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Combining Deterministic and Stochastic Processes in FAA Cost-Benefit Estimating

Federal Aviation Administration

Presented to: 2008 Joint International Society of Parametric Analysts (ISPA)/Society of Cost Estimating & Analysis (SCEA) Annual Conference in Industry Hills, CA

By: Katrina Hall, FAA Air Traffic Organization, Finance Service Unit, Office of Investment Planning and Analysis; and Mark Kipperman, BAE Systems, Inc.

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Overview

- **Background**
- The Problem
- FAA Progress to Date
- Next Steps
- Q&A

FAA Mission

- **Our mission is to provide the safest, most efficient aerospace system in the world**
- **Major FAA roles include:**
  - Developing and operating a system of air traffic control and navigation for both civil and military aircraft
  - Regulating civil aviation to promote safety
  - Researching and developing the National Airspace System and civil aeronautics

See also *http://www.faa.gov/about/mission/*

The Context of Investment Analysis: Applicable Orders and Guidelines

Government

Office of Management and Budget (OMB) A-94

- Benefit-Cost and Cost-Effectiveness Analysis
- Alternatives Analysis
- Net Present Value (NPV)
- Discount Rates

OMB A-11 (Exhibit A-300)

- New Budget Submittal Requirements (Capital Planning and Investment Control)
  - Business Case Focus
  - Return on Investment (ROI): NPV and Payback
  - Risk Analysis & Mitigation Plans

DOT

- Policy Values
  - Fatalities
  - Injuries
  - Passenger Time

FAA/APO

- Aviation Forecasts
- Economic Values
  - Aircraft Operating Costs
  - Aircraft Replacement Costs

Best Practices

FAA/ATO F & P

- Probabilistic Analysis
- Work Breakdown Structure of Costs and Benefits
- Risk Analysis

Legislation/Congress

- Clinger–Cohen Act (IT investment management)
- Government Performance and Results Act (GPRA)
- Chief Financial Officer's (CFO) Act

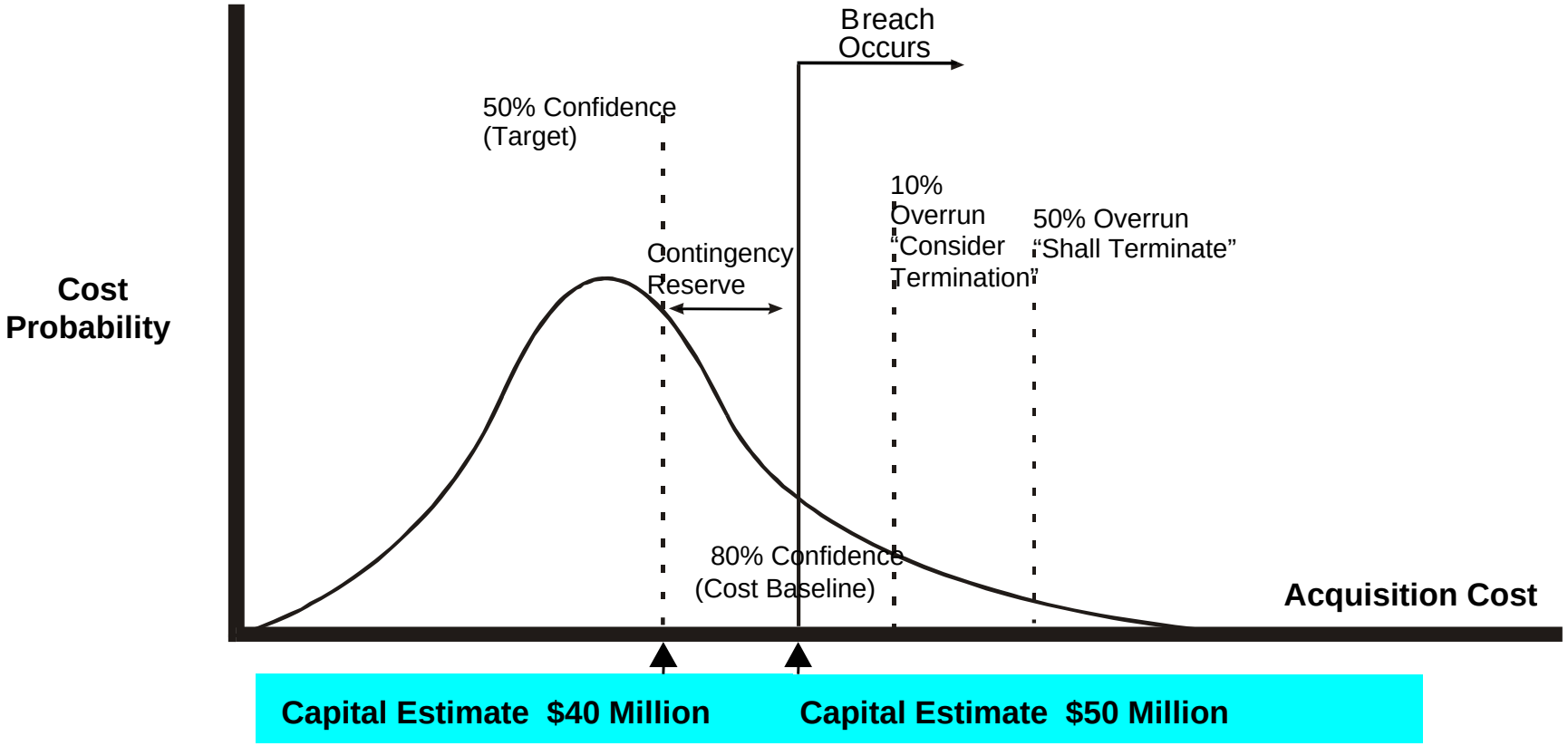
Acquisition Management System – Economics

