

Aviation Safety Research Portfolio Assessment Methods at NASA

Dr. Sharon Monica Jones
NASA Headquarters

Mary S. Reveley
NASA Glenn Research Center

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Outline

- Introduction
- Framework Metrics
- Portfolio Analysis Results Presentation Methods
- Conclusion

Introduction

“The proponents of many R&D project-selection methods have not appeared too concerned about the level of complexity of their particular technique. Some approaches presented in the literature are so mathematically elaborate that they necessitate the assistance of an expert decision analyst in order to be usable by most real-world managers. As a consequence, very little use has been made by managers of many of these approaches.”

Henriksen & Traylor (1999)

Introduction

Aviation Safety Technology Frameworks

- JIMDAT* process for evaluating proposed Commercial Aviation Safety Team (CAST) system enhancements
- FAA Next Generation Air Transportation System safety risk models
- National Aerospace Laboratory (NLR) of the Netherlands' aviation system modeling activities

* *Joint Implementation Measurement and Data Analysis Team*

Framework Metrics

Overview

“Cost considerations and mathematical formulas, however, should never be dispositive in making policy determinations regarding aviation safety they are one input for decision making. Further, non-quantifiable safety and security benefits should be included in the analysis of proposals.”

White House Commission on Aviation Safety and Security
(1997)

Framework Metrics

- Projected Impact on Current Safety Tall Poles
- Projected Impact on Future Safety Tall Poles
- Technical Development Risk
- Implementation Risk
- Projected Impact on Aviation Safety Risk Scenarios

Framework Metrics

Projected Impact on Current Safety Tall Poles

- Qualitative assessment of the expected impact of a technology (research outcome, technology or safety enhancement) on a Current Safety Tall Pole
- Current Safety Tall Poles were originally developed in 2010 based on 1997-2006 data
- Updated version (2013) based on all recorded accidents and incidents from 2001–2010,
- Limited to commercially built fixed-wing airplanes operating under the following Federal Aviation Regulations (FAR)
 - Part 121 (scheduled air carriers)
 - Part 135 (air charter)
 - Part 91 (general aviation)

Framework Metrics

Current Safety Tall Poles

Part 121	Part 135-S	Part 135-NS	Part 91 (1997-2006 data)
Abrupt maneuver	-	-	-
-	Abnormal runway Contact	-	Abnormal runway Contact
-	-	-	Collision with object-takeoff or landing
-	Controlled flight into terrain	Controlled flight into terrain	Controlled flight into terrain
Fire-post impact	-	Fire-post impact	-Fire-post impact
Ground collision	-	-	-
Ground handling	-	-	-
-	Icing	-	-
-	-	-	Low altitude Operations
Loss of control-in flight	Loss of control-in flight	Loss of control-in flight	Loss of control-in flight
-	-	-	Loss of control-on ground
-	-	-	Power loss-fuel
-	Runway excursion	Runway excursion	Runway excursion
SCF-powerplant	SCF-powerplant	SCF-powerplant	SCF-powerplant
SCF- non-powerplant	SCF-non-powerplant	SCF-non-powerplant	SCF-non-powerplant
Turbulence encounter	-	-	-

Framework Metrics

Projected Impact on Future Safety Tall Poles

- Qualitative assessment of the expected impact of a technology on a Future Safety Tall Pole
- Addresses safety concerns that may or may not exist in the current National Airspace System
- Original set of Future Safety Tall Poles were developed as part of the 2010 NASA Systems Analysis of Aviation Safety study
- Updated in 2013 to incorporate more recently published reports regarding aviation safety issues

Framework Metrics

Future Safety Tall Poles

2010

Runway safety
Loss of control-in flight
Increasing complexity and reliance on automation

Icing/ice detection
Enhanced survivability in the event of an accident
Human fatigue

Inadequate protection, analysis, and dissemination
of safety data

Super density operations

Aircraft mixed fleet equipage
Approach and landing accident reduction

2013

Runway safety
Loss of control-in flight
Increasing complexity and reliance on automation

Icing/ice detection
Enhanced survivability in the event of an accident
Human fatigue

