Summer 2009

A Study of Decision Analysis Methods in Aerospace Technology Assessments

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A STUDY OF DECISION ANALYSIS METHODS IN AEROSPACE TECHNOLOGY ASSESSMENTS

by

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A Dissertation Submitted to the Faculty of
Old Dominion University in Partial Fulfillment of the
Requirement for the Degree of

DOCTOR OF PHILOSOPHY

ENGINEERING MANAGEMENT

OLD DOMINION UNIVERSITY
August 2009

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ABSTRACT

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Managers of aerospace technology programs and projects are faced with the challenge of making technology portfolio decisions under conditions of limited data, rapidly changing macro level factors and organizational uncertainties. To help make these technology investment decisions, some aerospace managers and analysts have used techniques from the field of decision analysis. In addition, there have been a limited number of research studies of real decision problems.

This dissertation presents the results of a non-experimental examination of the use of decision analysis methods for the assessment of aerospace technology portfolios. A web-based survey instrument was developed based on the results of a pilot study conducted using cognitive interviewing techniques. Quantitative data was collected from government and industry aerospace researchers and managers with experience in research and/or with the development of aerospace technology portfolios and the completion of their assessments. Structural equation modeling techniques were used to test the study hypotheses. Conclusions were drawn and recommendations were made for future research.

This dissertation is dedicated to Allie Star and Andy.

ACKNOWLEDGEMENTS

I would like to thank my dissertation advisor, Rafael Landaeta, and the other members of my dissertation committee, Jim Luxhøj, Ariel Pinto and Resit Unal, for their guidance and patience throughout this journey. I would also like to acknowledge other members of the Engineering Management Department, Chuck Keating, Ghaith Rabadi and Andres Sousa-Poza, for their help in getting me started in this process.

I am extremely grateful to my management and colleagues at NASA, ODU classmates, friends and members of the aerospace community for their support and assistance with this work. Thanks also to the aerospace researchers who took time out of their busy schedules to complete the survey, especially the pilot survey participants.

I am especially indebted to the members of my immediate family who made sure this process did not significantly alter my kids' childhood. During the times that I was busy with classes, exams and writing, they stepped in to provide everything from nightly bedtime stories, video games, karaoke, basketball, ballet rehearsal appointments, trips to the park and even a vacation in Myrtle Beach.

Finally, I would also like to acknowledge my husband and kids for their tolerance and sacrifices during this endeavor. The most memorable was being unable to attend a James Taylor concert because it coincided with the due date for my candidacy exam. The person that I gave my ticket to went to the concert,

sat in the front row, shook hands with JT and obtained his autograph. I got a t-shirt.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure Page

1. INTRODUCTION

PROBLEM STATEMENT

The key to a good manager in a technology-oriented organization is the ability to make wise decisions about research and development (R&D) investments. This includes being able to predict what technologies are needed in the future and also periodically measuring the value of these investments to determine if R&D goals are achieved. In other words, technology managers have to make decisions about the composition of their R&D portfolios, which often requires the use of technology forecasting and assessment methods.

Managers of aerospace technology programs and projects in particular are faced with challenges that parallel those of financial investment advisors. Often, decisions must be made with very little time to acquire sufficient background data. Even when there is time for data collection, there are several uncertainties that can impact the value of their future respective portfolios (i.e., set of technologies or stocks) such as politics, global economics, environmental changes, etc. In addition to these macro level factors, other uncertainties (e.g., employee retention, company profit/funding sources), within the organization can also impact investment decisions. To help make these investment decisions, some managers and analysts have used techniques from the field of decision analysis.

The style for this dissertation conforms to the *Engineering Management Journal* model.

“Decision analysis is concerned with helping people make better decisions (Keeney, 2004a, p. 193)”. The field, which originated in mathematical based disciplines such as operations research and statistical decision theory (Raiffa, 2002), has evolved to encompass the qualitative aspects of good decision making. These qualitative aspects include the proper formulation of the decision problem itself and the subjective generation of objectives, values and alternatives (Clemen, 1996). The steps in the decision analysis process, adapted from Clemen, are shown in Figure 1.

The “prescriptive” approach to decision analysis is concerned with “how an analytically inclined person should and could make wise decisions” (Raiffa, 2002). Zopounidis and Doumpos (2002) documented the use of these methods in the development and assessment of financial portfolios. Since the majority of long term aerospace research and development in the United States is being conducted by government agencies (Sternberg, 1996), investments in aerospace are often the result of decisions impacted by public policy. There have been recent examinations of the use of decision analysis methods in policy decisions (Bots and Lootsma, 2000; Keeney 2004b), but historically there has been disagreement within the decision analysis community about the value of these methods in policy related decisions (Brown, 1992; Howard, 1980, 1992). Empirical research to determine whether managers and analysts agree (or disagree) that decision analysis methods are effective in the assessment of aerospace technology portfolios could help resolve these competing viewpoints.

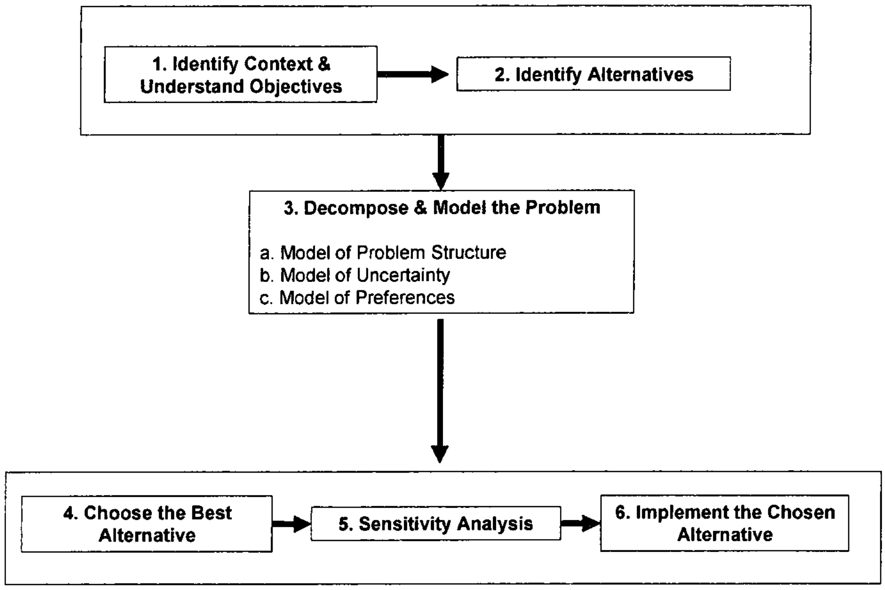

Figure 1 – Steps in Decision Analysis Process (Adapted from Clemen, 1995)

PHENOMENON

The phenomena to be observed are decision analysis methods and their impact on the outcome of the aerospace technology assessment process. Using a derivative of the aspects (i.e., effectiveness, efficiency and legitimacy) of quality public decision making described by Bots and Lootsma (2000), three particular types of outcomes will be examined: (1) decision maker (i.e., a manager in this investigation) and analyst satisfaction with the process, (2) implementation and preparation times and (3) actual usage of process results in making the final decision. In addition, the characteristics of the process input will also be examined to determine their impact on the outcome.

Aerospace Technology Assessment

There are at least three different processes for examining the impact of a set of technologies: technology assessment, technology forecasting and technology foresight. Mohr (1999) defines technology assessment as a process for measuring the impact of established or new technologies. Technology forecasting looks at the impact of technologies “at some time in the future” (Porter et al., 2003) but differs from the process of “technology foresight” in which the objective is to “examine the use of future technology to produce the greatest societal benefit” (Salo, 2003). In the aerospace community, the term technology assessment is sometimes used to describe technology forecasting activities (Smith, 2001); therefore, in this study the term “aerospace technology assessment” will encompass both technology “assessment” and “forecasting” of aerospace portfolios.

Decision Analysis Methods

Decision analysis is an interdisciplinary field and has expanded to include any methods to help people make better decisions. Over the years, a number of decision frameworks (Raiffa, 1968; Saaty, 1980; von Winterfeldt and Edwards, 1986) have been developed, mostly based on and taught using laboratory exercises (Winkler and Clemen, 2004). The decision analysis methods that will be analyzed in this study were selected based on (a) the lack of empirical research on the effects of these methods upon aerospace technology assessments and (b) the potential impact that the results of this investigation can have upon the outcomes of aerospace assessments due to their availability in commercial off the shelf (COTS) software packages and simplicity of use.

The four specific methods that will be examined in this study are: (1) decision trees (2) influence diagrams (3) "criteria aggregation methods" (e.g., Analytic Hierarchy Process, Weighted Sum Model) and (4) "explicit tradeoff approaches" (e.g., MAUT, SMART, SMARTER) (Clemen, 1996; Belton and Stewart, 2002). Outranking methods such as ELECTRE and TOPSIS (Yoon and Hwang, 1995) were not included primarily because they are not popular in the United States (Larichev and Brown, 2000). Optimization techniques were also excluded because real world applications are often complex with a great deal of uncertainty and therefore require solutions that "satisfice" (Simon, 1996) instead of optimize.

Aerospace Technology Assessment and Decision Analysis Methods

The relevance of decision analysis methods to the aerospace technology process is depicted in Figure 2. As previously stated, the goal of the technology assessment process is to measure the impact of established or new technologies. The aerospace technology assessment process involves dealing with a set of technologies (i.e., alternatives) that have a great deal of uncertainty (e.g., technical development risk) and competing objectives (e.g., reduce emissions vs. reduce travel time). Decision analysis methods can be used to model the decision problem, uncertainty and/or preferences for dealing with competing objectives.