- Discount Rates from OMB Circular No. A-94
  - **Programs with user benefits: 7 percent (real)**
  - **Other programs: based on length of program and rates on Treasury Notes and Bonds**
- Measures of Merit
  - **Net Present Value (NPV): discounted benefits minus discounted costs**
  - **Benefit-Cost Ratio (B/C): discounted benefits divided by discounted costs**
  - **Payback Year: Year when cumulative discounted benefits first exceed cumulative discounted costs**

Acquisition Management System - Policy

- Risk assessment guidelines part of Acquisition Management System Toolset
- Uncertainty in estimates is one identified risk area
- FAA standard is 80 percent confidence (risk-adjusted) estimates
  - Costs: 80 percent probability of being met or under run
    - FAA Costs are divided into Facilities and Equipment (F&E) and Operations and Maintenance (OPS)
    - Normally calculated separately since they are separately funded
  - Benefits: 80 percent probability of being met or exceeded

FAA Cost Baseline Management Approach



Contingency Reserve = S $(80% Confidence – 50% Confidence) Estimates

$10M = $50M - 40M

Example of how the cost baselining process will work for a hypothetical new program. The Service Unit must deliver the program for $50 million, but should be expected to deliver it at lower cost. Program will report spending of contingency reserve.

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Problem

Addressing uncertainty in estimated costs and benefits has not been applied consistently across programs

- Many programs used a deterministic process (simple subtraction and division of discounted benefits and costs) to calculate economic measures of merit
- Advantages:
  - **Simple to use**
  - **Numbers "added up"**
- Disadvantages:
  - **Calculated economic measures of merit not at FAA standard of 80 percent confidence**
  - **Generally at greater than 80 percent confidence**

Problem (cont'd)

- A more robust stochastic/probabilistic process was needed
  - **NPV and B/C needed to be at the 80 percent confidence level**
  - **To do that, risk analysis on combined costs and benefits was needed**
- Advantages
  - **In accordance with FAA standard**
  - **Provides better basis of comparison across programs**
- Disadvantages
  - **Benefits and cost probabilities need to be analyzed together**
  - **Potential confusion for decision makers: Numbers don't "add up"**

