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Proceedings of the American Society for Engineering Management 2014 International Annual Conference
S. Long, E-H. Ng, and C. Downing eds.

A FRAMEWORK FOR ASSESSMENT OF AVIATION SAFETY TECHNOLOGY PORTFOLIOS

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Abstract

The programs within NASA's Aeronautics Research Mission Directorate (ARMD) conduct research and development to improve the national air transportation system so that Americans can travel as safely as possible. NASA aviation safety systems analysis personnel support various levels of ARMD management in their fulfillment of system analysis and technology prioritization as defined in the agency's program and project requirements. This paper provides a framework for the assessment of aviation safety research and technology portfolios that includes metrics such as projected impact on current and future safety, technical development risk and implementation risk. The paper also contains methods for presenting portfolio analysis and aviation safety Bayesian Belief Network (BBN) output results to management using bubble charts and quantitative decision analysis techniques.

Keywords

Portfolio assessment, technology assessment, research and development (R&D), aviation safety, decision analysis, systems analysis, metrics

Introduction

The programs within the National Aeronautics and Space Administration's (NASA) Aeronautics Research Mission Directorate (ARMD) conduct research and development to improve the national air transportation system so that Americans can travel as safely as possible. NASA aviation safety systems analysis personnel support various levels of ARMD management in their fulfillment of system analyses and technology prioritizations as defined in the agency's Research and Technology Program and Project Management Requirements (National Aeronautics and Space Administration, 2013). Traditionally, multidisciplinary optimization techniques have been used in aerospace systems analyses (Alexandrov, Kaplan, Oran & Boris, 2010; Tong, Jones, Arcara & Haller, 2005), but overly complex methods can sometimes have pitfalls:

> *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)*

Many organizations external to the NASA ARMD are also developing frameworks and methods for evaluating the impact of National Airspace System (NAS) enhancements. Examples include the Joint Implementation Measurement and Data Analysis Team's (JIMDAT) process for evaluating proposed Commercial Aviation Safety Team (CAST) system enhancements (CAST, 2004), the Federal Aviation Administration's (FAA) development of models to determine the safety risks in the Next Generation Air Transportation System (Goldner & Borener, 2006) and the National Aerospace Laboratory (NLR) of the Netherlands' aviation system modeling activities (Roelen &

Blom, 2013). The metrics and portfolio analysis results presentation methods for aviation safety systems analyses used by NASA ARMD are presented in this paper.

Framework Metrics

Almost two decades ago, when the White House Commission on Aviation Safety and Security (1997) challenged the Federal Aviation Administration (FAA), NASA and industry to reduce the aviation fatal accident rate. In their recommendation, the Commission stated the following:

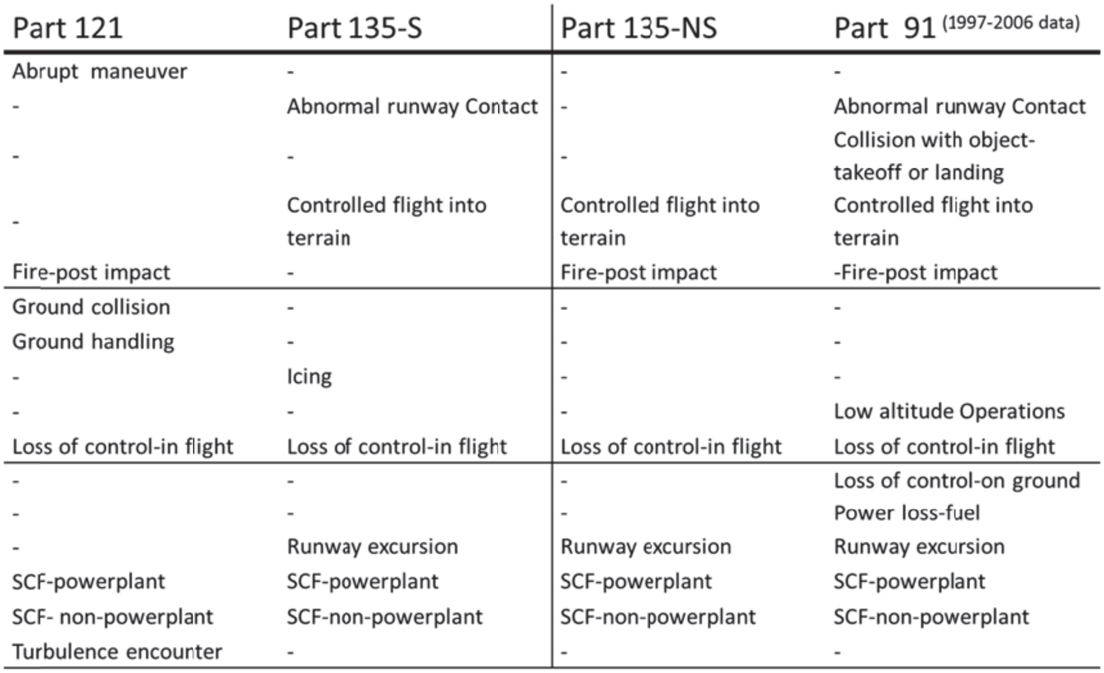
> *Cost considerations and mathematical formulas, however, should never be dispositive in making policy determinations regarding aviation safety they are one input for decision making. Further, non-quantifiable safety and security benefits should be included in the analysis of proposals.*

Both qualitative and quantitative metrics were chosen by the safety system analysis personnel at NASA based on experience obtained from conducting analyses for a variety of unpublished internal studies (e.g., Quick Tall Poles Study of Modified Vehicle System Safety Technologies (VSST) Project Technical Challenges in 2011). The analyses are conducted using a combination of the following five (5) metrics: (1) Projected Impact on Current Safety Tall Poles (Evans, 2014), (2) Projected Impact on Future Safety Tall Poles, (3) Technical Development Risk, (4) Implementation Risk and (5) Projected Impact on Aviation Safety Risk Scenarios.