Vulnerability discovery through data sharing and
dissemination

Loss of separation/near midair collision

-
-

Framework Metrics

Technical Development Risk

- Structured means of executing the NASA Technology Assessment (TA) process
- Examines the potential impediments in developing a technology from a baseline Technology Readiness Level (TRL) to an expected TRL
- Based on risk assessment approaches from several sources, including:
 - The Aerospace Corporation
 - Sandia National Laboratories
 - Volpe National Transportation Center

Framework Metrics

Technical Development Risk Criteria

Risk Driver Category	Low (1)	Medium (2)	High (3)
Required Technical Advancement	Use of existing hardware/software or minor modifications	Use of existing hardware with major modifications; use of existing software with some new modules/code development.	State of the Art or beyond.
Technology Status	In use or prototype exists	Under development	Concept stage
Complexity	Technology design simple and/or consists of few parts	Technology design moderately complex and/or consists of multiple parts.	Technology design highly complex and uncertain and/or consists of multiple, highly integrated parts.
Dependencies	Independent of other technologies	Dependent on proven technologies, equipment, and/or test data.	Dependent on unproven technologies, and/or test data.
Testability/Verifiability	Technology performance can be fully tested/verified using existing data/information	Test/verification of technology performance requires development of new data/information; all adverse conditions can be modeled.	Technology performance cannot be tested/verified under all adverse conditions.
Impact on Technology Goal	nonessential or minimum impact on technology performance	partial technology performance can be obtained or alternatives available	"show stopper" technology cannot be developed and is infeasible

Framework Metrics

Implementation Risk

- Examination of the possible impediments to actual implementation of proposed technologies in the National Airspace Systems (NAS)
- Helps NASA project managers identify implementation risk drivers
- Based on assessment techniques used by the FAA and industry

Framework Metrics

Implementation Risk Criteria

Risk Driver Category	Low (1)	Medium (2)	High (3)
Implementation Readiness Level (IRL) Impacts	Current certification process easily adaptable	Certification process historically difficult and/or rigorous. No FAA mandate; advisory only	Certification may be controversial, precedent setting, or untried. International rule-making required
Dependencies	No new training or infrastructure requirements	Dependent on immature technologies. Additional automation/IT infrastructure required for transfer of NASA research and technology (R&T).	Requires FAA regulation modification. Infrastructure builds dependent upon or diverse from FAA NAS Architecture Study.
Market Penetration	Business as usual level of stakeholder investment requirements. FAA mandate with retrofit or training subsidization program	Provides product line growth in established market. FAA mandate without subsidization	Large stakeholder investment requirements.
Market Impact	User acceptance high (customer pull/shared costs). Airline ops impacts minimal. Includes transfer of improved processes to established programs. Decreased direct operating costs (DOC).	Airline ops impacts. Additional training requirements. Initiation of applicable programs required for transfer of NASA R&T. Increased DOC.	User acceptance low. Entrepreneur market.

Framework Metrics

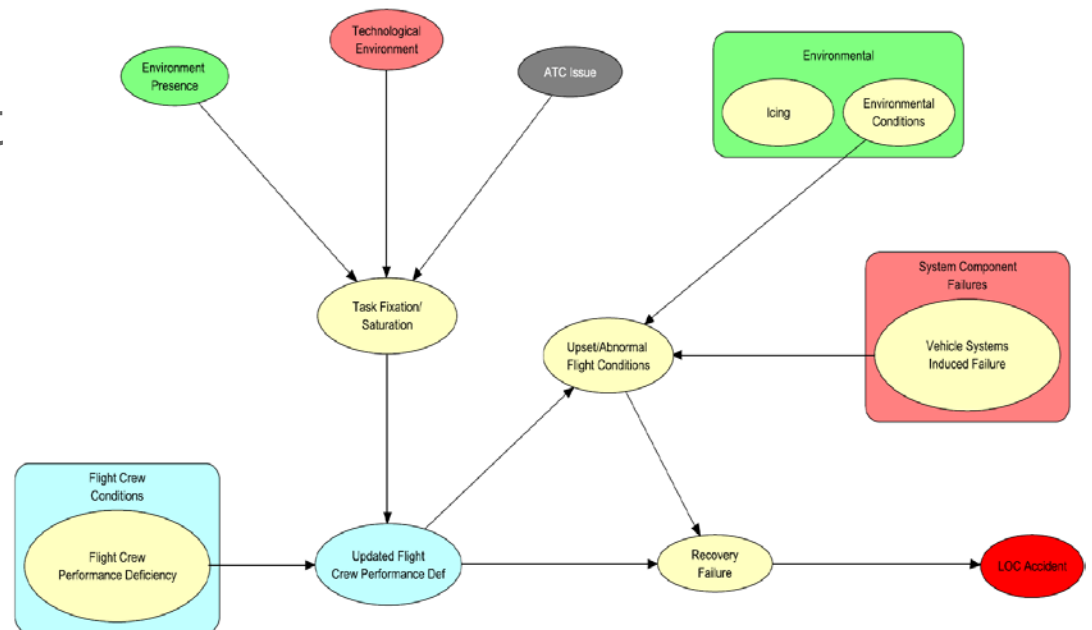
Projected Impact on Aviation Safety Risk Scenarios