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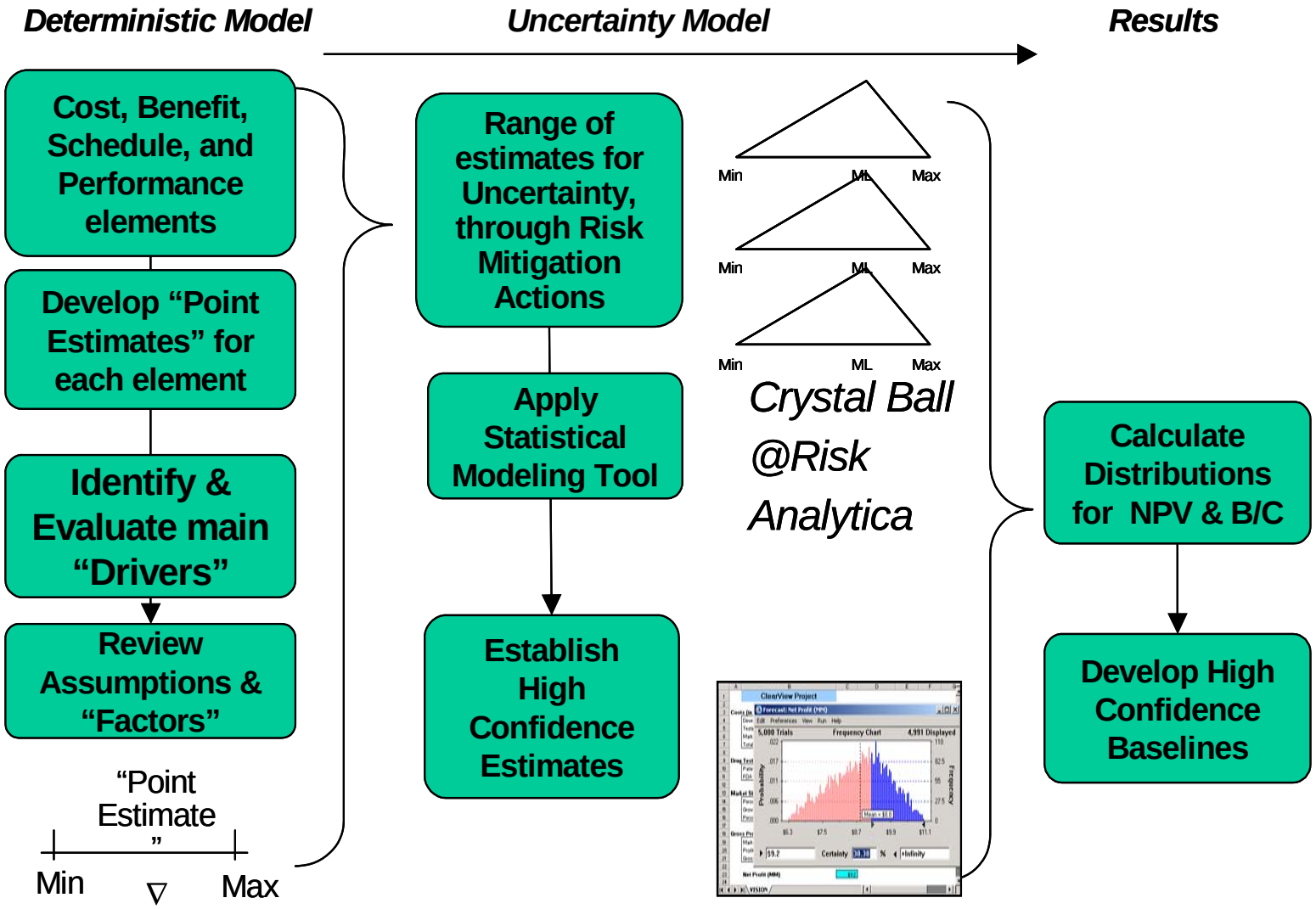
Tools to Address Uncertainty

Once the areas of risk/uncertainty have been identified, a model can help quantify them. Sample listing of tools/models:

- Cost Tools
  - Crystal Ball: Performs Monte Carlo simulations of Excel spreadsheets
  - FARAD: FAA tool that distributes risk by WBS
- Cost & Schedule Tools
  - @Risk: Microsoft Project or Excel spreadsheet embedded schedule risk analysis tool that runs Monte Carlo simulations around task durations
  - SEER-SEM, COCOMO-II, COCOTS: Software development
- Schedule Tools
  - Risk+: Microsoft Project embedded schedule risk analysis tool that runs Monte Carlo simulations around task durations
- Program Teams
  - Risk Radar (FAA Tool): database software package that allows the program office to document over time how risk is changing and the steps that it has taken to reduce and manage risk

Calculation of Cost, Schedule, Benefit and Performance Risk



Economic Analysis Template

- **We developed an economic analysis template to standardize inputs from different programs**
- **Allow tailored approach to uncertainty**
  - Deterministic process sufficient for low-cost programs and those requesting investment analysis readiness decision: extra analysis not justified
  - Stochastic process needed for other programs