Projected Impact on Current Safety Tall Poles

The White House Commission on Aviation Safety and Security recommended that the FAA, NASA and industry "should establish a national goal to reduce the aviation fatal accident rate by a factor of five within ten years and conduct safety research to support that goal". The NASA Aviation Safety Program (AvSP) that was created in 1997 in response to this recommendation used the aviation fatal accident rate as a metric to evaluate the NASA AvSP technology portfolio. A more qualitative metric for evaluating current safety was developed as part of the Systems Analysis of the Aviation Safety Program (SAoAS) study (Jones, Reveley, Withrow, Evans, Barr & Leone, 2013) that was conducted for the Aeronautics Research Mission Directorate in early 2010. The metric, Projected Impact on Current Safety Tall Poles is a qualitative assessment of the expected impact of a technology (research outcome, technology or safety enhancement) on a Current Safety Tall Pole. The Current Safety Tall Poles that were developed in 2010, are based on all recorded accidents and incidents from 1997–2006, involving commercially built fixed-wing airplanes operating under Federal Aviation Regulations (FAR) Part 121 (scheduled air carriers), Part 135 (air charter) or Part 91 (general aviation). An updated version of the Current Safety Tall Poles based on 2001-2010 data was developed in 2013 (Barr, 2013) and are summarized in Exhibit 1.

Exhibit 1. Updated Current Safety Tall Poles for FAR Parts 121, 135-S, 135-NS and 91



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	-	-	-

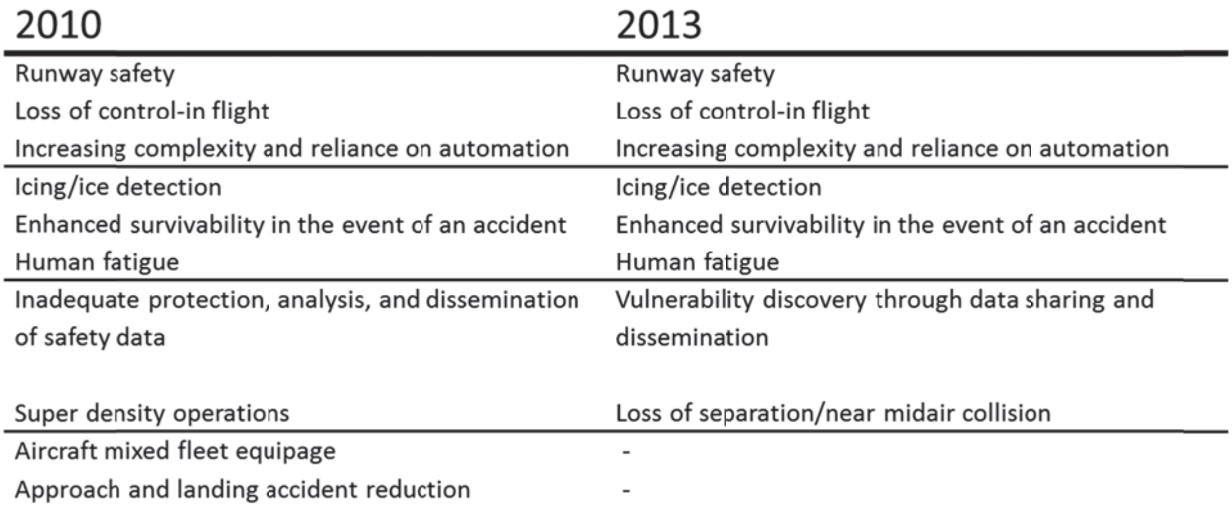
The Projected Impact on Current Safety Tall Poles is defined as the impact that a technology will have on reducing the likelihood of a future occurrence of a particular Current Safety Tall Pole. Also, for the assessments that were conducted with this metric, the technologies were assumed to be fully realized. Through a process of consensus between aviation safety systems analysis team members, each technology in the research portfolio was evaluated against the set of Current Safety Tall Poles. Prior to delivery of final assessment results to upper management, safety systems analysis personnel conduct meetings with technical leads and researchers to review accuracy of assumptions and preliminary results

Projected Impact on Future Safety Tall Poles

Similarly, the Projected Impact on Future Safety Tall Poles is the expected impact of a technology on a Future Safety Tall Pole. The rationale for developing this metric is to address safety concerns that may or may not exist in the current National Airspace System. Just as texting while driving is a new risk in automobile safety that did not exist in historical accident data, changes in aircraft and airspace related technologies (e.g., composite materials) impact the future risks of aviation.

The original set of Future Safety Tall Poles was also created during the 2010 SAoAS study. The Future Safety Tall Poles are the most critical future safety risk issues that were identified by multiple experts, external to NASA, as areas of concern in terms of aviation safety. The Future Safety Tall Poles have also been updated since the SAoAS study to incorporate more recently published reports regarding aviation safety issues. A comparison of the 2010 and 2013 versions of the Future Safety Tall Poles is displayed in Exhibit 2. The implementation of the Projected Impact on Future Safety Tall Poles metric is identical to process described in the previous section for the Current Safety Tall Poles metric.

Exhibit 2. Comparison of 2010 and 2013 Future Safety Tall Poles.