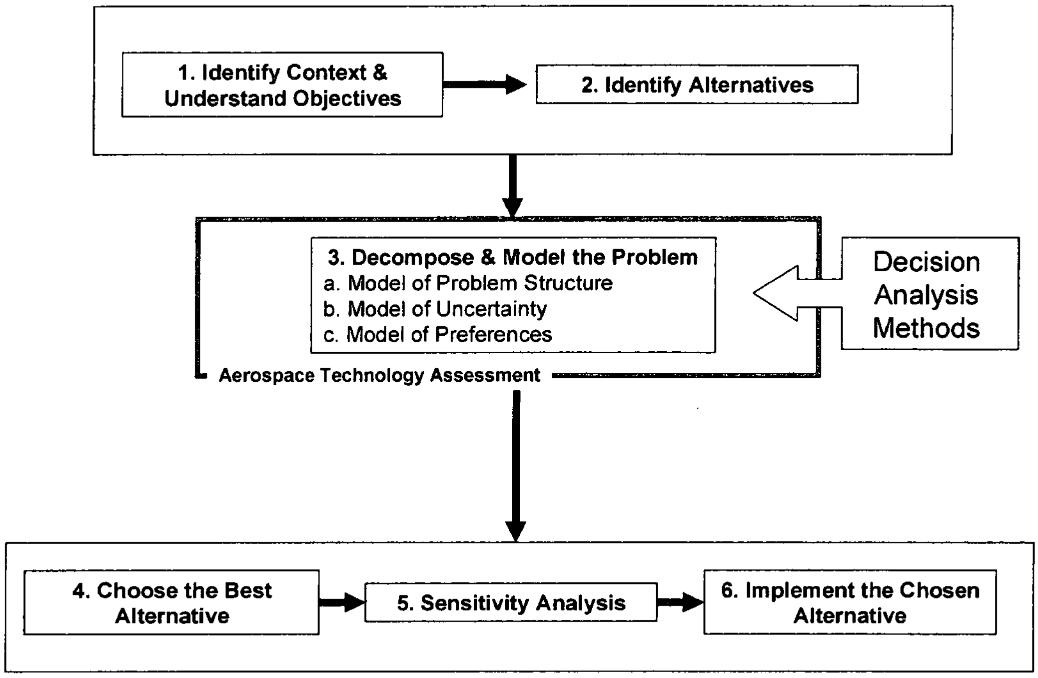

Figure 2 – Location of Aerospace Technology Assessment in Decision Analysis Process

RELEVANCE OF THIS RESEARCH

For Aerospace Engineering Managers

Several aviation related agencies within the United States are using decision analysis frameworks for technical portfolio ranking. The Joint Implementation Measurement and Data Analysis Team (JIMDAT) is composed of researchers and analysts from aerospace manufacturers, airlines, the Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration (NASA). The purpose of the JIMDAT is to provide data and information needed by decision makers on the Commercial Aviation Safety Team (CAST), which is chartered to improve aviation safety in the National Airspace System (NAS). One of the tasks of the JIMDAT is to rank a set of proposed enhancements to the NAS based on perceived impact on aviation safety (Azevedo, 2003). The enhancements are ranked by maximizing a set of subjective probabilities and weighted numbers.

Another similar activity was conducted at NASA within the Program Assessment element of the former Aviation Safety and Security Program (AvSSP). One of the goals of Program Assessment was to determine the future impact of technologies that were developed by the AvSSP on aviation safety. Criteria used to evaluate the technologies were fatal accident rate, technical development risk, implementation risk, safety cost benefits and projected impact on safety risk (Jones and Reveley, 2003). Although the overall portfolio development was not ranked using a structured decision analysis framework, influence diagrams were used to calculate the project impact on safety risk

(Luxhoj, 2003) and behavioral decision analysis consultants were required for knowledge elicitation. A final related example of technology portfolio development is the Future Aviation Safety Team (FAST) and their use of the Analytical Hierarchy Process to determine future aviation safety risks (Smith, 2001).

In all three of these examples, a large amount of time and money were allocated and spent on the technology portfolio development process. All of these efforts required travel funds to assemble teams of subject matter experts for subjective technology assessments and forecasts. Additional funds were spent on decision analysis software and training. These resources were committed based on the assumption that the use of decision analysis methods would improve the ability to develop technology portfolios. The results of this study will provide guidance to engineering managers and analysts who are contemplating the future use of decision analysis for aerospace technology assessments.

For Decision Analysis Researchers

Ralph Keeney recently articulated (pp. 202-204, 2004a) his belief that the field of decision analysis should be focused on making better decision makers and specifically outlined five issues that need to be addressed in order to "effectively use decision analysis" to achieve this goal. The subset (three of the five issues) that is relevant to this investigation is as follows:

(1) "**Develop concepts, tools, and procedures to help decision makers**. My experience is that many people, including well-educated people, have a very difficult time in structuring their decisions. They can get mixed up about the difference between fundamental concepts such as alternatives and objectives."

(2) *"**Use real decisions, not just laboratory problems in decision research**. We have learned a great deal from all the laboratory settings where decision experiments have been conducted. There have also been some research studies of real decision problems. I feel there is much more to be gained by having more of this type of research."*

(3) ***"Teach people what they can and will learn and use.*** *As stated earlier, hundreds and thousands of people have had at least a course that included a substantial part on decision analysis and very few have probably ever conducted a formal decision analysis. Once we find out what people can and will learn and use, that should constitute the basis for much of our teaching of decision analysis."*

The results of this study will provide decision analysis researchers with additional knowledge about (1) which decision analysis methods are most helpful to decision makers, (2) how decision analysis methods are used in real decision problems and (3) why and when people use decision analysis in the real world.

RESEARCH QUESTION

The research question this study will address is:

What are the contextual variables that impact the effectiveness of decision trees, influence diagrams, criteria aggregation methods and explicit tradeoff approaches on aerospace technology assessment?

RESEARCH SUB-QUESTIONS

The following research sub-questions will be explored in order to answer the research questions:

(a) What is aerospace technology assessment, and does it differ from technology assessment in other R&D disciplines?

(b) What are graphical modeling tools for decision analysis?

(c) What are criteria aggregation methods for decision analysis?

(d) What are explicit tradeoff approaches for decision analysis?

(e) Which decision analysis methods are most effective for aerospace technology assessment and under what conditions?

RESEARCH MODEL

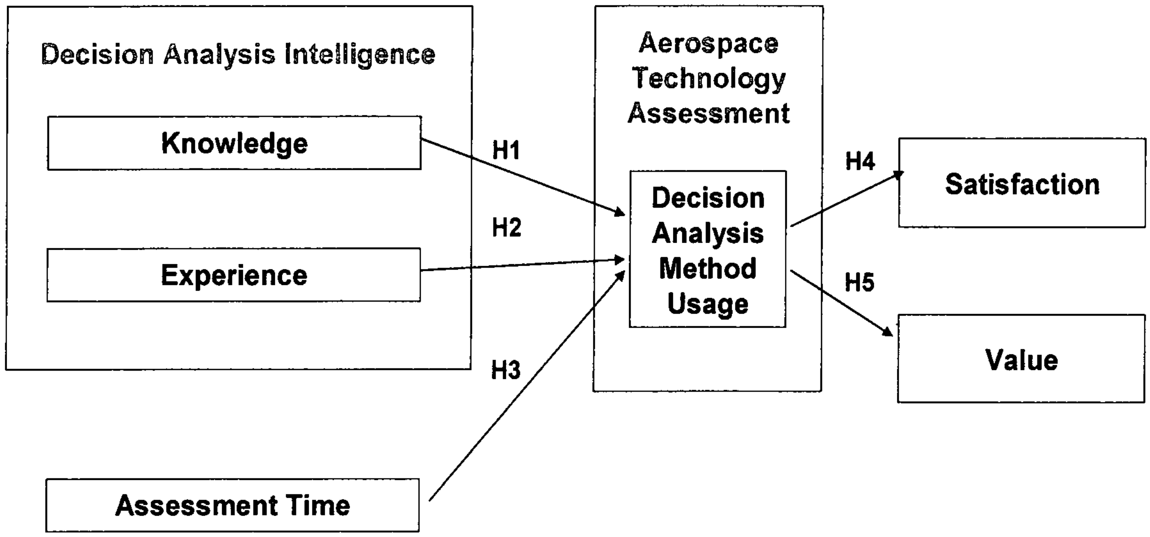

Figure 3 – Research Model

RESEARCH OBJECTIVES

This investigation focuses on the advancement of the state of the body of knowledge on the effectiveness of decision analysis methods in aerospace technology assessment through the empirical test of the following hypotheses:

H1: The greater the amount of training an analyst or manager (decision maker) possesses in a type of decision analysis method, the more often that type of decision analysis method is used in aerospace technology assessment.

H2: The greater the amount of real world experience an analyst or manager (decision maker) possesses in a type of decision analysis method, the more often that type of decision analysis method is used in aerospace technology assessment.

H3: The shorter the assessment time, the less often any type of decision analysis method is used in aerospace technology assessment.

H4: The greater the amount of usage of any type of decision analysis method in aerospace technology assessment, the higher the satisfaction with the aerospace technology assessment process.

H5: The greater the amount of usage of any type of decision analysis method in aerospace technology assessment, the higher the perceived value with the aerospace technology assessment process.

Belton and Hodgkin (1999) examined the possibility of designing an "intelligent" decision support system that could be useful to three categories of people: facilitators, decision makers and the do-it-yourself users. Their research was not specific to technology assessment, but many commercial-off-the-shelf (COTS) decision support systems are used in technology assessment. Belton and Hodgkin questioned whether it is possible or even necessary to design decision support systems that can be used by persons of all types of decision analysis knowledge and experience. However, they also acknowledged that if decision support systems are designed such that more decision makers (i.e., managers) are able to effectively use decision support software, it will enhance the expansion of the field of decision analysis.

Instead of attempting to design intelligence into decision analysis software as in the Belton and Hodgkin paper, hypotheses #1 and #2 were proposed to examine the relationship between user intelligence (i.e., knowledge + experience) and actual decision analysis usage. The most closely related discussion of these relationships in the literature was articulated by Larichev and Brown (2000). They discussed how the decision maker's decision analysis education impacts their acceptance of numerical decision analysis (NDA) approaches. They also noted that the method for decision analysis was based on culture. For example, consultants from the United States used Analytic Hierarchy Process (AHP) and Multi-Attribute Utility Analysis (MUA) decision analysis methods, whereas consultants from France used ELECTRE and those from Russia used verbal decision analysis (VDA).

Hypothesis #3 examines the impact of total allocated technology assessment time on real world decision analysis usage. Humphrey et al., (2004) conducted a study in which they examined the impact of project completion time on economic and completion goals. Project completion time is somewhat related to allocated assessment time in that at the beginning of a program or project, analysts may be more likely to use decision analysis methods in the technology assessment process than towards the end of a program when resources and time do not allow model development time.

The study conducted by Vlahos and Ferratt (1995) investigated manager "satisfaction" with use of computer based information systems (e.g., spreadsheets, word processing software, etc.) to support decision making. Jessup and Tansik (1991) asked participants to rate their satisfaction with group decision support systems using a Likert scale. Hypothesis #4 is focused on four specific types of decision analysis methods (i.e., decision trees, influence diagrams, criteria aggregation methods and explicit tradeoff approaches) and their application to aerospace technology assessment.

Vlahos and Ferratt (1995) also queried participants about the value of computer based information systems. In other relevant literature in which the value of using a decision analysis method was examined (Clemen and Kwit, 2001; Keisler 2004; Rzasa et al., 1990), value was often expressed in terms of the expected net present value (ENPV) of using decision analysis methods. Hypothesis #5 employs a different definition of the term value and is defined as the likelihood of using the decision analysis method again for future aerospace technology assessments. For example, if the decision maker or analyst believes that the decision analysis method was useful for aerospace technology assessment, that person is more likely to use the same type of method again in the future.