Key Features of Economic Analysis Template

- **Standard Work Breakdown Structure(WBS)**
- **Cost estimates for legacy and program alternatives**
- **Includes both user benefits and FAA cost savings**
- **Produces output slides for budget and economic analysis**
- **Risk adjustment to 80% confidence level**

Treatment of Uncertainty for NPV and B/C

- **Allows deterministic process for smaller programs**
- **NPV and B/C can be imported if calculated outside template**
- **With cost and benefit probability distribution function (PDF) inputs, template can calculate stochastic NPV and B/C**
- **Without PDF inputs, template uses higher-level risk inputs to calculate estimated NPV and B/C**
- **First template trials did not use correlation; positive correlation between costs and benefits generally results in higher NPV and B/C**

Template Trials

- **Cost and benefit estimates for several programs were entered into the templates**
  - Looked at comparison of deterministic and stochastic results
  - As expected, all showed higher NPV and B/C with stochastic process
  - B/C increases ranged from 1 to 11 percent
  - Higher uncertainty creates a higher difference
- **Special case: if benefits or costs are fixed (no uncertainty), deterministic and stochastic results are the same**

Sample EA Template Output

BUSINESS JUSTIFICATION
(Risk Adjusted, Present Value $M)

	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19 - Beyond	Total
Costs (Incremental to Legacy Case)												
F&E Capital Investment	7.9	9.2	12.9	0.8			0.7				0.6	32.1
Operations and Maintenance				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	1.1
Aviation System User												
Other Entities												
Total FAA, User, and Other Costs	**7.9**	**9.2**	**12.9**	**0.9**	**0.1**	**0.1**	**0.8**	**0.1**	**0.1**	**0.1**	**1.0**	**33.1**
FAA Benefits												
OPS Savings				4.1	4.0	4.3	4.2	4.1	3.9	3.8	17.6	46.0
Avoided F&E												
Total FAA Benefits				4.1	4.0	4.3	4.2	4.1	3.9	3.8	17.6	46.0
User Benefits												
Total User Benefits												
Total Benefits				**4.1**	**4.0**	**4.3**	**4.2**	**4.1**	**3.9**	**3.8**	**17.6**	**46.0**
Net Cash Flow	-7.9	-9.2	-12.9	3.3	3.9	4.2	3.4	4.0	3.8	3.7	16.5	12.9
Cumulative Net Cash Flow	-7.9	-17.1	-30.0	-26.7	-22.8	-18.6	-15.2	-11.3	-7.4	-3.7	12.9	

ECONOMIC ANALYSIS SUMMARY - DETERMINISTIC MODEL

	Base Case
Real Discount Rate	2.9%
Costs (PV$M)	$33.1
Benefits (PV$M)	$46.0
Net Cash Flow (PV$M)	$12.9
B/C Ratio	1.39
Payback Year	FY20
IRR	8.4%