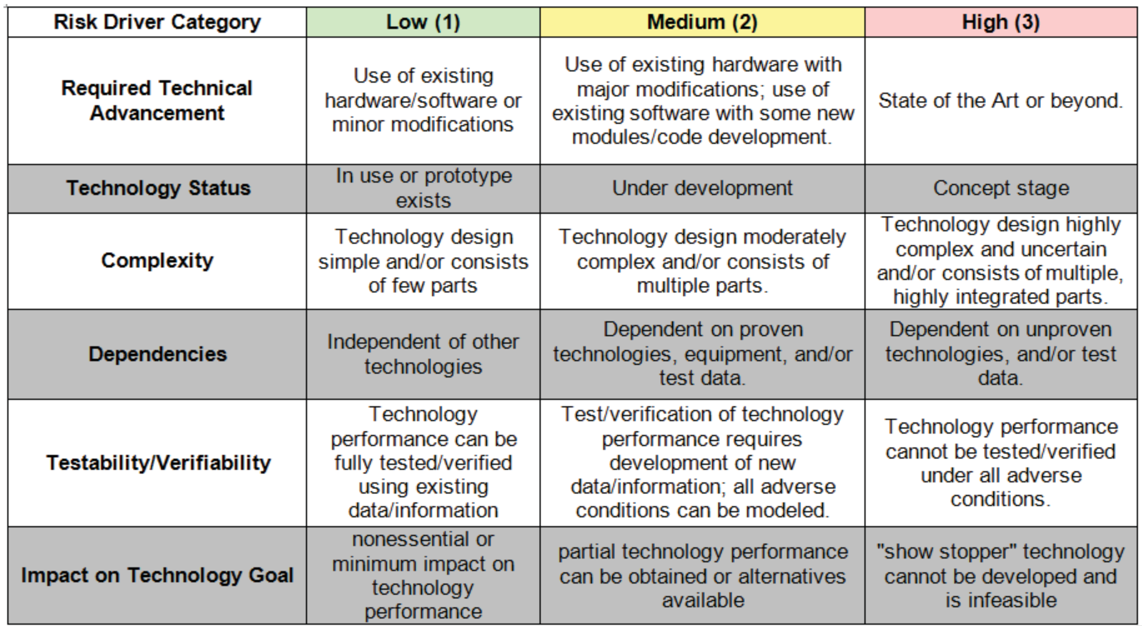
2010	2013
Runway safety	Runway safety
Loss of control-in flight	Loss of control-in flight
Increasing complexity and reliance on automation	Increasing complexity and reliance on automation
Icing/ice detection	Icing/ice detection
Enhanced survivability in the event of an accident	Enhanced survivability in the event of an accident
Human fatigue	Human fatigue
Inadequate protection, analysis, and dissemination of safety data	Vulnerability discovery through data sharing and dissemination
Super density operations	Loss of separation/near midair collision
Aircraft mixed fleet equipage	-
Approach and landing accident reduction	-

Technical Development Risk

Technical Development Risk (TDR) is a structured means of executing the NASA Technology Assessment (TA) process (National Aeronautics and Space Administration, 2007) by examining the potential impediments in developing a technology from a baseline Technology Readiness Level (TRL) to an expected TRL. The TDR metric, which is based on risk assessment approaches from several sources (Cox, 2000; Abramson & Book, 2000; Volpe National Transportation Center, 1997), does not include management risks that are associated with program/project resources (e.g., labor, travel), infrastructure, milestones, etc.

To implement the TDR assessment process, aviation safety systems analysis team members review project plans, technology lists and interview project managers, technical leads and researchers to gather information about each technology in the project portfolio. Using this information and the criteria shown in Exhibit 3, NASA aviation systems analysis personnel determine the TDR ratings for each technology in the portfolio via consensus.

Exhibit 3. Technical Development Risk Criteria



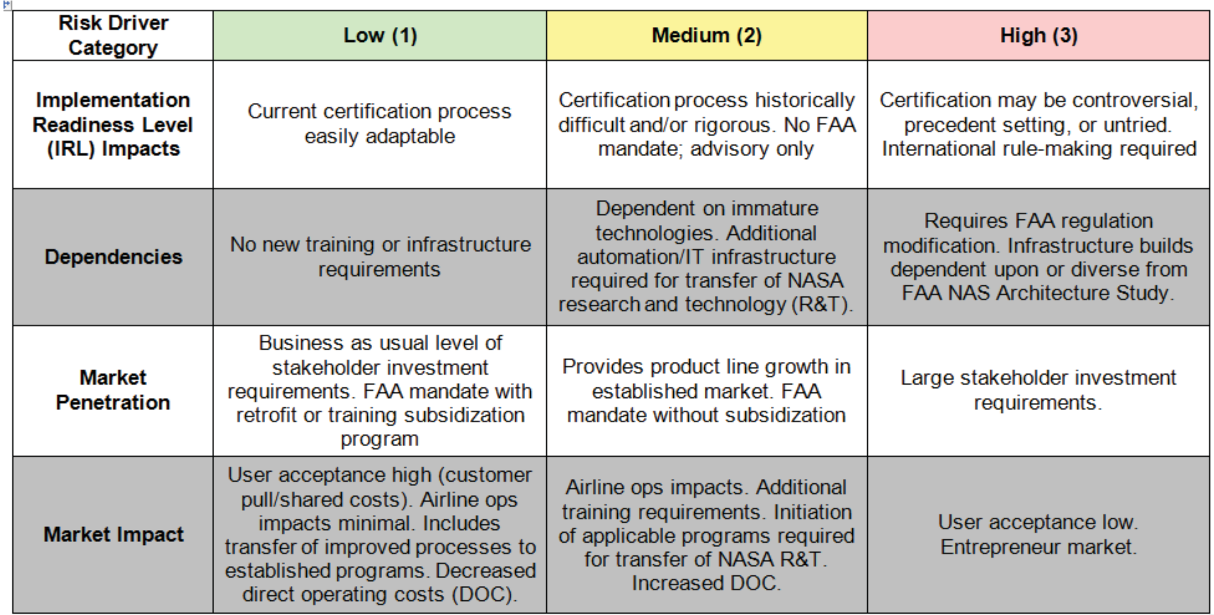
Risk Driver Category	Low (1)	Medium (2)	High (3)
Required Technical Advancement	Use of existing hardware/software or minor modifications	Use of existing hardware with major modifications; use of existing software with some new modules/code development.	State of the Art or beyond.
Technology Status	In 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