	Technology Assessment		Aerospace Environment		Technology Assessment in Aerospace	
Authors *Journal Name*	**In general**	**In programs and/or project portfolios**	**In general**	**In programs and/or project portfolios**	**In general**	**In programs and/or project portfolios**
H1: Knowledge and Decision Analysis Usage						
Belton and Hodgkin (1999) *European Journal of Op. Research*	X					
Larichev and Brown (2000) *Journal of MCDA*	X					
H2: Experience and Decision Analysis Usage						
Belton and Hodgkin (1999) *European Journal of Op. Research*	X					
Larichev and Brown (2000) *Journal of MCDA*	X					
H3: Time and Decision Analysis Usage						
Humphrey et al.(2004) *Organization Behavior & Human Decision Processes*		X				
H4: Decision Analysis Usage and Satisfaction						
Jessup and Tansik (1991) *Decision Sciences*	X					
Vlahos and Ferratt (1995) *Info. & Mgmt.*	X					
H5:Decision Analysis Usage and Value						
Clemen and Kwit (2001) *Interfaces*		X				
Keisler (2004) *Decision Analysis*		X				
Rzasa et al. (1990) *Research Tech. Mgmt.*		X				
Vlahos and Ferratt (1995) *Info. & Mgmt.*	X					

Table 1 – Literature Gap for Hypotheses

Relationship of Hypotheses to Practice

Technology assessments and the implementation of decision analysis methods in any environment require time, personnel and funding investments. Aerospace technology assessments are unique because they involve research and development of technologies with long development times that are greatly related to policy and are primarily funded by the government. None of the five proposed hypotheses have been examined specifically in an aerospace environment. The results of this study will provide guidance to engineering managers and analysts who are contemplating the use of decision analysis for aerospace technology assessments.

Relationship of Hypotheses to Research

As previously stated, Ralph Keeney recently articulated (pp. 202-204, 2004) his belief that the field of decision analysis should be focused on making better decision makers and specifically outlined five issues (pp. 202-204, 2004) that need to be addressed in order to "effectively use decision analysis" to achieve this goal. The results of this proposed research will provide decision analysis researchers with additional knowledge about (1) which decision analysis methods are most helpful to decision makers, (2) how decision analysis methods are used in real decision problems and (3) why and when people use decision analysis in the real world.

HIGH-LEVEL RESEARCH METHODOLOGY DESCRIPTION

Additional literature searches will be conducted to answer research sub-questions (a) – (d) and a quantitative research study based on a correlational research methodology will be used to answer the research question. The population for this study will be government and industry aerospace researchers and managers who have aerospace experience in research and/or with the development of technology portfolios and the completion of their assessments. A draft survey instrument will be developed and a pilot study will be conducted with a small subset of this population in order to refine the survey instrument. Quantitative data will be collected from the entire study population via web-based surveys. After the acquisition of the data, direct correlation and analysis of variance (ANOVA) statistical methods will be used to test the hypotheses.

2. LITERATURE REVIEW

DECISION ANALYSIS KNOWLEDGE, EXPERIENCE & ASSESSMENT TIME

Three independent variables will be investigated in the proposed research: (1) decision analysis knowledge, (2) decision analysis experience, and (3) assessment time. For the purposes of the proposed research, decision analysis knowledge is defined as any training (e.g., college courses, computer based training, employer short courses) that a study participant has received in specific decision analysis methods. The specific decision analysis methods to be examined are (a) decision trees (b) influence diagrams (c) "criteria aggregation methods" (e.g., Analytic Hierarchy Process, Weighted Sum Model) and (d) "explicit tradeoff approaches" (e.g., MAUT, SMART, SMARTER) (Belton and Stewart, 2002; Clemen, 1996). Literature searches conducted to this point have not located any peer reviewed documents that address decision analysis knowledge in technology assessment, aerospace or aerospace technology assessment.

The second proposed independent variable, decision analysis experience, will measure the level of a participant's prior usage of decision analysis methods in the real world. During the past 20 years, many students in engineering and management curriculums have been taught at least one of the four types of decision analysis methods to be addressed in this research. However, some students complain that these methods are never really used in the real world. Loostma (1999) surveyed attendees at two multi-criteria decision analysis

(MCDA) conferences and workshops to determine their actual usage of MCDA. Lootsma's questionnaire did not limit respondents to any particular type of MCDA and was not specific to technology assessment.

Dillon et al., (2003), developed the Advanced Programmatic Risk Analysis and Management Model (APRAM) to help NASA project managers allocate resources during NASA's former "faster, better, cheaper" project environment. The third independent variable, assessment time, defined as the total time allocated for technology assessment, is also related to projects in a limited resources environment. The reason for examining this variable is to determine if decision makers and analysts, with limited time allocated for aerospace technology assessment, will use decision analysis methods in the assessment process.

	Technology Assessment		**Aerospace Organizations**		**Technology Assessment in Aerospace**	
Authors *Journal Name*	**In general**	**In programs and/or project portfolios**	**In general**	**In programs and/or project portfolios**	**In general**	**In programs and/or project portfolios**
IV1: Decision Analysis Knowledge						
NO RELEVANT LITERATURE ENCOUNTERED THUS FAR						
IV2: Decision Analysis Experience						
Lootsma (1999) *Journal of MCDA*	X					
IV3: Assessment Time						
Dillon et al. (2003) *Op. Research*				X		

Table 2 – Literature Gap for Independent Variables

DECISION ANALYSIS USAGE, SATISFACTION AND VALUE

Three dependent variables will be investigated in the proposed research: (1) decision analysis usage, (2) satisfaction, and (3) value. Literature relevant to dependent variable #1 was limited to real world usage of one of the four specific types of decision analysis methods to be investigated in this research: (a) decision trees (b) influence diagrams (c) "criteria aggregation methods" (e.g., Analytic Hierarchy Process, Weighted Sum Model) and (d) "explicit tradeoff approaches" (e.g., MAUT, SMART, SMARTER) (Belton and Stewart, 2002; Clemen, 1996).

Peer-reviewed literature that has been accumulated up to this point in the research includes the usage of decision trees for pharmaceutical portfolios (Sharpe and Keelin, 1998) and forecasting (Ulvila, 1985), AHP and other criteria aggregation methods (Rajasekera, 1990; Belton and Goodwin, 1996; Meade and Presley, 2002) and multi-attribute utility theory (MAUT) related methods (Bots and Hulshof, 2000). There were also several examples of decision analysis applications at NASA such as decision trees for the Europa mission (Manvi et al., 2003) and AHP for selecting safety improvement strategies (Frank, 1995) and Mars mission architectures (Tavana, 2004). One decision application area presented among many highlighted by Walker (2000) was analysis of a set of transportation infrastructure, including airport, options.

The second proposed dependent variable measures a participant's satisfaction with use of decision analysis for aerospace technology assessment.

Literature searches conducted to this point have not uncovered any peer reviewed documents that address satisfaction in technology assessment, aerospace or aerospace technology assessment.

The third dependent variable, value, is defined as the likelihood of using a particular type of decision analysis method again in the future for aerospace technology assessment. In other words, if the decision maker or analyst believes that a specific decision analysis method was useful for aerospace technology assessment, that person is more likely to use the same type of method again in the future. Howard (1988) discusses a similar concept, the ability to assess the quality of a decision, and presents a form in his paper that outlines the elements of decision quality.

	Technology Assessment		Aerospace Organizations		Technology Assessment in Aerospace	
Authors *Journal Name*	**In general**	**In programs and/or project portfolios**	**In general**	**In programs and/or project portfolios**	**In general**	**In programs and/or project portfolios**
DV1: Decision Analysis Usage						
Belton and Goodwin (1996) *Int'l Journal of Forecasting*	X					
Bots and Hulshof (2000) *Journal of MCDA*		X				
Frank (1995) *Reliability Eng. and System Safety*			X			
Manvi et al. (2003) *Journal of Aerospace Eng.*						X
Meade and Presley (2002) *IEEE Trans. on Eng. Mgmt.*		X				
Rajasekera (1990) *IEEE Trans. on Eng. Mgmt.*		X				
Sharpe and Keelin (1998) *Harvard Business Review*		X				
Tavana (2003) *Computers and Op. Res.*				X		
Ulvila (1985) *J. of Forecasting*	X					
Walker (2000) *Journal of MCDA*					X	
DV2: Satisfaction						
NO RELEVANT LITERATURE ENCOUNTERED THUS FAR						
DV3: Value						
Howard (1988) *Management Science*	X					

Table 3 – Literature Gap for Dependent Variables

AEROSPACE TECHNOLOGY ASSESSMENT

Technology Assessment, Forecasting and Foresight

There are at least three different processes for examining the impact of a set of technologies: technology assessment, technology forecasting and technology foresight. Mohr (1999) defines technology assessment as a process for measuring the impact of established or new technologies. Technology forecasting looks at the impact of technologies "at some time in the future" (Porter et al., 2004) but differs from the process of "technology foresight" in which the objective is to "examine the use of future technology to produce the greatest societal benefit" (Salo, 2003).

Terminology in Technology Assessment

Within the technology assessment (TA) discipline, researchers have identified several different types or forms of technology assessment that have evolved (Palm and Hansson, 2006; Van Den Ende et al., 1998). Another method for categorizing technology assessments is based on their institutional context (Berloznik and Langenhove, pp. 25-26, 1998). These categories are outlined below and will be used to categorize some examples of aerospace technology assessment later in this document.

Types of Technology Assessment

- *Awareness (or Traditional) TA* – "Forecasting technological developments and their impacts, to warn for unintended or undesirable consequences (Van Den Ende et al., pp. 8, 1998)."
- *Participatory TA* – The same as "Traditional TA", but stakeholders (e.g., experts, politicians, lay people) participate in the technology assessment process.
- *Constructive TA (CTA)* – The same as "Participatory TA", but technology assessment process is implemented early so that it can impact the design and development of the technology. The goal is to make sure the technology design is for the greater good of society. This type of assessment originated in the Netherlands.
- *Innovative TA* – The German version of CTA.
- *Strategic TA* – The purpose of assessment is to support specific persons (e.g. U.S. President, Congress or project manager in private industry) in formulating policy or strategy.
- *Health TA* – A specialized form of technology assessment that examines the safety and effectiveness of medical technologies prior to their introduction into society.
- *Backcasting* – This process involves the formulation of future scenarios and the development of innovative technologies that are appropriate for these scenarios.

Institutional Forms of Technology Assessment

- *Academic TA* – The purpose is to advance the field of technology assessment by developing, evaluating and implementing new models and methods for performing technology assessments and examining theoretical aspects in relation to science and technology developments.
- *Industrial TA* – Technology assessment is one of many tools in the strategic planning process. This is sometimes called "entrepreneurial planning" or "applied TA".
- *Parliamentary TA* – The goal is to assist members of parliament (or legislature) with decisions related to science and technology (e.g., federal budget) and those that are impacted by developments in science and technology (e.g., CO_2 taxes). The former Office of Technology Assessment served this function in the United States from 1972 until it was abolished by Congress in 1995 (Herdman and Jensen, 1997).
- *Executive Power TA* – Technology assessment is a tool used by government decision makers to evaluate or support their policies.
- *Laboratory TA* – Technology assessment is performed by researchers in an organization and used as a tool for the design and development of technologies.

Technology Assessment Literature Search

Three search engines (Engineering Village 2, IEEE Xplore and Science Direct) were used to find peer-reviewed publications related to aerospace technology assessment. Since Engineering Village contains Compendex and IEEE Inspec publications, the results from the IEEE Xplore queries are essentially a subset of those from Engineering Village 2. The specific search terms and their corresponding results are shown in Table 4.