ECONOMIC ANALYSIS SUMMARY
STOCHASTIC MODEL

Net Cash Flow (PV$M)	$18.0
B/C Ratio	1.55
Payback Year	2019
IRR	10.33%

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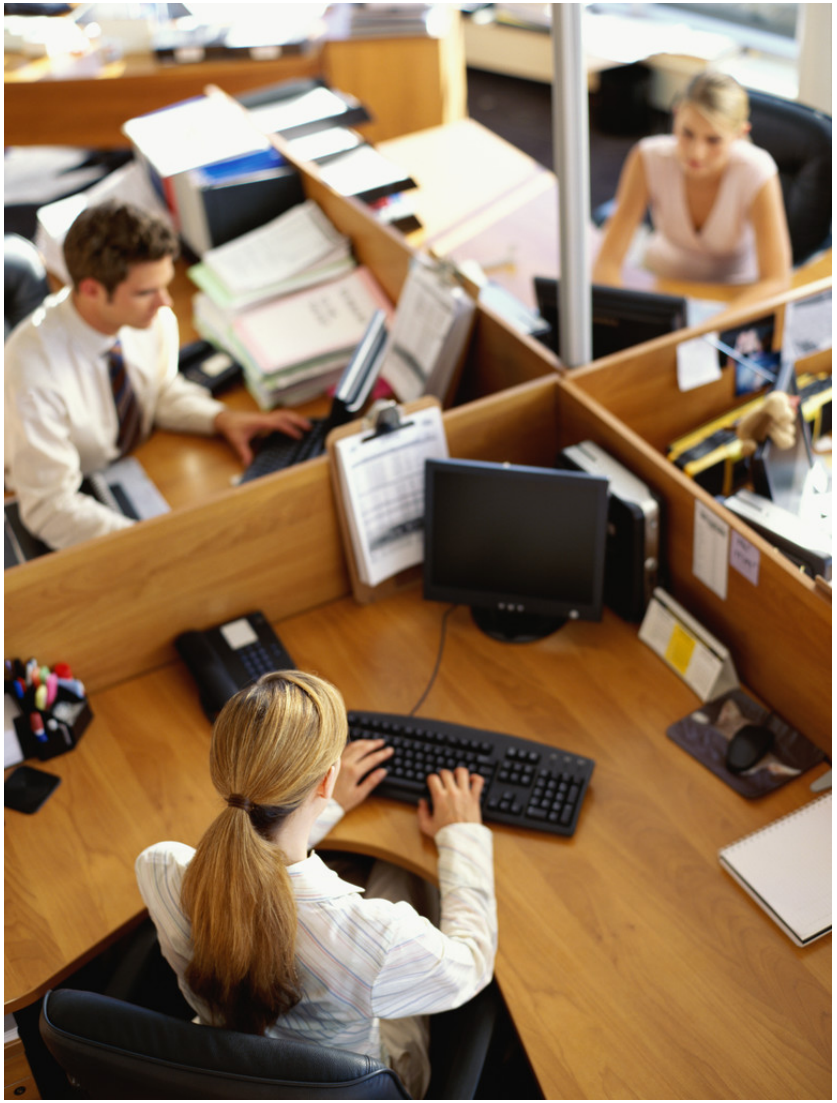

Next Steps

- **Allow use of the same template for programs in any stage of development or cost analysis**
  - Include those variables in template instructions
  - Maximize template versatility without unduly increasing size
- **Accurately identify correlation between cost and benefit elements**
  - Optimize accuracy of risk-adjusted cost estimates
- **Database costs and benefits of FAA programs**

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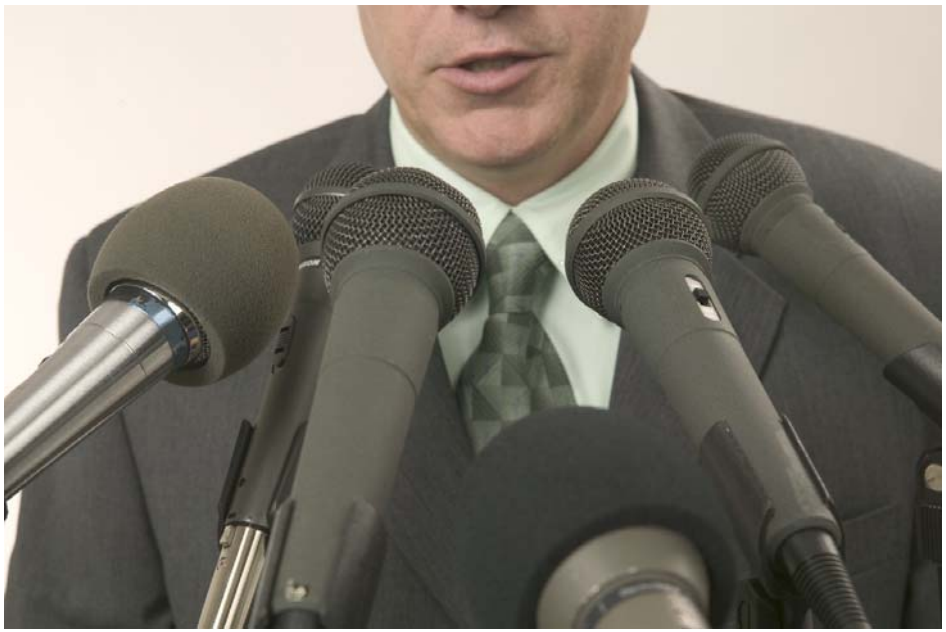

QUESTIONS?