- Provides a more quantitative means of evaluating the Safety Tall Poles
- Various aviation safety scenarios are being modeled at NASA using Bayesian Belief Networks (BBNs)
- Models are populated using a combination of historical accident data and subject matter expert knowledge

Framework Metrics

Projected Impact on Aviation Safety Risk Scenarios

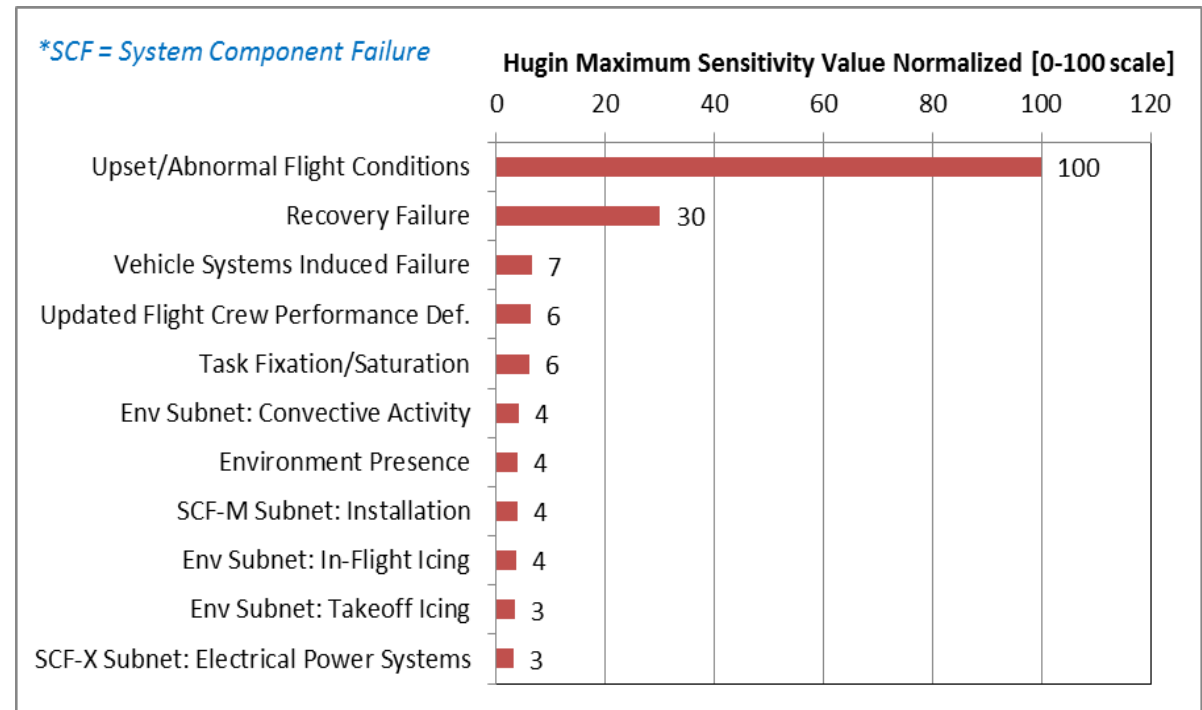
- Current models include:
 - Loss of control accident framework (LOCAF)
 - FLight Automation Problems (FLAP)
 - Runway Incursion (RI) model