SEARCH TERMS	SEARCH ENGINE RESULTS (# Peer Reviewed Articles)		
	Engineering Village 2	IEEE Explore	Science Direct
"Technology Assessment"	1037	27	742
"Technology Assessment" + "Aerospace"	14	0	0
"Technology Assessment" + "Aeronautics"	2	0	1
"Technology Assessment" + "Space"	24	0	13
"Technology Assessment" + "R&D"	20	0	13
"Technology Assessment" + "Research"	299	5	136
"Technology Assessment" + "Portfolio"	6	1	1
"Technology Assessment" + "Decision"	192	4	128
"Technology Assessment" + "Decision Analysis"	11	1	12

Table 4 – Technology Assessment Literature Search Results

Aerospace Technology Assessment

Based on a review of the literature and personal experience with the actual usage of technology assessment in an aerospace environment, aerospace technology assessments are primarily "Traditional TA" (Batson and Love, 1988; Rogers et al., 1993; Shishko, Ebbeler and Fox, 2004; Wilhite, 1982). The majority of long term aerospace research and development in the United States is being conducted by government agencies (Sternberg, 1996); therefore, technology development investments in this area are often the result of decisions impacted by public policy. As a result, aerospace technology assessments frequently contain an indirect form of "Strategic TA" since the assessments are often done for government administrators who report to policymakers in the executive and legislative branches of government.

In addition, three institutional forms of technology assessment were found in aerospace environments: "Academic", "Industrial" and "Laboratory". Aerospace technology assessments connected to the development and design of new technologies were classified as "Academic" instead of "Laboratory" if the results of the assessment were not immediately used for actual technology development. A sample of aerospace technology assessments found in the literature, along with corresponding type and institutional form of TA, is located in Table 5.

Author (Year)	Journal Title	Type of TA	Institutional Form of TA
Batson and Love (1988)	Journal of Aircraft	Traditional	Academic
Rogers et al. (1993)	Journal of Aerospace Engineering	Traditional	Laboratory
Shishko, Ebbeler and Fox (2004)	Systems Engineering	Strategic	Industrial
Wilhite (1982)	Journal of Spacecraft and Rockets	Traditional	Academic

Table 5 – Examples of Aerospace Technology Assessment in Literature

Technology Assessment in Aerospace Compared to Other R&D Disciplines

There are three dimensions that are useful in comparing aerospace technology assessments to those in other R&D environments: (1) technology development time (2) relationship to policy decisions and (3) source of research funding. Research and development time for aerospace technologies is often long term (5 or more years), which is similar to the development of new medicines and medical technologies but differs from consumer products such as computers, home electronics (e.g. televisions, video cameras) and automobiles. The assessment of aerospace technologies is also similar to medical related technologies because of the impact of policy decisions that are made outside of the organization. However, aerospace technology assessment differs from medical TA because most of the funding for long term aerospace technology research is provided by the government in the United States, but private industry is the funding source for research in new medicines and medical technologies.

Table 6 summarizes the similarities and differences between technology assessments in aerospace versus other R&D disciplines.

R&D Technology Assessment Discipline	Technology Development Time *(Long or Short)*	Related to Policy Decisions *(Y or N)*	Primary Research Funding Source *(Government or Private)*
Aerospace	Long	Yes	Government
Automotive	Short	No	Private
Computers	Short	No	Private
Home Electronics	Short	No	Private
Medical	Long	Yes	Private

Table 6 – Comparison of Aerospace Technology Assessment and TA in Other R&D Disciplines

DECISION ANALYSIS METHODS

Graphical Modeling Tools for Decision Analysis

Two of the most commonly used methods for graphically structuring decisions are decision trees and influence diagrams (Clemen, 1996). Decision trees (Figure 4) typically contain three types of nodes: decision, chance and consequence. Decision nodes, which are typically depicted as squares, connect to branches of alternatives that must be selected by the decision maker, but only one of these alternatives can be selected at a time. Chance nodes, which are depicted as circles, connect to branches that correspond to a set of mutually exclusive and exhaustive outcomes. The consequence nodes, which are sometimes depicted using triangles, can be found at the right side of the decision tree on the end of each branch. Decision trees are read from left to right.

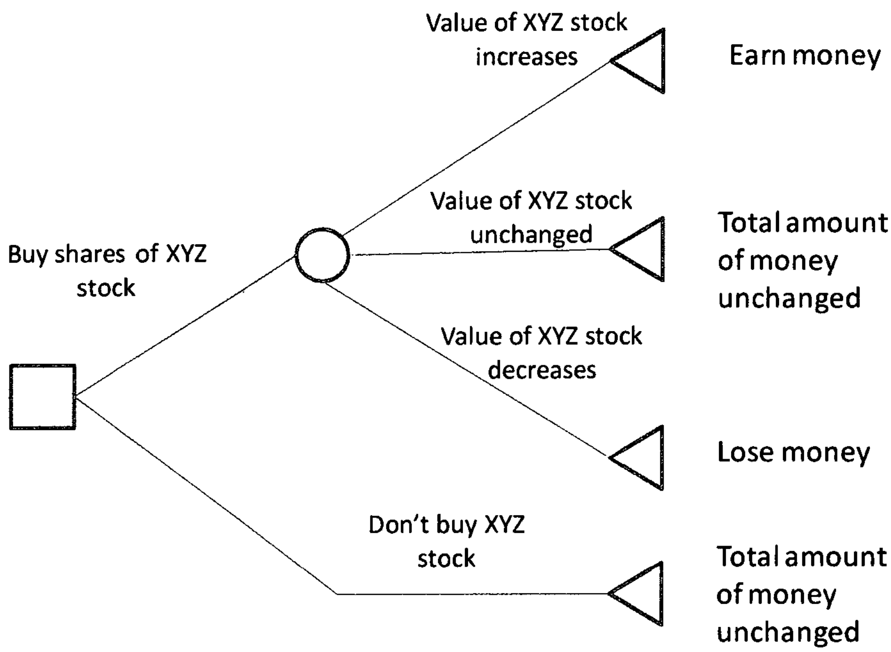

Figure 4 – Decision Tree Example

Influence diagrams are another popularly used method for graphically structuring decisions. They are similar to decision trees in that they also contain decision, chance and consequence (or constant value) nodes. However, in influence diagrams (Figure 5) decision, chance and consequence nodes are depicted using rectangles, ovals and rounded rectangles, respectively.

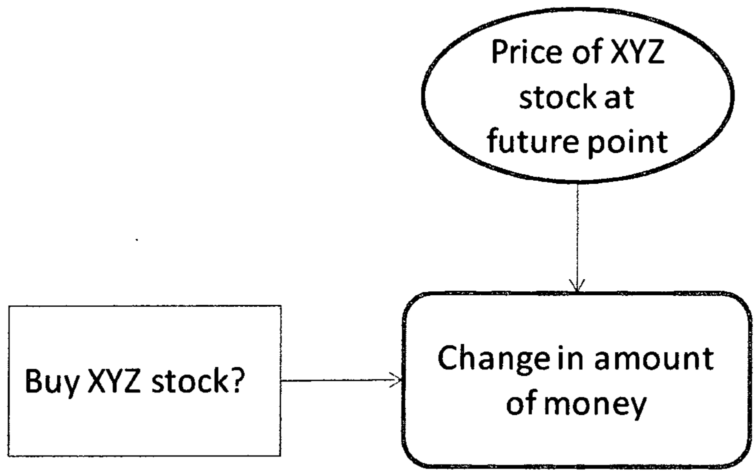

Figure 5 – Influence Diagram Example

Explicit Tradeoff Approaches for Decision Analysis Methods

Explicit tradeoff approaches are decision analysis methods based on "value functions" that attempt "to map changes of values of performance of the alternatives in terms of a given criterion, into a dimensionless value" (Triantaphyllou and Baig, 2005, p. 213). Methods in this category include Multi-Attribute Utility Theory (MAUT) and the simplified multi-attribute rating approach (SMART) (Belton and Stewart, 2002).

Criteria Aggregation Approaches for Decision Analysis Methods

In criteria aggregation methods, two sets of aggregated indices are developed and used to evaluate the alternatives in the decision problem. Methods in this category include Saaty's (1980) Analytical Hierarchy Process (AHP) and its derivatives, the weighted product model (WPM) and the weighted sum model (WSM). An algorithm for a simple WSM is as follows (Triantaphyllou, 2000):

$$A^*_{WSM\text{-}score} = \max_i \sum_{j=1}^{n} a_{ij}, w_j, \text{ for } 1=1,2,3,\ldots m$$

where,

$A^*_{WSM\text{-}score}$ = the WSM of the best alternative
n = the total number of criteria
a_{ij} = the score of the i-th alternative in terms of the j-th criterion
w_j = the weight of importance of the j-th criterion

Authors	Sequential Graphing Methods (Decision Trees, Influence Diagrams)	Criteria Aggregation Methods (AHP, weighted sum model, weighted product model)	Explicit Tradeoffs Approaches (MAUT, SMART, SMARTER)	Technology/Portfolio Assessment, Forecasting and Foresight	Aerospace	Satisfaction/ Effectiveness	Implementation Time	Real World Usage
Ammarapala (2002)		X	X		X			
Belton and Hodgkin (1999)		X	X			X		
Bots and Hulshof (2000)			X	X				X
Halal et al. (1998)				X	X			
Kasanen et al.(2000)		X	X			X		
Kirby and Mavris (2002)				X	X			
Meade and Presley (2002)		X		X				X
Larichev and Brown (2000)				X				X
Lootsma (1997)	X	X	X					
Pattanapanchai (1997)		X				X	X	
Sabuco-Muggenthaler (2000)		X	X	X		X	X	
Salo et al. (2003)		X	X	X		X		
Ward (1998)			X	X	X			X
Zanakis et al. (1998)		X	X			X		
Zopoundis and Doumpos (2002)		X	X	X				X
Jones (2009)	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

Table 7 – Analysis of the Gap in the Literature

3. METHODOLOGY

INTRODUCTION

As previously stated (Keeney, 2004a), several research studies have been conducted that evaluate decision analysis methods in laboratory settings, but there is a need for more research concerning the results of using decision analysis for real problems. The purpose of this research is to provide decision analysis researchers, decision makers and analysts insight about what factors contribute to the effective use of decision analysis for aerospace technology assessment. A non-experimental correlational research method will be used to answer the research question, where non-experimental research is defined as follows:

> *"Nonexperimental research is systematic empirical inquiry in which the scientist does not have direct control of independent variables because their manifestations have already occurred or because they have inherently not manipulable. Inferences about relations among variables are made, without direct intervention, from non concomitant variation of independent and dependent variables" (Kerlinger and Lee, 2000, pg. 558)*

The type of non-experimental method chosen for this study was correlational rather than historical or descriptive, because the objective is to examine the relationship between variables (Salkind, 2006, pg. 191). Input data will be collected via a survey method and the relationships among the dependent, and independent variables in the research model will be evaluated using structural equation modeling (SEM) techniques. SEM is appropriate for this study because of the unique characteristics that distinguish it from other multivariate data analysis techniques: (1) it uses separate relationships for each set of dependent variables and (2) it has the ability to incorporate latent variables into the analysis and account for measurement error in the estimation process (Hair et al., 1998, pp. 584-585).