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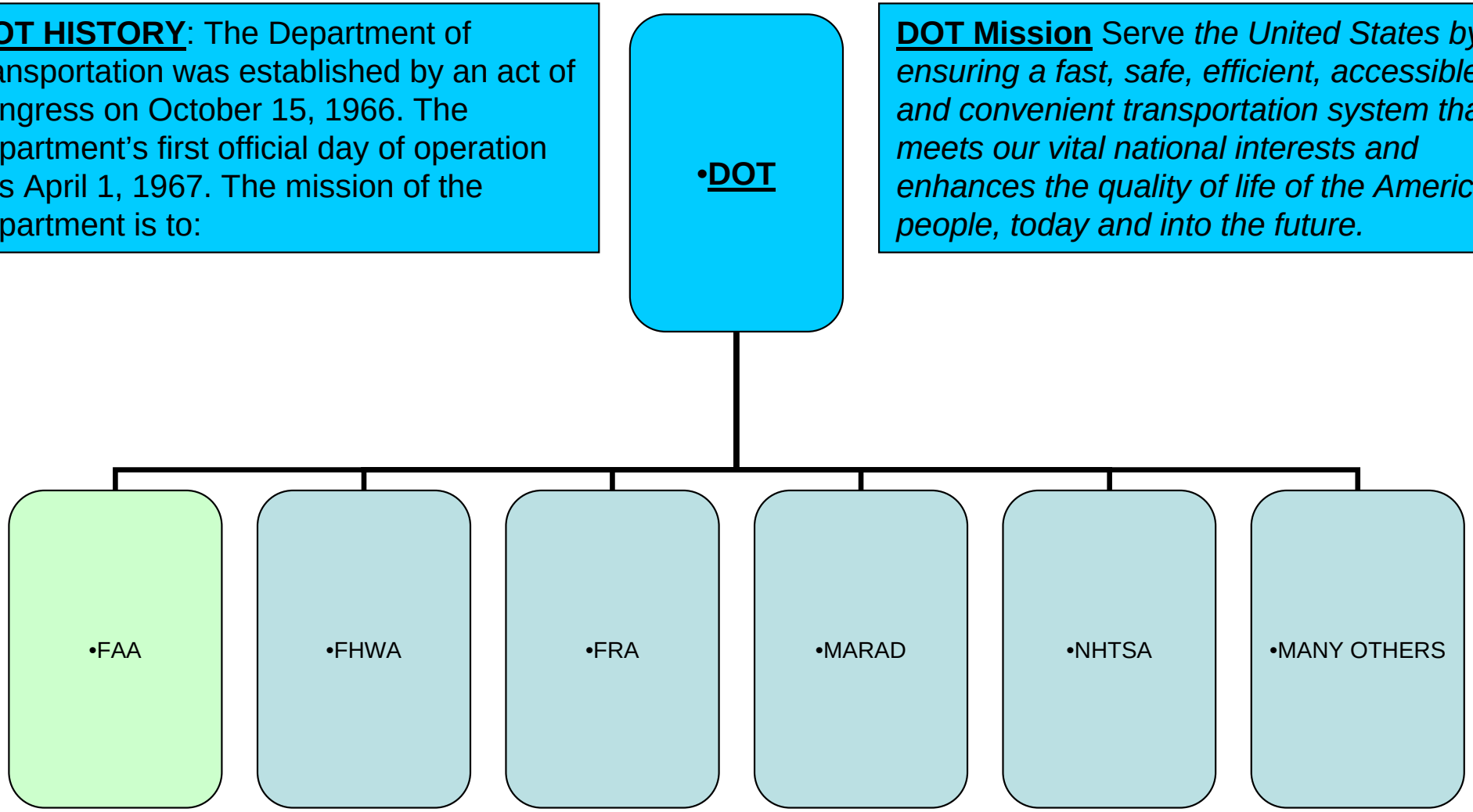
- **Backup**