Framework Metrics

Projected Impact on Aviation Safety Risk Scenarios

- Models are being developed using a commercial-off-the-shelf (COTS) software tool that contains a sensitivity analysis function
- This function is being used to identify the most influential nodes in the models



Framework Metrics

Projected Impact on Aviation Safety Risk Scenarios

$$r_i = \sum_{j=1}^m a_{ij} c_j$$

Technology impact on node <i>j</i>	<i>a_{ij}</i>
Positive	+1
None	0
Negative	-1

Where

a_{ij} = impact of technology *i* on Scenario causal node *j*

c_j = normalized maximum sensitivity value for Scenario causal node *j*

Portfolio Analysis Results Presentation Methods

- Summary Tables
- Bubble Charts
- Portfolio Ranking Using Quantitative Decision Analysis (DA) Techniques

Portfolio Analysis Results Presentation

Methods

Summary Tables

[illegible]

	Product Name	Abnormal Runway Contact	Controlled Flight into Terrain	Fire – Post Impact	Icing	Loss of Control – In Flight	Runway Excursion	SCF - Powerplant	SCF - Non-Powerplant
1	Product 1	✓			✓	✓	✓	✓	
2	Product 2	✓			✓	✓	✓	✓	
3	Product 3	✓			✓	✓	✓	✓	
4	Product 4	✓			✓	✓	✓		
5	Product 5	✓			✓	✓	✓		

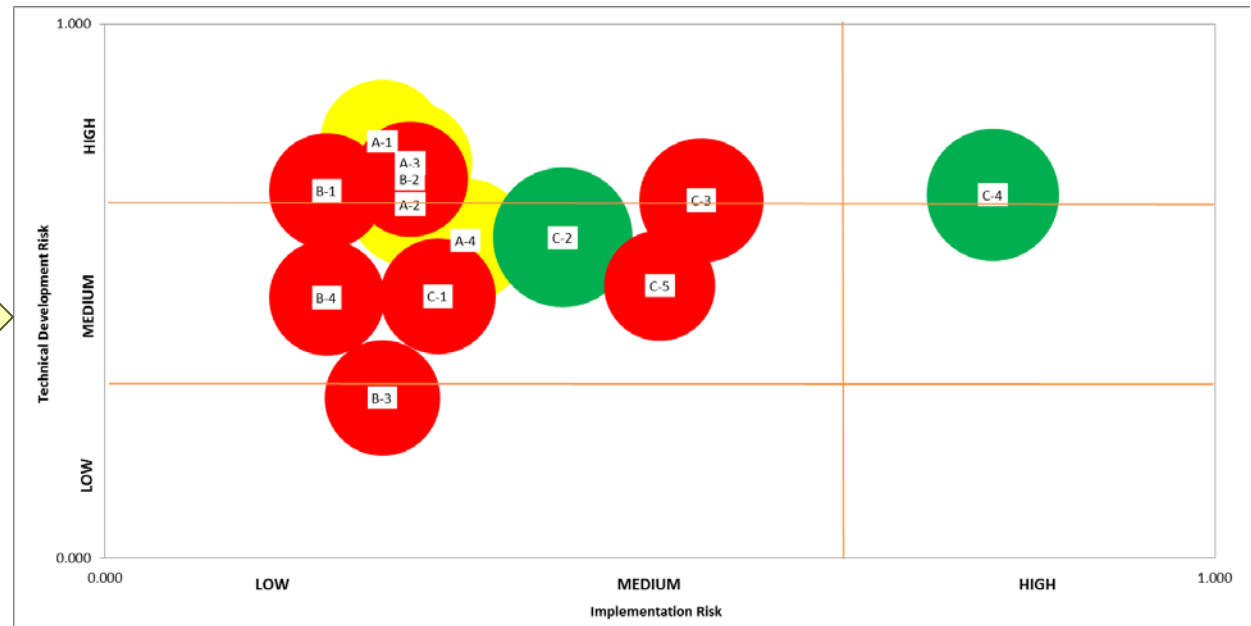
	Required Technology Advancement	Current Technology Status	Technology Complexity	Technology Dependencies	Testability/ Verifiability	Impact of Technology Goal	OVERALL TDR SCORE
A-1	H	H	H	H	H	H	H
A-2	M	M	M	M	M	H	M
A-3	H	M	H	H	H	H	H
A-4	H	L	H	H	M	M	M