Implementation Risk

The Implementation Risk (IR) assessment is an examination of the possible impediments to actual implementation of proposed technologies in the NAS. One of NASA's strategic objectives is advance aeronautics research to "enable a revolutionary transformation" of air travel "for safe and sustainable U.S. and global aviation" (NASA, 2014). The importance of the IR metric in aviation safety portfolio assessment is that it helps project managers identify implementation risk drivers such as market penetration and dependencies (e.g., new training and/or infrastructure requirements).

The IR criteria are based on various assessment techniques used by the FAA and industry (Jones & Reveley, 2003). The criteria, shown in Exhibit 4, were applied to the project research portfolio using the same process described for the TDR assessment in the previous section.

Exhibit 4. Implementation Risk Criteria



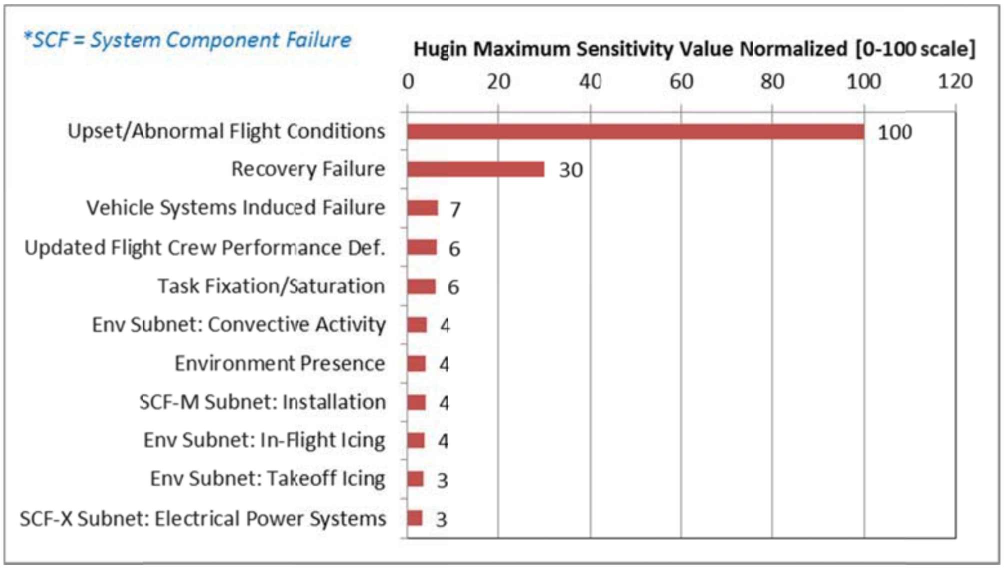
Risk Driver Category	Low (1)	Medium (2)	High (3)
Implementation Readiness Level (IRL) Impacts	Current certification process easily adaptable	Certification process historically difficult and/or rigorous. No FAA mandate; advisory only	Certification may be controversial, precedent setting, or untried. International 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.

Projected Impact on Aviation Safety Risk Scenarios

The newest metric added to the aviation safety assessment framework is the Projected Impact on Aviation Safety Risk Scenarios. The purpose of this metric is to provide a more quantitative means of evaluating the Safety Tall Poles. NASA aviation systems analysis personnel are modeling various aviation safety scenarios using Bayesian Belief Networks (BBN) that are based on a combination of historical accident data and subject matter expert knowledge. Loss of control (LOC) was selected as the first aviation safety risk scenario to be modeled because between 1997 and 2006, LOC accidents comprised 24% of fatal accidents and 54% of total fatalities for commercial air carriers (Jones, Reveley, Withrow, Evans, Barr & Leone, 2013). After the loss of control accident framework (LOCAF) model (Shih, Ancel, & Jones, 2012) was completed, two other aviation safety risk scenarios are in development to address other Safety Tall Poles. The FLight Automation Problems (FLAP) model examines issues related to the Future Safety Tall Pole Increasing Complexity and Reliance on Automation (Ancel & Shih, 2014). The Runway Incursion (RI) model addresses risks involved with runway incursions (Luxhøj, Ancel, Green, Shih, Jones & Reveley, 2014)

The BBN aviation safety risk models are built using a commercial-off-the-shelf (COTS) software tool that contains a sensitivity analysis function. This function can be used to identify the most influential nodes in a model. For example, the top causal risks in the LOCAF model are shown in Exhibit 5.