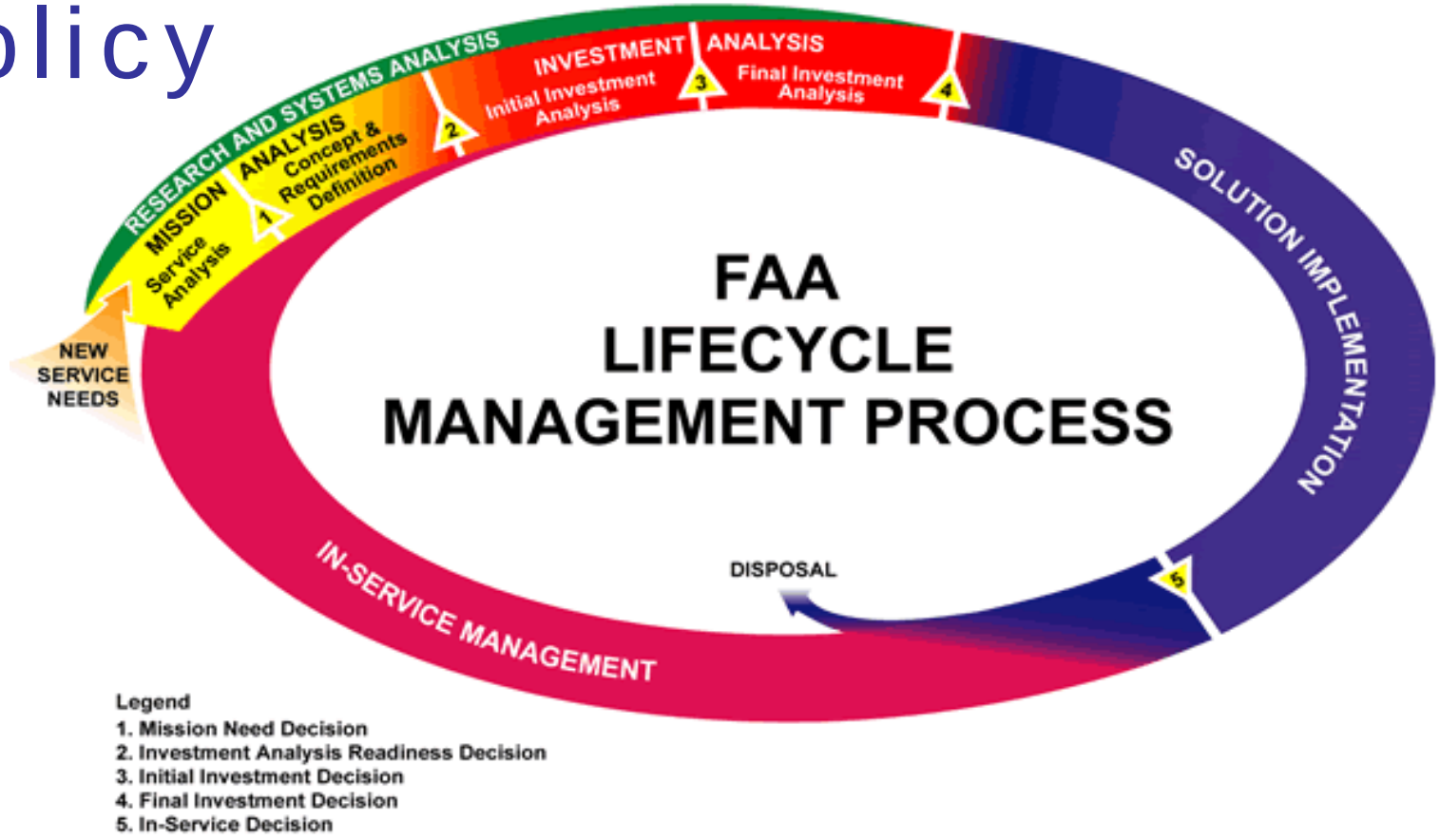
THE FAA

DOT HISTORY: The Department of Transportation was established by an act of Congress on October 15, 1966. The Department's first official day of operation was April 1, 1967. The mission of the Department is to:

DOT Mission Serve *the United States by ensuring a fast, safe, efficient, accessible and convenient transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future.*