POPULATION

The population for the study is current and former government and industry aerospace researchers and managers. The term "researcher" is defined as a scientist, engineer, computer scientist, operations researcher or mathematician who is or has either conducted aerospace research or analysis of aerospace research and technology. For the purposes of this study, "manager" encompasses individuals who have or currently hold the position of manager of an aerospace research and/or development project or program. According to the following excerpt, Old Dominion University's guidelines (2005, pg.6) for studies involving human subjects does not apply to this study:

> *If a degree seeking student at ODU is employed through another agency such as EVMS and no faculty member is involved from ODU then the degree seeking student that is an employee at EVMS*

or any other agency that has an IRB [Internal Review Board] should seek approval through that agency's IRB and not ODU's IRB.

At the time of this study, the degree seeking student and author of this investigation was employed by NASA Langley Research Center and believed that the organization did not have a local internal review board. Therefore, it was assumed that NASA survey research only needed to comply with the Office of Management and Budget (OMB) guidelines (United States Geological Survey, 2007). Based on the published OMB policy, if all of the surveys in this study are sent to federal agencies, bureaus, labs, etc. (e.g., NASA, FAA) or if less than 9 or fewer persons outside of these designated locations are surveyed, then OMB approval is not required in order to conduct the survey.

SAMPLE SIZE

The general rule of thumb for minimum sample size in SEM studies is 200 (Jackson, 2003). However, there are typically four factors that are used to determine sample size in SEM: model misspecification, model size, departures from normality and estimation procedure. Using the guidelines for number of model parameters and ability to account for nonnormal data, the minimum sample size for this study should be 75. However, if the most common estimation procedure is used, maximum likelihood estimation (MLE), then the minimum sample size should be 100 to 150 (Hair et al., 1998).

SURVEY PROCEDURE

Surveys were distributed using a commercially available web based survey service. The advantages of using a web-based survey over mail, face-to-face or telephone interviews (de Leeuw, 2008) are: cost, short collection time and ease of data transfer. Over a period of two weeks, a pilot study was conducted in which surveys were distributed to 10 persons. The total completion time of the web-based survey was recorded for each of the pilot study participants, and they were asked to provide feedback about the clarity of the questions. Based on results from the pilot study, changes were made to the survey length and question design to incorporate the suggestions from the pilot participants.

SURVEY QUESTION DEVELOPMENT PROCESS

The survey questions were developed using a combination of: (1) prior survey based research studies in which similar variables were measured, especially those related to decision analysis and/or technology assessment and (2) question design research literature.

Questions in Prior Survey Based Studies

Some of the variables can be measured using techniques found in similar research studies. Recall that in this study decision analysis knowledge is defined as any training (e.g., college courses, computer based training, employer short courses) that a study participant has received in specific decision analysis methods. In a survey based study of individual characteristics and personality versus computer anxiety (Korukonda, 2007) participants' math skills were verified by adding up the number of correct responses to eight simple mathematical problems. Using this form of measurement, the survey instrument will also contain short math problems corresponding to each specific decision analysis method. As a result, decision analysis knowledge will be measured using a combination of questions related to training and diagnostic math test results.

In another research study, Cabral-Cardoso and Payne (1996) surveyed R&D managers to determine their usage and attitudes towards formal selection techniques for R&D project selection. Their definitions of usage and attitudes are analogous to those for satisfaction and value, respectively, in this study. Therefore, this research will use questions from Cabral-Cardoso and Payne (1996) to collect data with respect to these variables.

Question Design Research Literature

For the remaining variables to be measured in the study and also to validate the survey techniques used, techniques from recent question design research will be used. For instance, Foweler and Cosenza (2008) developed a framework for writing effective survey questions that is based on question design research by Tourangeau et al. (Jabine et al., 1984; Tourangeau et al., 2000). Using the framework, in order to answer a survey question a respondent must:

(a) Understand the question

(b) Have or retrieve information needed to answer the question

(c) Translate relevant information into the form required to answer the question

(d) Provide the answer by writing it on a form, entering it into a computer or telling an interviewer.

To ensure that the questions developed for this study meet the above guidelines, cognitive pretesting methods will be used in the pilot study. In cognitive pretesting, pilot study participants will be asked to verbally state their thought processes as they complete the survey (Krosnick, pg. 542).

Relationship of Survey Questions to Study Variables

Figure 6 contains the data collection model, which maps the survey question numbers to the study variables. The operational definitions for the study variables along with the corresponding survey question numbers are shown in Table 7, and the complete list of survey questions is located in Appendix A. As previously stated, a diagnostic decision analysis math test was going to be added to the survey instrument but was not because the addition of this test would have significantly increased the total survey completion time.

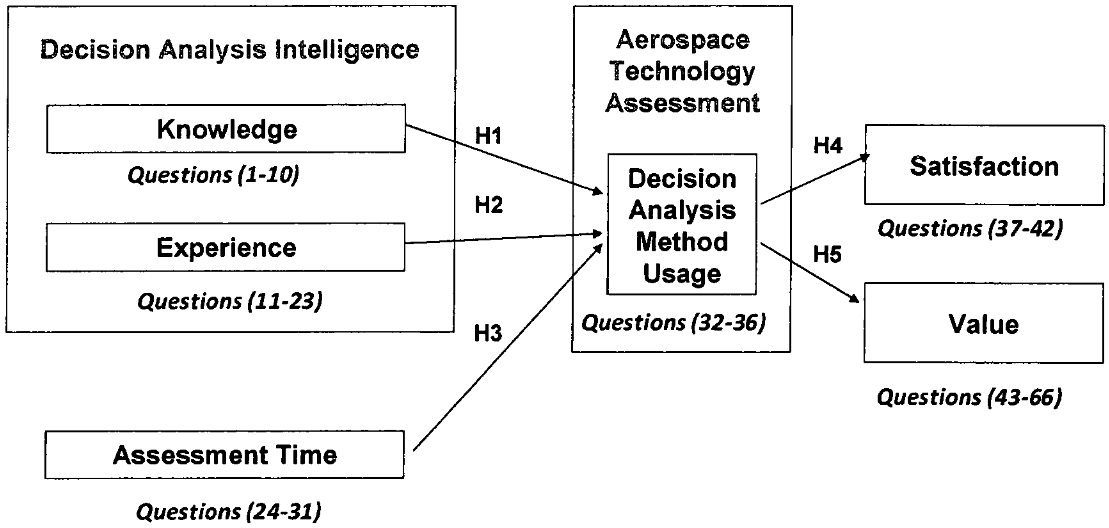

Figure 6 – Data Collection Model

Variable	Operational Definition	Survey Question Numbers
Knowledge	Any training (e.g., college courses, computer based training, employer short courses) that a study participant has received in specific decision analysis methods	1-10
Experience	The level of a participant's prior usage of decision analysis methods in the real world	11-23
Assessment Time	The total time allocated for technology assessment	24-31
Decision Analysis Usage	Real world usage of decision analysis methods for aerospace technology assessment	32-36
Satisfaction	The participant's satisfaction with using decision analysis for aerospace technology assessment	37-42
Value	The likelihood of using a particular type of decision analysis method again in the future for aerospace technology assessment	43-66

Table 8 – Operational Definitions and Corresponding Survey Questions

Research Validity

Ahrire and Davaraj (2001), examined three different approaches for validating measurement instruments in engineering management research. They concluded that a “Hybrid Approach”, should be used for survey-based engineering management research. Table 8 summarizes the approaches that will be used in this study to test validity.

Validity Index	Description	Method/Test
Development of the Measurement Instrument		
Content Validity	"The representativeness or sampling adequacy of a measuring instrument" (Kerlinger and Lee, 2000)	▪ Cabral-Cardoso and Payne (1996) ▪ Question design research literature
Face Validity	The extent to which the measurement instrument appears to measure what it is supposed to measure (Kerlinger and Lee, 2000)	▪ Pilot study using cognitive pretesting methods
Empirical Implementation and Validation of Instrument (Ahire and Davaraj's Hybrid Approach)		
Unidimensionality	"The extent to which observed indicators are strongly associated with each other and represent a single concept"	▪ Principal Components Factor Analysis followed by Confirmatory Factor Analysis
Reliability	"The degree of consistency or stability of a scale"	▪ Cronbach's alpha ▪ Werts-Linn-Jöreskog coefficient
Convergent Validity	"The extent to which varying approaches to construct measurement yield the same results"	▪ Bentler-Bonnett Coefficient
Discriminate Validity	"The extent to which a concept and its indicators differ from another concept and its indictors"	▪ Cronbach's Alpha versus Average Interscale Correlation ▪ Maximum Interscale Correlation Magnitude ▪ Average Item-to-total Correlations of Scale Items versus Non-Scale Items ▪ Percent Variance Extracted versus Maximum Interscale Correlation
Post-Implementation Validation		
Nomological Validity	The extent to which the proposed relationship between the constructs is true (Ahire and Davaraj, 2001)	▪ Structural Equation Modeling

Table 9 – Summary of Research Validation Indices

Data Collection and Analysis Plan

Figure 7 summarizes the steps in the data collection and analysis plan for this research study.

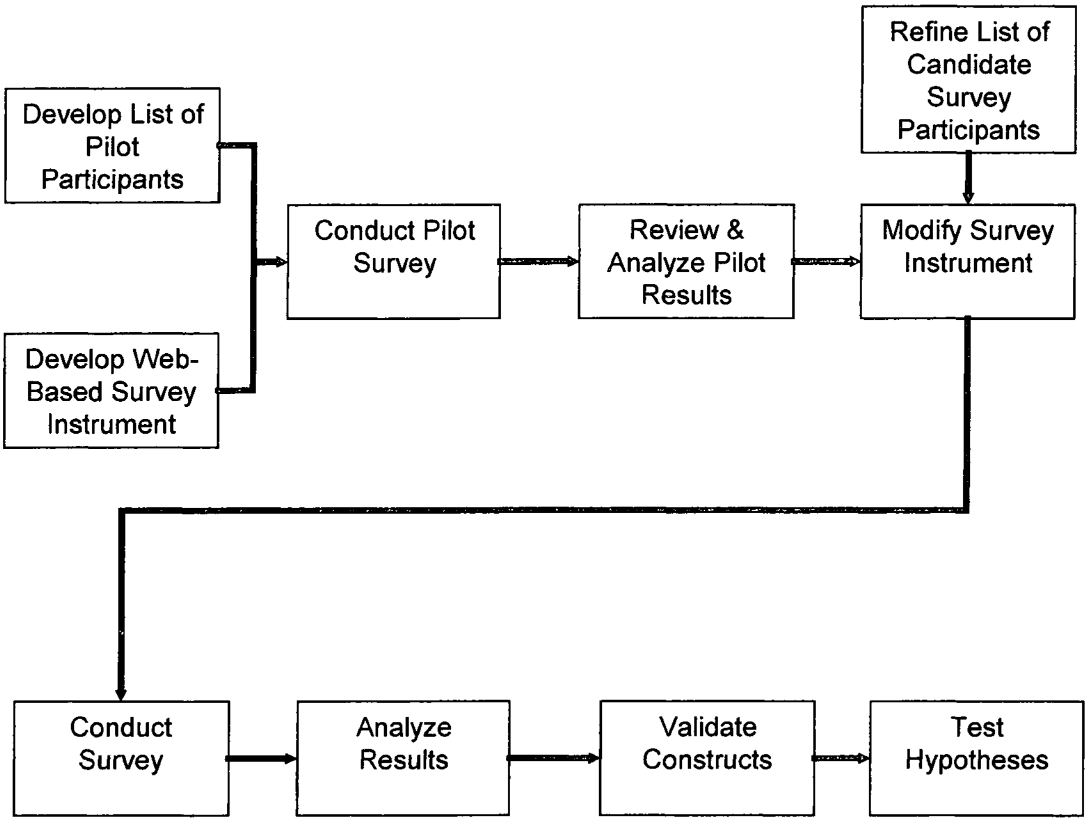

Figure 7 – Data Collection and Analysis Plan

4. RESULTS

WEB-BASED INSTRUMENT

Several web-based services were investigated as possible vehicles for development and distribution of the survey instrument. Several commercially available services were examined including “Survey Monkey”, “Zoomerang”, “Survey Gizmo” and “Instant Survey”. Zoomerang was selected due to the set of available survey question types, survey distribution options, visual appeal of the survey templates, customer service and ease of results analysis.