Exhibit 5. Top Causal Risks from Sensitivity Analysis of LOCAF Baseline Model



All of the nodes in a scenario model are normalized and the Projected Impact on Aviation Safety Risk Scenario, r_i, is calculated as follows:

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

Where

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

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

Technology impact on node *j*	a_{ij}
Positive	+1
None	0
Negative	-1

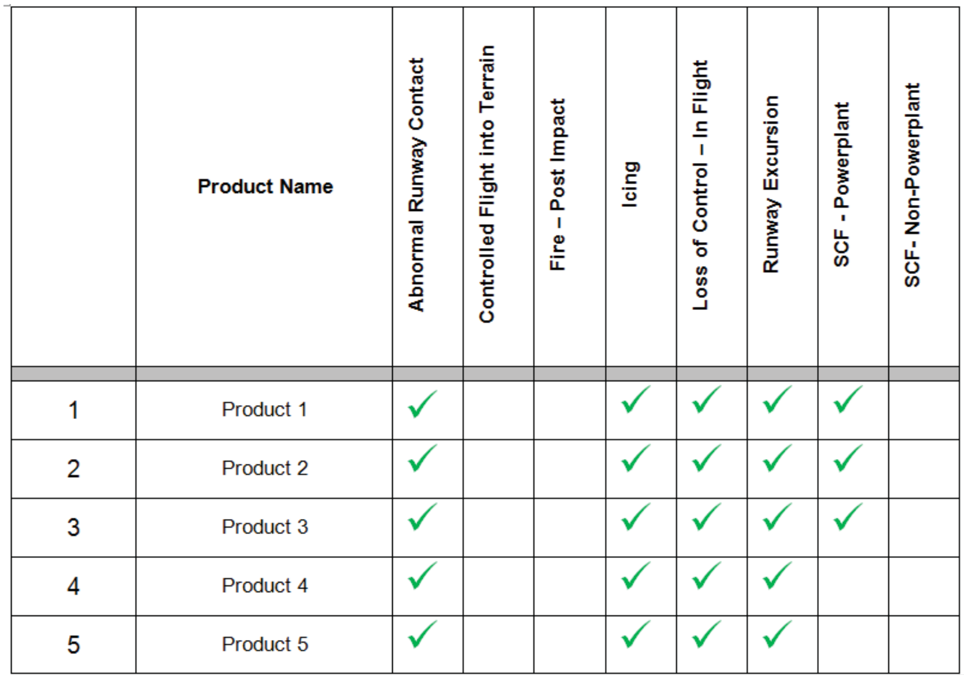
Portfolio Analysis Results Presentation Methods

A number of methods have been used by the aviation safety systems analysis personnel to display the portfolio assessment results that can be generated using the metrics defined in the previous section. In this section of the paper, some of the methods most frequently used by the NASA ARMD for aviation safety technology portfolio assessments are described.

Summary Tables

Simple summary tables of metric results have been used by NASA ARMD for several safety systems analysis studies. In Exhibit 6, technologies that were identified as having a potential impact on a Safety Tall Pole are indicated by ✓ in the table.

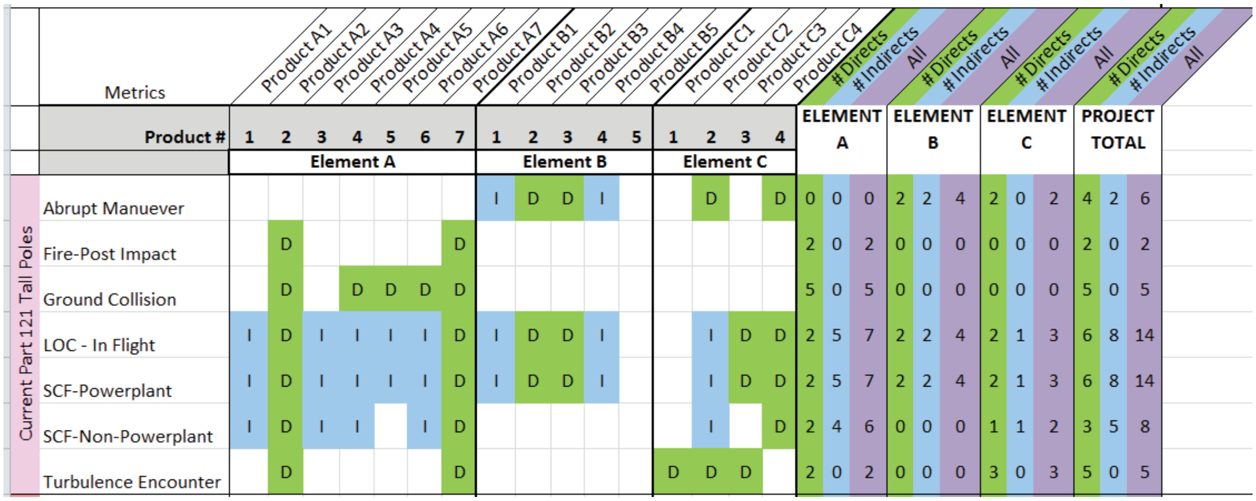
Exhibit 6. Sample Current Part 135 Safety Tall Poles Results Using Checkmark Ratings.



	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	✓			✓	✓	✓		

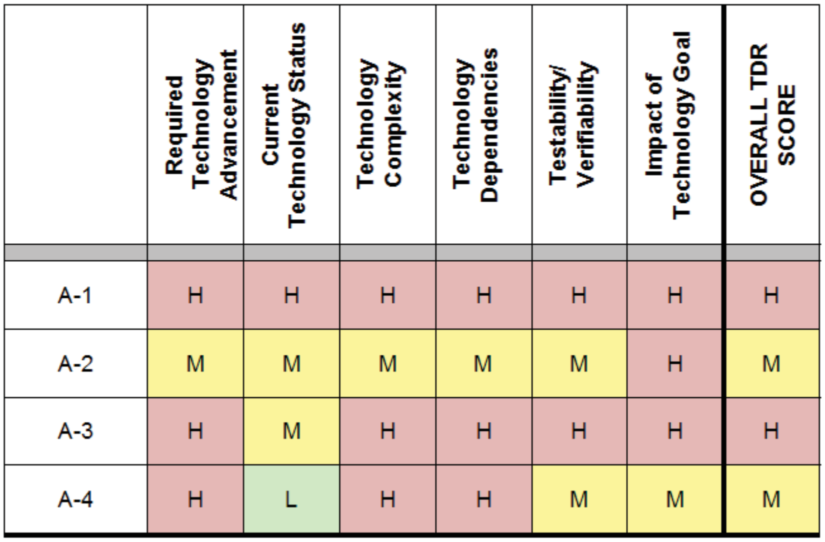
Exhibit 7 also uses the Safety Tall Poles metrics, but technologies were rated using values of direct, indirect or no impact. The Technical Development Risk and Implementation Risk metrics are evaluated using high, medium and low ratings. A table containing sample TDR results is shown in Exhibit 8.

