not specify what needs to be purchased or installed:
  - Some schedule and priority information is documented
  - The inter-relationship with other IWP elements is referenced
  - For the far-term costs (2019 and beyond), there are no detailed requirements in place that describe what would be implemented

To develop cost estimates, the Enablers are grouped into broad categories according to functionality

- At the highest level, the Enablers are categorized into three functional groups, called Cost Modules:
  1. Airports
  2. Aircraft
  3. Air Traffic Management Solutions
- Within those three groups, subcategories provide further distinctions between Enablers
- The hierarchy of categories is a system to track costs
- This process of categorization is done for the majority of Enablers. Enablers are excluded if:
  - Costs cannot be estimated because of the nature or content of the Enabler description
  - They are related to Policy Issues

Cost Module	Cost Category
Airports	Airside
	Landside
Aircraft	Communications
	Navigation
	Surveillance
	Integration
	UAV's
	Airframes and Engines

Cost Module	Cost Category
Air Traffic Management Solutions	Communications
	Navigation
	Surveillance
	Automation
	Safety
	Facilities
	Enterprise Services
	Airspace - En Route
	Airspace - TRACON

NextGen Highest Level Cost Element Structure

Enabler Cost Categories

Once the Enablers are grouped into broad cost categories, they are further grouped into smaller Proxy Programs

- A Proxy Program groups all Enablers that relate to similar functionality
- Once the Enablers are categorized, other elements from the IWP are associated with the Proxy Program
  - Research, Development, and Policy Issues can be associated with a unique Proxy Program
- Proxy Programs represent theoretical programs that could be implemented by industry or the government at some point in the future
- Proxy Programs also include items outside of the scope of the IWP that may need to be implemented to realize NextGen benefits, such as:
  - Runways
  - Expanded landside facilities
  - Airspace redesign

Proxy Programs represent logical groupings of functional requirements that are designed to reflect either the functionality included in a real program/system that is currently being implemented or the functionality that is planned to be implemented in the future

Proxy Programs are formed by grouping like enablers

Enabler Name	Initial Availability
Deployable Incident Data Recorder Regulation	2011
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Water Quality Management	2016

EN–5013: The current runway friction measurement at an airport is disseminated on a continuous basis to users, based upon reports from ground and/or aircraft sensors (per EN-5014 and EN-5015, respectively) depending on which system(s) is/are in use at an airport at a given time. Potentially, one or both systems could be used at an airport. The real-time runway friction measurement data is used by aircraft operators to estimate safe runway landing distance. The data is also used by airport operators to evaluate the need to treat the runways for rubber removal or snow/ice accumulation.

EN–5014: Advanced, ground vehicle based sensors and/or technology are used to measure runway friction at airports. Program requirements and regulations are modeled after the International Civil Aviation Organization (ICAO) SnowTam program and are included in 14 CFR Part 139 for applicable airports. The runway friction data is used by airport operators to define the need to treat the runways for rubber removal or snow/ice accumulation. The data may also be used by aircraft operators to estimate runway landing distance.