Questions were developed based on approaches that spanned the spectrum from short surveys at professional meetings to extensive validated research in decision analysis literature (Belton & Hodgkin, 1999; Bots and Lootsma, 2000; Cabral-Cardoso, 1993; Dillon et al., 2003; Humphrey et al., 2004; Jessup & Tansik, 1991; Lootsma, 1999; Vlahos and Ferratt, 1995). Most of the questions in the SATISFACTION and VALUE sections of the instrument were either taken directly or were modifications of questions from the survey instrument used by Cabral-Cardoso (1993).

According to OMB guidelines, if the total number of non-government survey participants was nine or less, formal approval was not required prior to distribution of the survey. It was believed that this constraint on the potential survey participants would not be a true reflection of the population. Therefore, requests for formal approval were submitted to the Old Dominion University Institutional Research Board (IRB) and the Langley Research Center IRB.

To increase the likelihood of obtaining approval for distribution of the survey, the questionnaire was designed such that the identities of participants remained anonymous. The link to the survey could only be used once on a particular computer, thereby almost eliminating the chance of a participant completing the survey multiple times. The additional advantage of this survey option is that the link could be forwarded to other potential participants.

PILOT SURVEY

A subset of the population participated in a pilot survey conducted using think aloud cognitive interviewing techniques (Hak et al., 2008; Jobe and Mingay, 1989; Rothgeb et al., 2001; Willis, 2005). Ten persons were asked to complete the online questionnaire shown in Appendix A. In addition to the instructions on the introduction page to the questionnaire, it was reiterated to each of these individuals that they could decline to participate in the survey at any point in the process without any risk of future adverse retaliation. Participants were instructed to provide all thoughts and comments, both favorable and unfavorable, about any of the questions as they completed the online survey. This information was manually recorded, and the names of participants in the pilot survey remained anonymous in the final documentation of the results.

SURVEY INSTRUMENT MODIFICATION

Changes were made to the questions in the survey instrument based on feedback obtained through the pilot survey process, reliability analysis of the pilot survey data and additional comments from the ODU IRB, recent doctoral students and the dissertation advisor. The final survey can be found in Appendix B.

SURVEY APPROVAL AND DATA COLLECTION

To ensure that the data collection process did not violate NASA and/or ODU guidelines, the survey was submitted for approval to both the NASA Langley and ODU Institutional Review Boards. The letters of approval obtained from these organizations are shown in Appendix C.

An e-mail invitation to participate in the survey was distributed to 260 persons. Due to the anonymous design of the survey, a follow-up e-mail reminder was sent to the entire distribution list approximately one month after the initial invitation.

Demographic Data

The survey received 154 visits, with 16 partial survey responses and 99 complete survey responses. Out of the 99 completed surveys, 76% of the respondents were male and 24% were female, which corresponds to the expected gender of the population as communicated to the ODU IRB. Additional demographics of the survey respondents are shown in Figures 8-11.