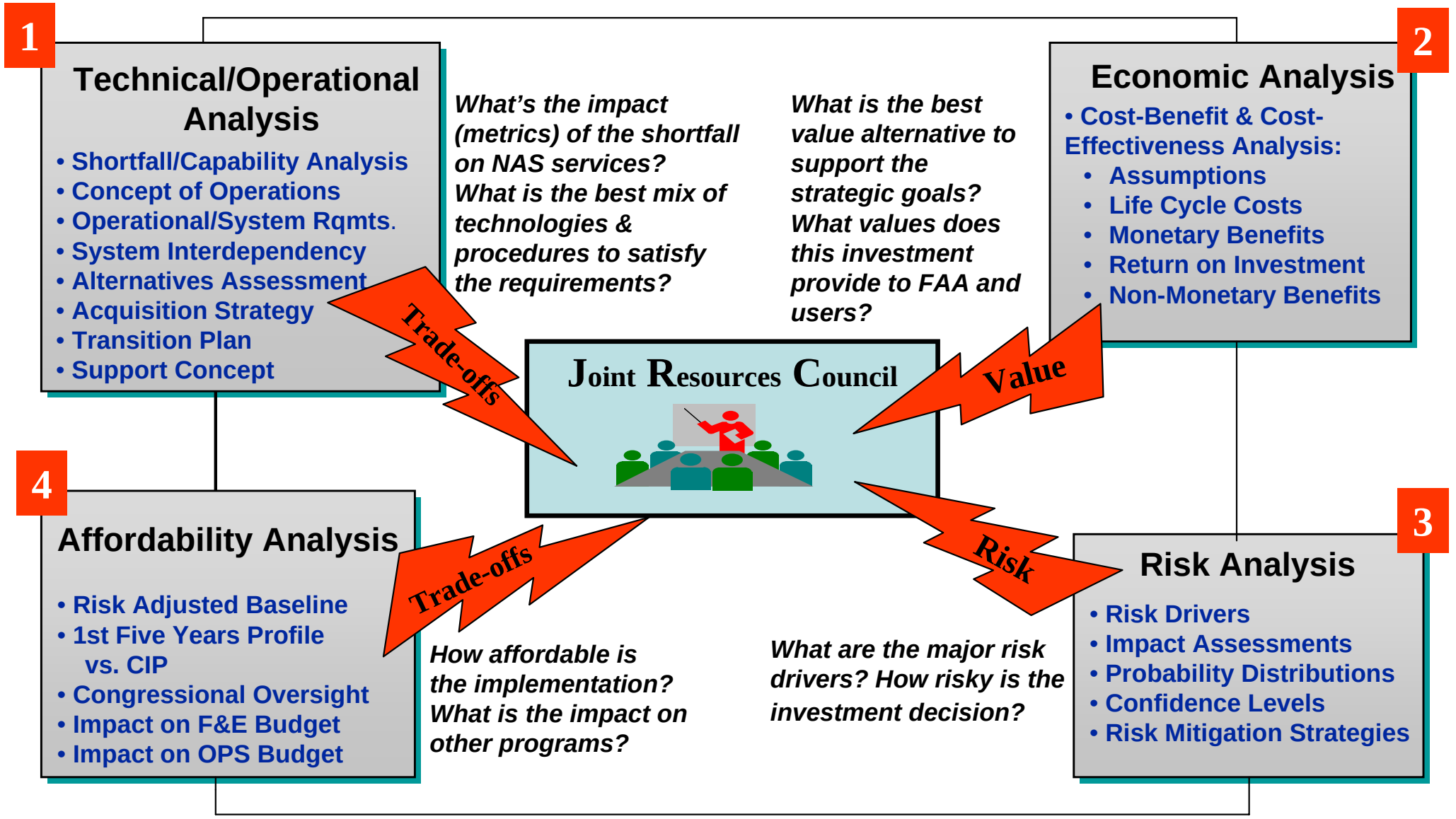


Acquisition Management System - Policy



- **AMS launched – April 1996**
- **Investment Analysis responsibility defined – October 1996**
- **Initial and Final Phases published in the FAA Acquisition System Toolset (FAST) – March 2001**
- **Mission Analysis change approved November 2004**

Building the Business Case



FAA Investment Planning & Analysis (IP&A) Group Responsibilities

- **Ensures that new, proposed, and existing National Airspace System (NAS) investments meet established business case and economic criteria, including schedule and risk assessments**
- **Validates the business justification of NAS programs**
- **Ensures business case and investment analysis policies, procedures, standards and training are established and maintained**

Next Steps (cont'd)

- **The Agency has made progress toward improving the cost estimating capability at the FAA**
  - Conducted 6 course offerings of Introduction to Cost Estimating
  - In FY2006 the agency met all of its cost performance target and remained within acceptable cost baseline limits
  - Aligned agency goals to improving capability
  - Defined plan and milestones for getting off the GAO High Risk List
- **Continue work to build a quality cost estimating presence at FAA**
  - Define other Cost Estimating Standards and Guidance for agency wide use
  - Establish in-house databases that collect cost data for tracking actuals to program estimates
  - Offer comprehensive Cost Estimating Training Curriculum
  - Partner with other established/benchmarked cost estimating communities