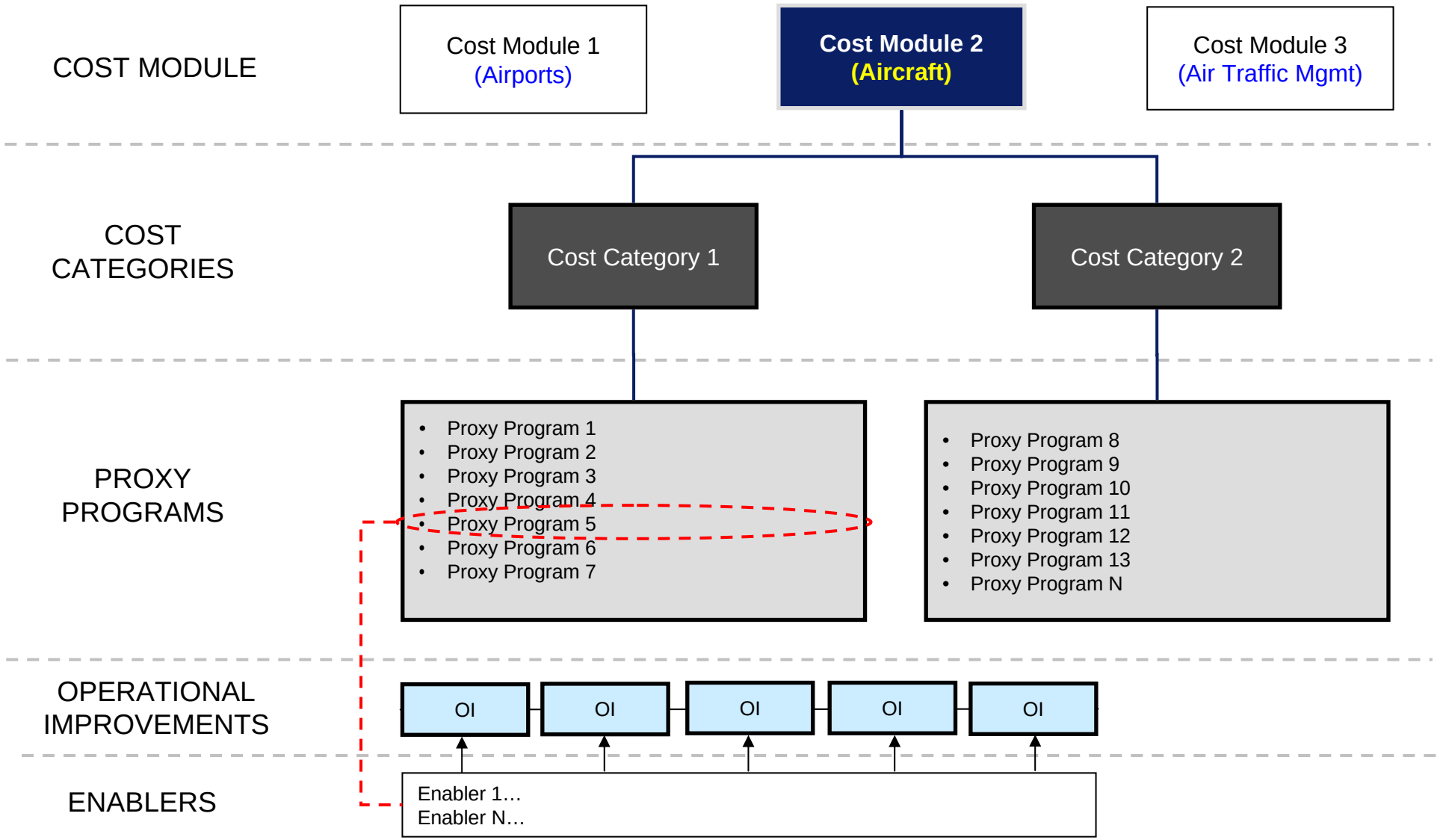
Proxy Program Name:

Ground-Based Friction Sensors

Proxy Program $_1$

Proxy Program $_N$

The hierarchical cost analysis structure for NextGen mirrors the hierarchy of the Integrated Work Plan