Exhibit 7. Sample Current Part 121 Tall Poles Results Using Direct/Indirect Ratings



	Metrics	Product A1	Product A2	Product A3	Product A4	Product A5	Product A6	Product A7	Product B1	Product B2	Product B3	Product B4	Product B5	Product C1	Product C2	Product C3	Product C4	# Directs	# Indirects	All	# Directs	# Indirects	All	# Directs	# Indirects	All	# Directs	# Indirects	All
	Product #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**ELEMENT A**			**ELEMENT B**			**ELEMENT C**			**PROJECT TOTAL**		
		Element A							**Element B**					**Element C**															
Current Part 121 Tall Poles	Abrupt Manuever								I	D	D	I			D		D	0	0	0	2	2	4	2	0	2	4	2	6
	Fire-Post Impact		D					D										2	0	2	0	0	0	0	0	0	2	0	2
	Ground Collision		D		D	D	D	D										5	0	5	0	0	0	0	0	0	5	0	5
	LOC - In Flight	I	D	I	I	I	I	D	I	D	D	I			I	D	D	2	5	7	2	2	4	2	1	3	6	8	14
	SCF-Powerplant	I	D	I	I	I	I	D	I	D	D	I			I	D	D	2	5	7	2	2	4	2	1	3	6	8	14
	SCF-Non-Powerplant	I	D	I	I		I	D							I		D	2	4	6	0	0	0	1	1	2	3	5	8
	Turbulence Encounter		D					D						D	D	D		2	0	2	0	0	0	3	0	3	5	0	5

Exhibit 8. Sample Technical Development Risk Results



	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

Bubble Charts

Bubble charts have been used in R&D portfolio analysis (Roussel, Saad, & Erickson, 1991; MacMillan & McGrath, 2002) to visually examine three or more metrics at one time. In the assessment framework used by the NASA aviation safety systems analysis team, each bubble in the chart represents a technology. The size of the bubble represents the total safety tall poles tally (i.e., total number of current and safety tall poles impacted by the product). The color of the bubble can be changed to help display pertinent information decision makers. For example, in Exhibit 9, all of the products in a project's technology portfolio are color coded based on their total impact on the current and future safety tall poles (green = greatest impact; red = least impact). A quick glimpse of the chart reveals that the two technologies color coded green (C-2 and C-4) are expected to have the greatest safety impact. Another display method used is to color code the bubbles based on the Project Subprojects as shown in Exhibit 10. All of the technologies in Subprojects A and B have mostly low implementation risks, but the technologies in Subproject C have a wide range of implementation risk.