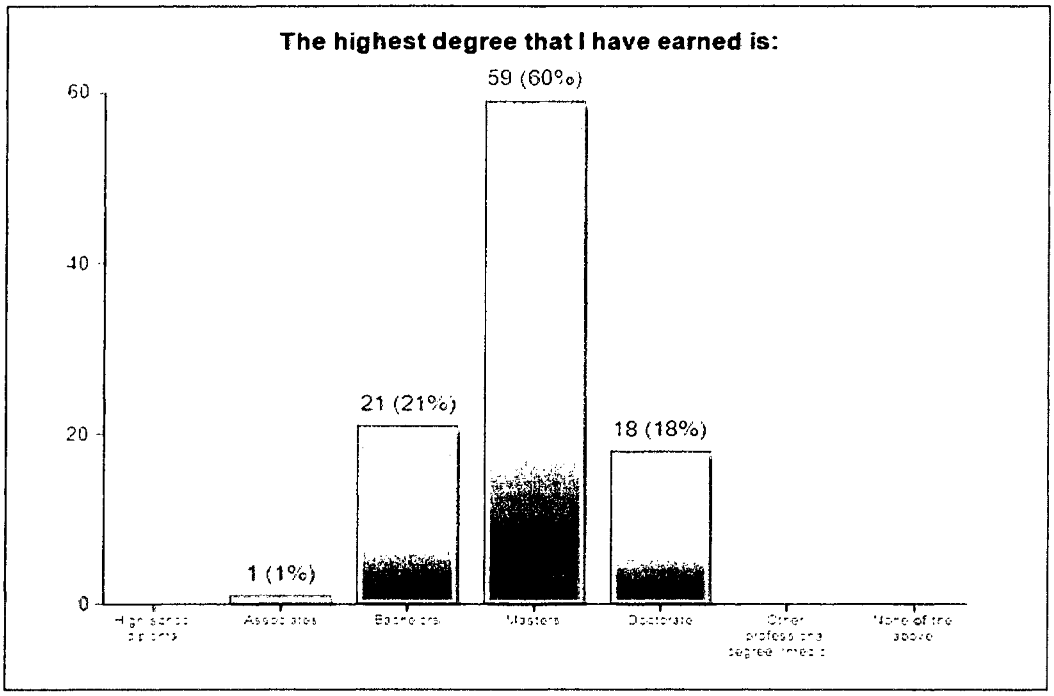

Figure 8 – Education Level of Survey Respondents

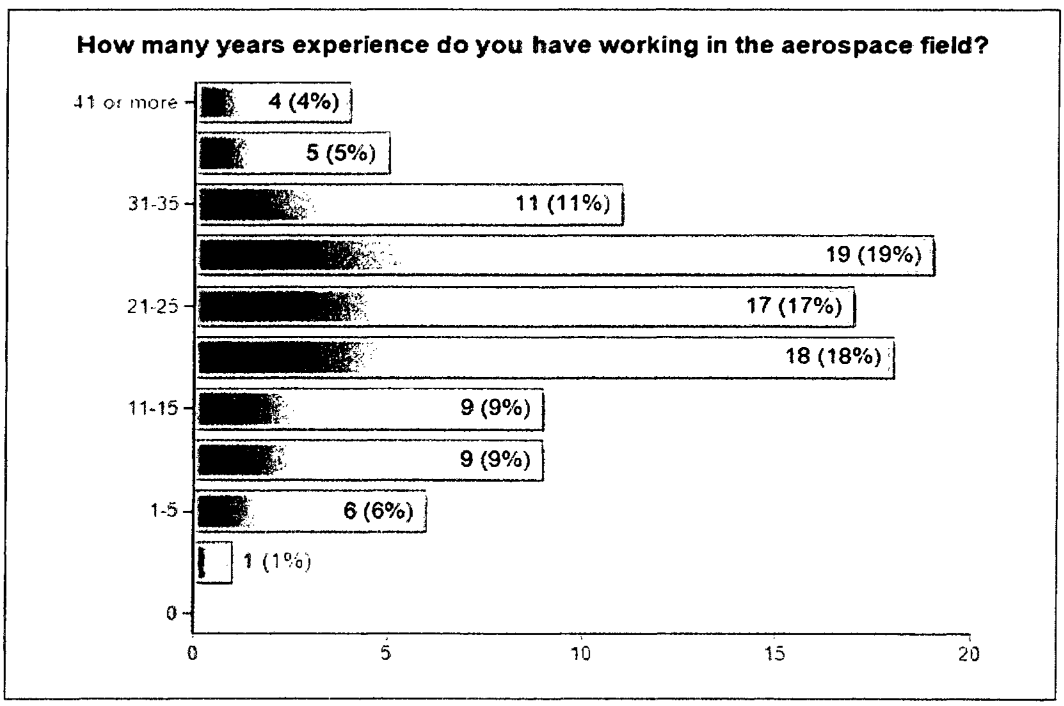

Figure 9 – Aerospace Work Experience of Survey Respondents

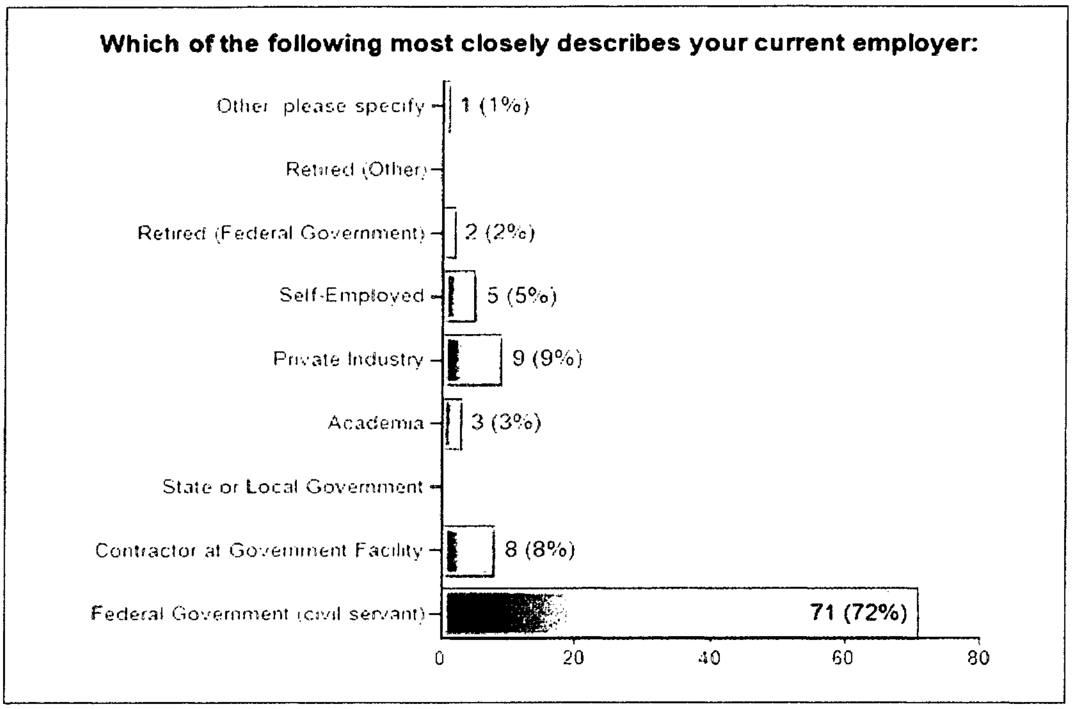

Figure 10 – Employer Type of Survey Respondents

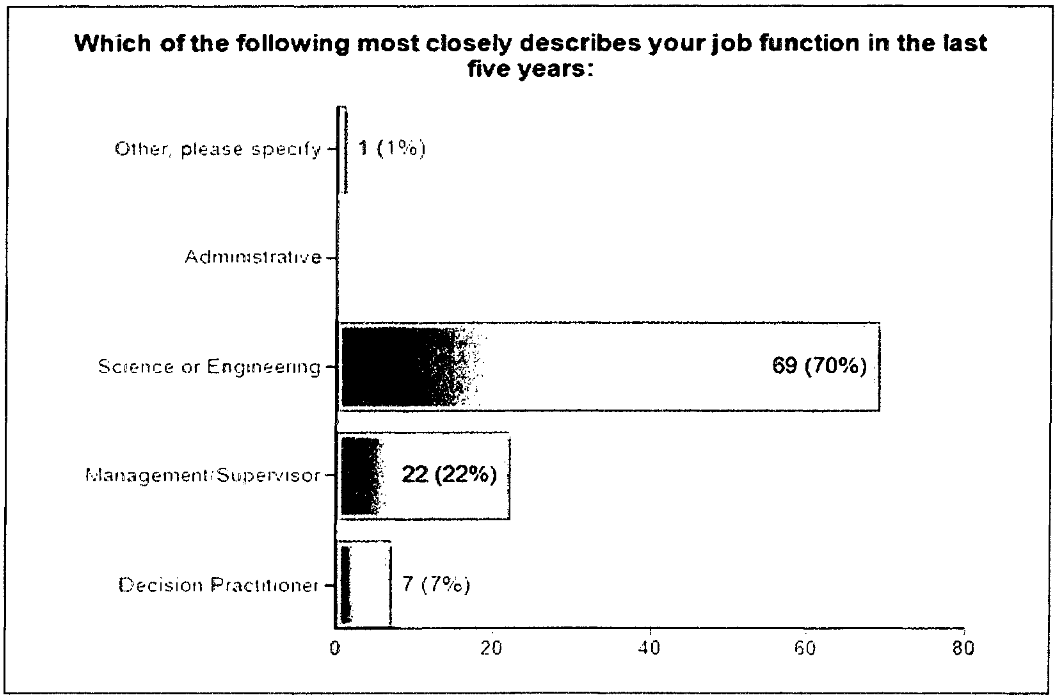

Figure 11 – Job Function of Survey Respondents

DATA ANALYSIS AND CONSTRUCT VALIDATION

The methodology for the validation of the constructs is primarily based on the hybrid approach described by Ahire and Davaraj (2001). This study was implemented using SPSS/Amos and verification of the SEM results through the use of models in the SAS software suite. Additional validation indices and guidelines for the use of these software packages were also incorporated into this study (Blunch, 2008; Byrne 2001; Garson, 2009; Hair et al., 1998; Hatcher, 1994; Kline, 2005).

Unidimensionality

According to Ahire and Davaraj, unidimensionality is assessed by the implementation of a principal component analysis (PCA) of the data followed by a confirmatory factor analysis (CFA).

A principal component analysis with varimax rotation was performed at the construct level. The anti-image correlation coefficient (measure of sampling adequacy or MSA) for each variable was examined, along with the overall Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. A large correlation between the variables was defined as a KMO greater than 0.6 (Garson, 2009). Common variance was defined as any variable in the anti-image correlation matrix with an MSA of 0.5 or greater (Hair et al., 1998). Any variable that did not meet these criteria was removed, and the entire process was repeated until both the KMO and MSA minimums were met.

Components within each construct were extracted using eigenvalues over 1.0. A cut off of 0.55 was interpreted as a very good loading (Rhiel, 2004). Variables that contributed to the inability of the failure to converge in 25 or less iterations and also those that did not load at least at the 0.55 level were removed from the dataset.

A confirmatory factor analysis using SEM techniques was implemented with Amos software. Strong unidimensionality was defined as a goodness of fit index (GFI) of 0.90 or greater (Ahire and Devaraj, 2001).

Reliability

Reliability was assessed using Cronbach's alpha, which was one of the indices in the hybrid approach proposed by Ahire and Devaraj (2001) for validation of constructs in engineering management research. The requirements for reliability were met when the Cronbach's alpha was 0.60 (Ahire and Devaraj, 2001). The Werts-Linn-Jöreskog (WLJ) coefficient was not calculated due to the inability to locate any other SEM based studies that also used this test for reliability.

Convergent Validity

The Bentler-Bonett coefficient was recommended by Ahire and Devaraj (2001) for assessment of convergent validity. The Bentler-Bonett coefficient, which is also known as the normed fit index (NFI), is indicative of a strong convergent validity for values of 0.90 and higher, but minimum values of 0.8 are acceptable (Ahire and Devaraj, 2001). However, the NFI “has the disadvantage of sometimes underestimating goodness of fit in small samples (Hatcher, 1994). For this reason, several researchers suggest the use of the Comparative Fit Index (CFI) for model evaluation because it takes into account the degrees of freedom (Blunch, 2008). Given that the sample size for this model is small relative to the suggested SEM sample size of N=200, the CFI will be used to evaluate the CFA model. A CFI value larger than 0.9 is an indication of a good model fit (Hatcher, 1994).

Discriminate Validity

Two of the indices recommended by Ahire and Devaraj for discriminate validity were used: (1) the average interscale correlation test and (2) maximum interscale correlation (MAXISC). Discriminate validity is established if the Cronbach’s α is "adequately larger” than the average interscale correlation (α - AVISC). In addition to the indices recommended in the work by Ahire and Devaraj, the confidence interval test was also used to evaluate discriminate validity in this study. Discriminate validity is demonstrated if the confidence interval does not include 1.0 (Hatcher, 1994).

Summary of Construct Validity Results

The results of the construct validity assessments are shown in Tables 10-11.

VALIDITY INDEX	CONSTRUCT	Knowledge	Experience		Time	Usage		Satisfaction	Value
	Component		*Years*	*Type*		*Projects*	*Length*		
Unidimensionality									
KMO		0.739	0.724		0.567	0.613		0.754	0.772
GFI		0.960	0.908		--	0.907		0.984	0.837
Reliability									
α		0.810	0.796	0.792	0.158	0.763	0.737	0.717	0.722
Convergent Validity									
CFI		0.975	0.926		--	0.936		1.000	0.907
Discriminate Validity									
AVISC		0.403	0.503	0.490	--	0.480	0.412	0.342	0.110
α -AVISC		0.407	0.293	0.302	--	0.283	0.325	0.375	0.612
MAXISC		0.785	0.672	0.582	--	0.710	0.605	0.617	0.766

Table 10 – Summary of Construct Validation Measures

Parameter			Estimate	Lower	Upper	P
USAGE	<-->	VALUE	.496	.321	.630	.018
VALUE	<-->	SATISFACTION	-.216	-.328	-.058	.033
USAGE	<-->	EXPERIENCE	.794	.630	.915	.032
EXPERIENCE	<-->	KNOWLEDGE	.591	.380	.762	.015
VALUE	<-->	KNOWLEDGE	.389	.263	.503	.013
USAGE	<-->	KNOWLEDGE	.575	.408	.700	.011
EXPERIENCE	<-->	VALUE	.423	.255	.533	.028
USAGE	<-->	SATISFACTION	-.356	-.517	-.229	.011
EXPERIENCE	<-->	SATISFACTION	-.482	-.640	-.326	.012
SATISFACTION	<-->	KNOWLEDGE	-.395	-.547	-.244	.005

Table 11 – Confidence Interval Test for Discriminate Validity Results

All of the constructs evaluated for this study met the requirements for validity with the exception of “TIME”. Whereas the other constructs were largely based on previously implemented studies and tests, the questions within the

TIME construct were new and based on concepts in relevant literature. Although there is the expectation that the Cronbach's α for new scales is typically lower than the ideal 0.7 (Hair et al., 1998), the exceedingly low Cronbach's α for the TIME construct was unexpected since the value for this construct in the pilot study was an acceptable 0.689. Also, note that the KMO for the TIME construct was less than 0.6 which is an indication of very little correlation between the variables in this construct and that factor analysis was not appropriate for this construct. Given the inability to validate the TIME construct, this concept was eliminated from the study along with the associated H3 hypothesis.

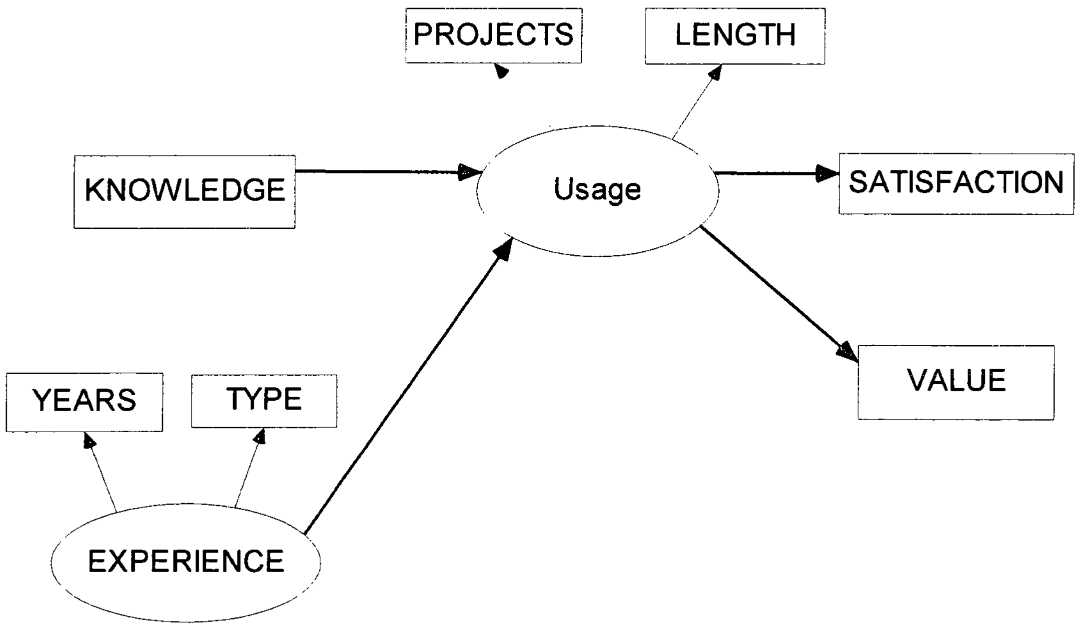

Figure 12 – Data Model After Validation of Constructs

Summary of Constructs After Validation

The composition of the data model (Figure 12) after the validation of the constructs is as follows:

- KNOWLEDGE: An observed exogenous variable that is a summated scale composed of questions 1-6
- EXPERIENCE: An unobserved exogenous variable that is measured by the indicators YEARS and TYPE
- YEARS: An observed endogenous variable that is a summated scale composed of questions 16-19
- TYPE: An observed endogenous variable that is a summated scale composed of questions 8-11
- USAGE: An observed endogenous variable that is measured by the indicators PROJECTS and LENGTH
- PROJECTS: An observed endogenous variable that is a summated scale composed of questions 28-31
- LENGTH: An observed endogenous variable that is a summated scale composed of questions 33-36
- SATISFACTION: An observed endogenous variable that is a summated scale composed of questions 38-42
- VALUE: An observed endogenous variable that is a summated scale composed of questions 43-60

Nomological Validity

Structural equation modeling techniques were used to evaluate the relationship between the constructs (nomological validity). As previously mentioned, a sample size of 100 is required for use of the maximum likelihood estimation (MLE) procedure. Given that the sample size (N=99) is very close to this minimum goal sample size, MLE was implemented using both SAS and SPSS/AMOS in order to verify that the model results were consistent and to take advantage of the analysis features that were exclusive to each particular model, such as unique fit indices.