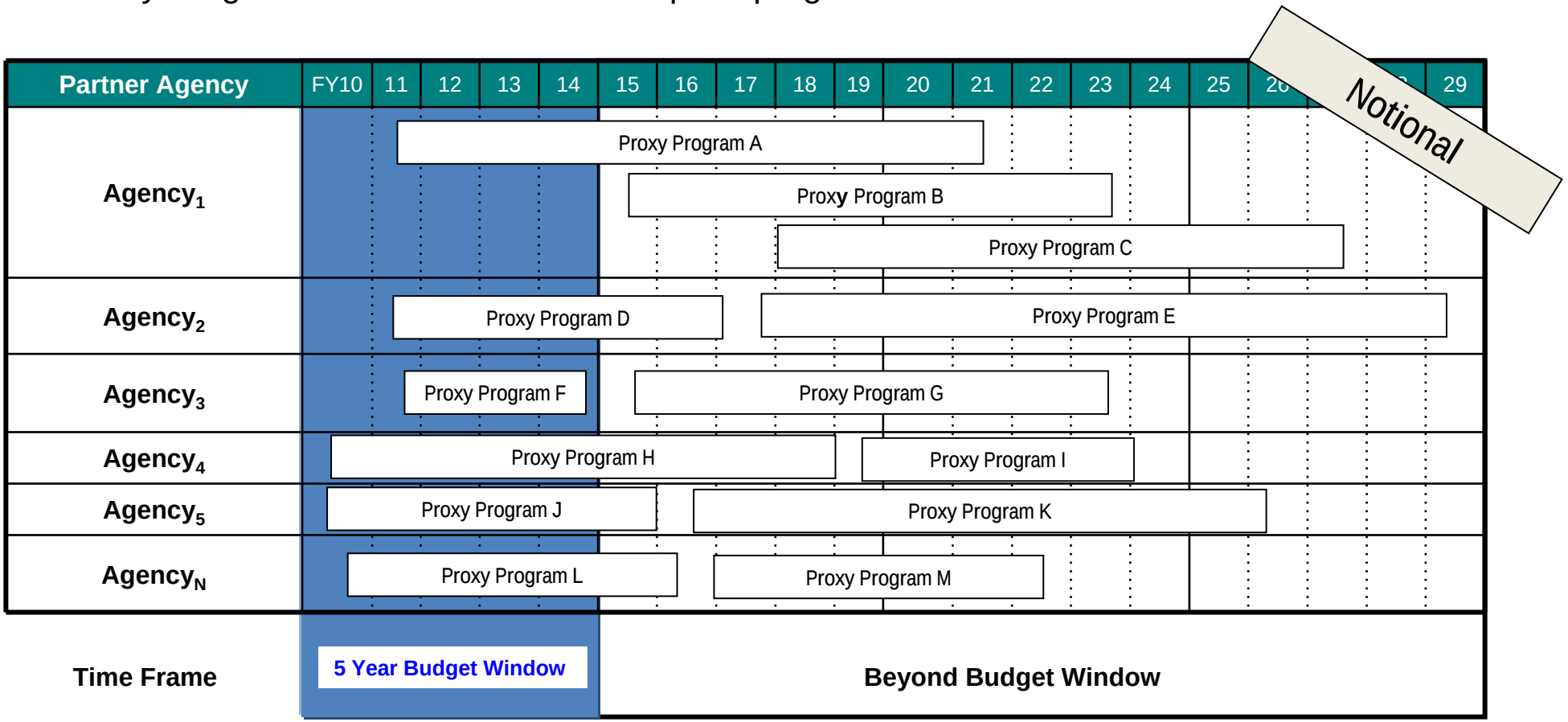
To develop individual cost estimates for the Proxy Programs, standard cost estimating techniques are used

- There are multiple cost estimating techniques used to define Proxy Program costs:
  - Cost Build Up
  - Cost by Analogy
  - Parametric Estimate
- GAO requirements for business case analysis are applied to develop cost estimates[1]
- Some of the data sources include:
  - agency budget submittals, internal cost estimates, and planning documents
  - aviation trade publications
  - previous government-commissioned studies of air transportation
  - government-maintained data repositories on transportation statistics

[1]GAO Cost Estimating and Assessment Guide, March 2009, GAO-09-3SP

To estimate the long term cost of NextGen, the Proxy Programs are individually estimated and their costs aggregated

- The schedule is based upon the JPDO IWP and the FAA's NextGen Implementation Plan
- Proxy Programs include real and conceptual programs



Summary Steps

1	**COLLECT**	▸ Identify all functional and operational objectives and requirements ▸ Collect cost data for existing programs and, as possible, for mid-term and far-term programs
2	**DEFINE**	▸ Analyze requirements and form logical groupings ▸ Assess logical groupings for balance and to be mutually exclusive and collectively exhaustive
3	**ESTIMATE**	▸ Develop cost estimates in conjunction with SCEA-accepted best practices ▸ Document methodology, assumptions, and results
4	**UPDATE**	▸ Re-shape logical groupings as requirements evolve ▸ Collect and apply updated cost data

Lessons Learned

- Identify all functional and operational requirements as a first step
- Don’t be overwhelmed by the task of estimating costs of a complex systems of systems
- Logical groupings help form the estimate into more manageable pieces
- Further, having logical groupings helps with the validation of functional requirements, cost and schedule data

Questions?

- For further information:
  - The Joint Planning and Development Office: www.jpdo.gov

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