Exhibit 9. Bubbles Colored Coded by Impact on Total Safety Tall Poles

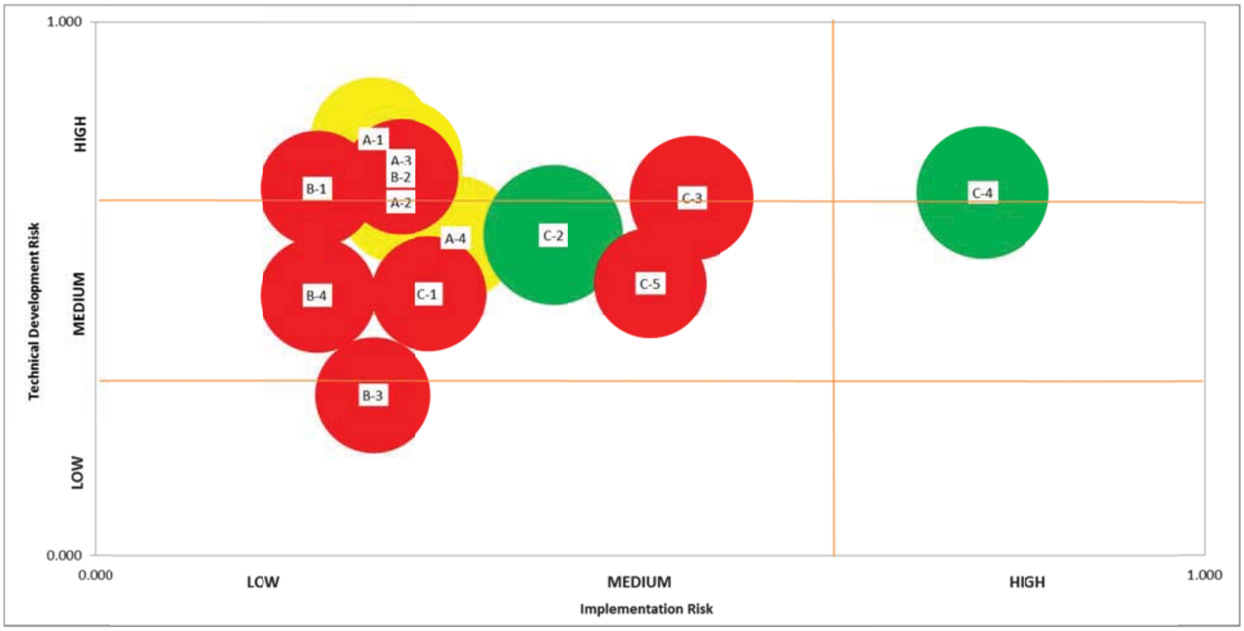
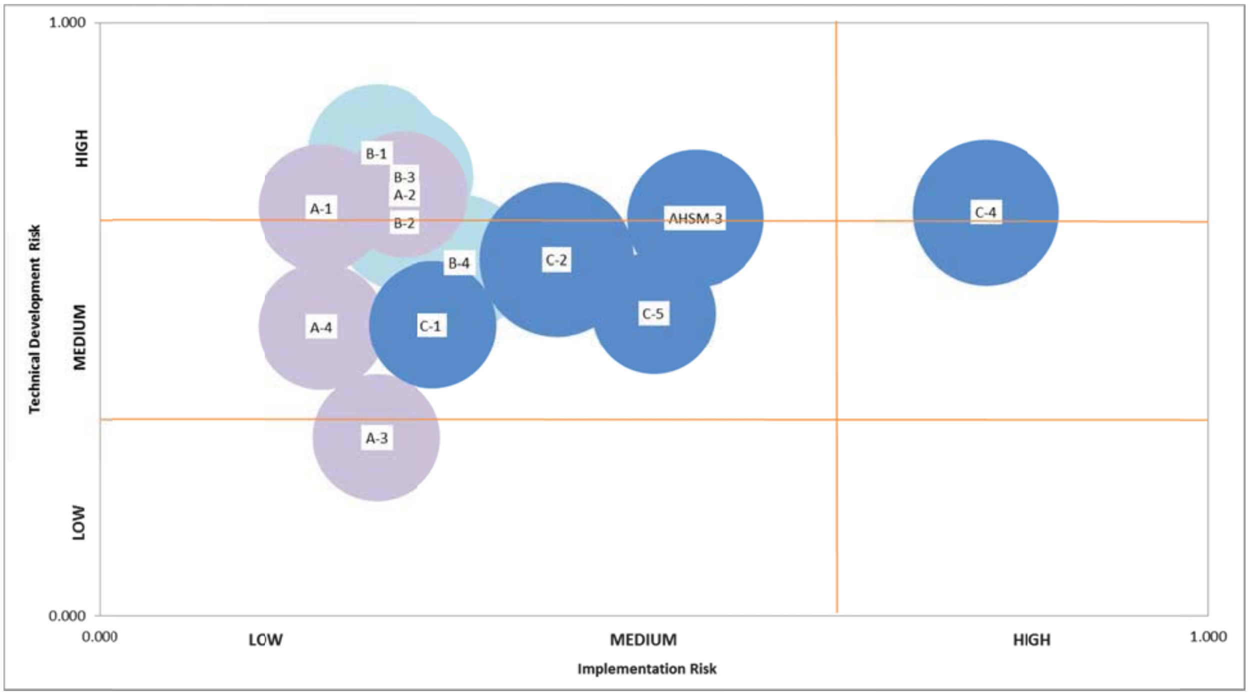


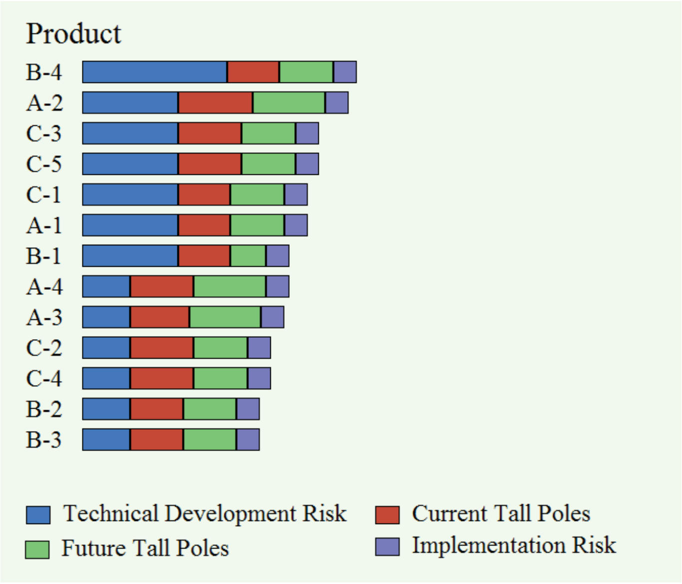
Exhibit 10. Bubbles Colored Coded by Notional Subproject



Portfolio Ranking Using Quantitative Decision Analysis Techniques
Traditional decision analysis methods such as weighted sum models and Analytic Hierarchy Process, have been used by NASA ARMD personnel to prioritize technologies in aviation safety portfolios (Exhibit 11). Metrics in the portfolio can have equal weights or program and project decision makers can assign weights to the metrics

according to their perceived value to their research goals. The weights assigned to each metric should be obtained from decision makers prior to implementation of any decision analysis method so that analysis results are not manipulated to obtain a desired outcome.

Exhibit 11. Sample Portfolio Prioritization Using Weighted Sum Model (All Metrics Equal)



Conclusion

The framework (metrics and presentation methods) presented in this paper has been developed as a result of over ten years of implementing analyses of aviation safety technology portfolios. The advantages of this framework include: (1) it is not mathematically elaborate and therefore usable by real-world managers, (2) it does not rely solely on fatal accident rate for measuring safety and (3) it includes multiple ways to measure non-quantifiable safety benefits. Future work will continue in the development of additional models for implementation of the Projected Impact on Aviation Safety Risk Scenarios metric. Other metrics pertaining to costs/safety benefits are also expected to be included in future version of this framework.