Portfolio Analysis Results Presentation

Methods

Bubble Charts

Colored Coded by Impact
on Total Safety Tail Poles



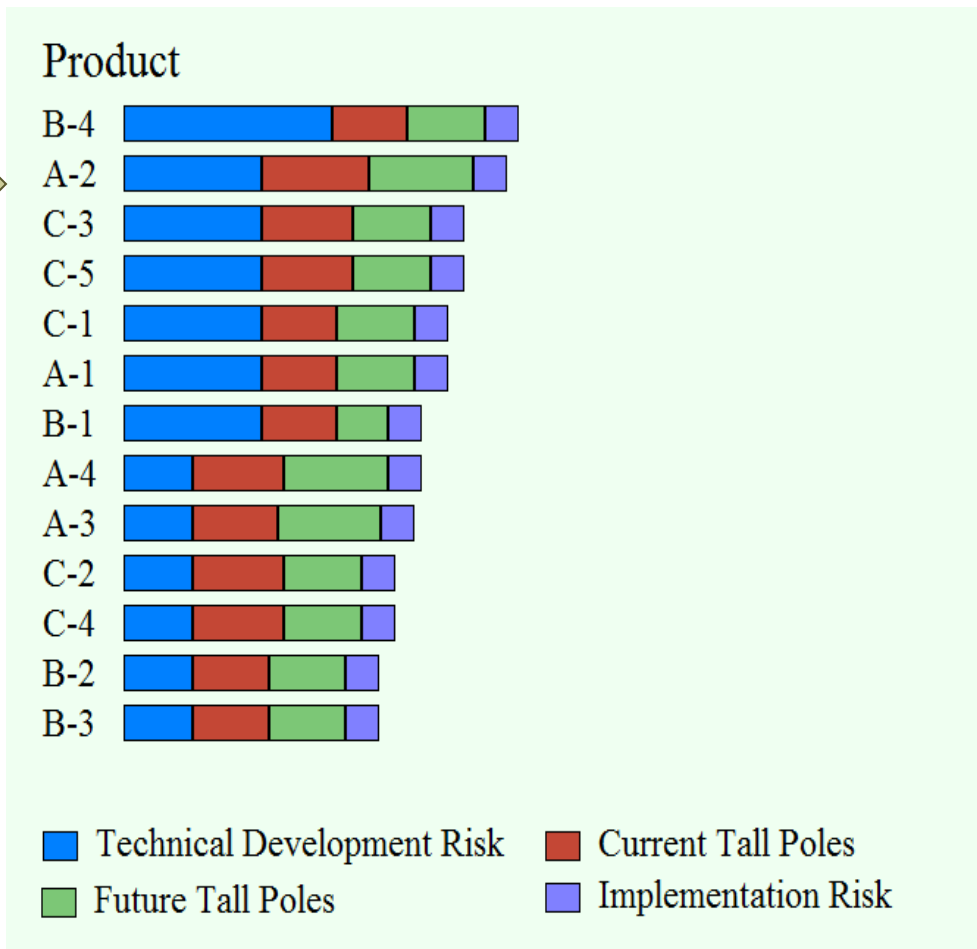
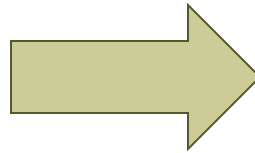
Bubbles Colored
Coded by Project



Portfolio Analysis Results Presentation Methods

Portfolio Ranking Using Quantitative DA Techniques

- Weighted Sum Models (WSM)
- Analytic Hierarchy Process (AHP)
- SMART and SMARTER



Conclusion

- Advantages of framework
 - 1) Not mathematically elaborate and therefore usable by real-world managers
 - 2) Does not rely solely on fatal accident rate for measuring safety
 - 3) Includes multiple ways to measure non-quantifiable safety benefits
- Future work
 - Development of additional models for implementation of the *Projected Impact on Aviation Safety Risk Scenarios* metric
 - Addition of a cost/safety benefit metric to framework