References

Abramson, R.L. & Book, S.A. (2000). A Quantification Structure for Assessing Risk-Impact Drivers, *24th Annual DOD Cost Symposium*, 1992 AIAA-2000-4501, presented at AIAA Modeling and Simulation Technologies Conference, Denver, CO, August 14-17, 2000, The Aerospace Corporation,

Alexandrov, N., Kaplan, C., Oran, E., & Boris, J. (2010). The Monotonic Lagrangian Grid for Fast Air-Traffic Evaluation, *Proceedings of 48th AIAA Aerospace Sciences Meeting*, 4-7 Jan. 2010; Orlando, Florida; United States

Ancel, E., & Shih, A. T. (2014). Modeling Increased Complexity and the Reliance on Automation: FLightdeck Automation Problems (FLAP) Model. *Proceedings of the 32nd International System Safety Training Symposium*, St. Louis, MO, Aug. 4-10.

Barr, L.C. (2013). *Qualitative Future Safety Risk Identification, an Update*. U.S. Department of Transportation, Volpe National Systems Center, Cambridge, MA 02142, May 3, 2013.

Commercial Aviation Safety Team (2004). *Process for Conducting Joint Implementation Measurement and Data Analysis Team (JIMDATs)*, July 2004, http://cfapp.icao.int/fsix/cast/JIMDAT Process Handbook 206-28-04 Draft.pdf

Cox, Roger (2000). *Assessment of Technical Risk Methodologies Applicable to the NASA Aviation Safety Program*, March 2000, Sandia National Laboratories.

Evans, J.K. (2014). *Frequency of Specific Categories of Aviation Accidents and Incidents During 2001-2010*. NASA CR-2014-218184, Hampton, Virginia: NASA, Langley Research Center.

Henriksen, A. D. & Traynor, A.J. (1999). A Practical R&D Project-Selection Scoring Tool, *IEEE Transactions On*

Engineering Management, Vol. 46, No 2, May 1999

Goldener, D.R. and Borener, S.S. (2006). Evaluating NGATS Research Priorities at JPDO, *Proceedings of the AIAA 6th Annual Aviation Technology, Integration and Operations (ATIO) Conference*, Wichita, Kansas, September 25-27, 2006.

Jones, S.M., Reveley, M.S., Withrow, C., Evans, J. K., Barr, L.C. & Leone, K. (2013). *Systems Analysis of NASA Aviation Safety Program – Final Report*. NASA TM-2013-218059. Hampton, Virginia: NASA, Langley Research Center.

Jones, S.M. & Reveley, M.S. (2003). An Overview of the NASA Aviation Safety Program Assessment Process, *Proceedings of the AIAA 3rd Annual Aviation Technology, Integration and Operations (ATIO) Forum*. Denver, Colorado, November 2003.

Luxhøj, J.T, Ancel, E., Green, L.L, Shih, A.T., Jones, S.M., & Reveley, M.S. (2014). Aviation Safety Risk Modeling: Lessons Learned from Multiple Knowledge Elicitation Sessions, *Proceedings of the 32nd International System Safety Conference*, St. Louis, MO, United States, August 1-10, 2014.

National Aeronautics and Space Administration (2014), *NASA Strategic Plan 2014*, http://www.nasa.gov/sites/default/files/files/2014_NASA_Strategic_Plan.pdf.

National Aeronautics and Space Administration (2013). *NASA Research and Technology Program and Project Requirements*, NASA NPR 7120.8, March 18, 2013.

MacMillan, I.C. & McGrath, R. G. (2002). Crafting R&D Project Portfolios, *Research-Technology Management*, 45(5): 48-59, September 2002.

Roelen, A. and Blom, H. A.P. (2013). Airport Safety Performance, in *Modelling and Managing Airport Performance* (eds K. G. Zografos, G. Andreatta and A. R. Odoni), John Wiley & Sons, Chichester, UK. doi: 10.1002/9781118535844.ch7

Roussel, P.A., Saad, K. N. & Erickson, T. J. (1991). *Third Generation R&D*, Harvard Business School Press, Boston, Massachusetts.

Shih, A.T., Ancel, E. & Jones, S.M. (2012). Object-Oriented Bayesian Networks (OOBN) for Aviation Accident Modeling and Technology Portfolio Impact Assessment. *Proceedings of the 2012 International Conference of the American Society for Engineering Management*. Virginia Beach, Virginia, October 17-20, 2012

Tong, M.T., Jones, S.M., Arcara, P.C, Jr. & Haller, W.J. (2005). A Probabilistic Assessment of NASA Ultra-Efficient Engine Technologies for a Large Subsonic Transport, *Proceedings of TURBO EXPO 2004*, June 14, 2004, Vienna, Austria.

Volpe Transportation Systems Center (1997). *Risk Assessment Guidelines for the Investment Analysis Process Report* No. WP-59-FA7N1-97-2, July 1997.

White House Commission on Aviation Safety and Security (1997). *Final Report to President Clinton*, Feb. 12, 1997

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Mary S. Reveley is an Aerospace Engineer at the NASA Glenn Research Center. Currently, she is on the Portfolio and Systems Analysis Team, supporting the NASA Airspace Operations & Safety Program as well as on the Capability Assessment Team, supporting investment data analysis for the NASA Aeronautics Evaluation and Test Capability Project. She received her B.S. in Aerospace Engineering from the Ohio State University, and her MBA from Cleveland State University. Mary has worked in systems analysis for NASA's Aviation Safety Program since 1998 performing cost analysis, safety risk analysis, portfolio assessments, state of the art assessments, and gap analyses. Mary is a Senior Member of the AIAA and a Member of the FAA's Integrated Safety Risk Assessment Advisory Committee.