Goodness of fit for the model was assessed with methods typically used for smaller sample sizes: chi-square (χ^2) divided by degrees of freedom and the Comparative Fit Index (CFI). The ratio of chi-square to degrees of freedom should be lower than 2.0 to be considered a good model fit (Hatcher, 1994). The Comparative Fit Index (CFI) is included because it is an absolute fit measure that considers the degrees of freedom in the model. As stated earlier, a CFI larger than 0.90 is an indication of a good fit (Hatcher, 1994). The fit indices for the models are summarized in Table 12, and the path analysis with standardized errors is shown in Figure 13.

FIT INDEX	METHOD	
	MLE with Amos	MLE with SAS
χ^2/ d.f.	.897	.8965
CFI	1.000	1.000

Table 12 – MLE Best Fit Indices Results

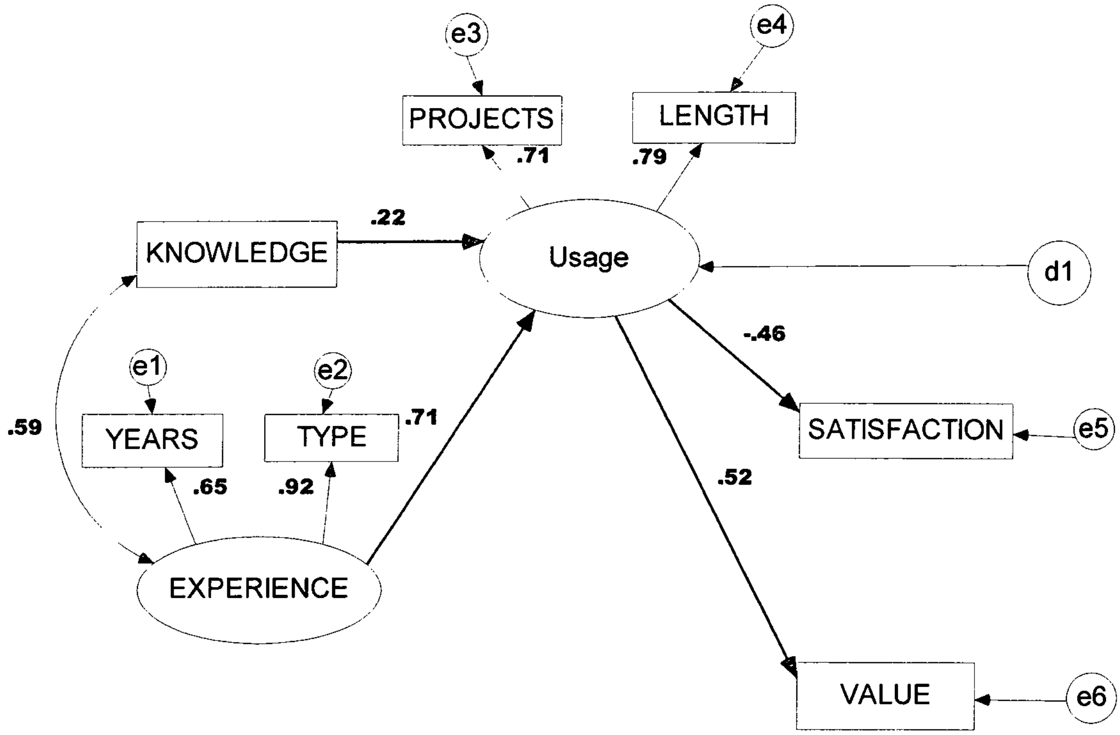

Figure 13 – Structural Equation Model with Standardized Estimates

Hypotheses Tests

H1: *The greater the amount of training an analyst or manager (decision maker) possesses in a type of decision analysis method, the more often that type of decision analysis method is used in aerospace technology assessment.*

The overall path from training (knowledge) to usage was not statistically significant ($p = .226$); therefore, the overall hypothesis that the greater the amount of decision analysis training or knowledge that an analyst or manager possesses, the more often decision analysis methods are used for aerospace technology assessment is not supported by the data.

H2: *The greater the amount of real world experience an analyst or manager (decision maker) possesses in a type of decision analysis method, the more often that type of decision analysis method is used in aerospace technology assessment.*

The overall path from experience to usage was statistically significant ($p = .023$) and positively related; therefore, the overall hypothesis that the greater the amount of real world decision analysis training or knowledge that an analyst or manager possesses, the more often decision analysis methods are used for aerospace technology assessment was supported by the data.

H3: *The shorter the assessment time, the less often any type of decision analysis method is used in aerospace technology assessment.*

This hypothesis was not tested due to inability to validate the "TIME" construct. During the data analysis, several models were developed using numerous combinations of the questions related to TIME, but they were inevitably unusable due to poor model fit.

H4: *The greater the amount of usage of any type of decision analysis method in aerospace technology assessment, the higher the satisfaction with the aerospace technology assessment process.*

The path from usage to satisfaction was statistically significant ($p = .009$) but negatively related; therefore, the overall hypothesis that the greater the amount of usage of decision analysis methods for aerospace technology assessment, the higher the satisfaction with the aerospace technology assessment process was not supported by the data.

H5: *The greater the amount of usage of any type of decision analysis method in aerospace technology assessment, the higher the perceived value with the aerospace technology assessment process.*

The path from usage to value was statistically significant ($p = .015$) and positively related; therefore, the overall hypothesis that the greater the amount of usage of decision analysis methods for aerospace technology assessment, the higher the perceived value with the aerospace technology assessment process was supported by the data.

Hypothesis Number	Construct Path	P-value	Statistically Significant?
H1	Knowledge->Usage	0.226	No
H2	Experience->Usage	0.023	Yes
H3	Assessment Time -> Usage	------	Untested
H4	Usage->Satisfaction	0.009	Yes
H5	Usage->Value	0.015	Yes

Table 13 – Summary of Hypotheses Test Results

Based on the results of this data analysis (Table 13), it is implied that a manager's or researcher's knowledge of decision analysis methods does not guarantee future usage of these methods for aerospace technology assessment (H1). However, the data does seem to imply that experience with decision analysis methods leads to increased usage of these methods for aerospace technology assessment (H2). This may be due to an organizational preference for the use of particular decision analysis methods, and these methods become part of the aerospace technology assessment culture.

Recall that although the relationship between usage and satisfaction was statistically significant, this relationship was negative. This is most likely due to the wording of the questions in the "SATIFACTION" construct. The questions in this construct were each 5-point Likert scales, but survey participants were given an option #6 of "no experience with aerospace technology assessments using this method". Therefore, the SATISFACTION values for persons with little or no usage of decision analysis methods for aerospace technology assessment would be greater than those for persons with extensive usage of decision analysis methods and high satisfaction. When the analysis was repeated again with 5 points on the scale, the standardize regression weight for this path changed from -0.464 to 0.745. However, since Amos required the use of estimated means and intercepts in order to produce this output, additional tests should be conducted prior to confidently reporting these results. For this reason, the results of H4 are considered inconclusive. Finally, the results of H5 imply that persons who have used decision analysis methods for aerospace technology assessment believe these methods add value to the process.

5. DISCUSSION AND CONCLUSIONS

INTRODUCTION

This section discusses the implication of the results for both aerospace engineering managers and decision analysis researchers. Recommendations for future research in this area are also presented.

IMPLICATION OF RESULTS TO ENGINEERING MANAGERS

The results of this study were intended to provide guidance to aerospace engineering managers who are contemplating the future use of decision analysis methods for aerospace technology assessments. Recall that technology assessments and the implementation of decision analysis methods in any environment require time, personnel and funding investments (e.g., decision analysis software acquisition and training). The expected outcome from using decision analysis methods in the aerospace technology assessment process was to improve the ability to develop technology portfolios.

Based on the individual question results and the overall results of H5, it appears that most researchers and managers believe that decision analysis methods improve the ability to develop technology portfolios. A majority of the respondents believe that if decision analysis methods are used in the aerospace technology process, they are better able to explain their results to senior managers. They also believe that decision analysis methods help reduce uncertainty about technology selection decisions and that they are helpful in explaining the technology selection process to external customers/end users.

IMPLICATION OF RESULTS TO DECISION ANALYSIS RESEARCHERS

One of the objectives of this study was to provide researchers in the decision analysis community with additional knowledge about the use of decision analysis methods in real world decisions. As previously stated, Keeney (2004a) believed that there is a need for more research about real decision problems as opposed to laboratory experiments. The data collected in the implementation of this research study provides previously unknown insight into the usage of decision analysis methods in the real world problem of aerospace technology assessment.

There are several key findings based on the analysis of the data that address issues of concern to decision analysis researchers. First, the results of H1 imply that education and training alone are not sufficient means for increasing the overall usage of decision analysis in real world problems. Secondly, over 50% of the researchers and managers surveyed responded that they are "very likely" or "somewhat likely" to use decision trees in future aerospace technology assessments, and at least 35% provided the same responses for the three remaining decision analysis methods. Finally, the survey respondents believed that the successful use of decision analysis methods in general depends on a number of factors including: (1) the selection criteria in the decision model, (2) the experience of the person that implements the decision method and (3) the reliability of the input data.

LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

There are several limitations of this study:

- The size of the sample is relatively low to generate generalizable results.
- The sample of the data represents a high percentage of aeronautics respondents when compared with the same number of space respondents.
- Collecting data using self-reported measures naturally raise concerns of source biases.

In order to address these limitations and continue to evolve the current body of knowledge the following enhancements are recommended for future research:

- To solicit more persons with project experience that is primarily space related;
- To incorporate other specific types of decision analysis methods not evaluated in this study (e.g., optimization methods) ;
- To evaluate an overall larger sample size;
- To examine the use of decision analysis methods in aerospace for purposes other than aerospace technology assessment;

- To examine the relationship between formal education only (college courses, etc.) and the usage of decision analysis for aerospace technology assessment;
- To examine the relationship between in-house training (workshops, seminars, etc.) and the usage of decision analysis for aerospace technology assessment and to include the impact of management reinforcement of training (e.g., periodic follow-up training).

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APPENDICES

A. PILOT SURVEY QUESTIONNAIRE

Decision Analysis Methods in Aerospace Technology Assessment

SECTION 1 - Knowledge/Education/Training

Knowledge is defined as any training that you have received in specific decision analysis methods and related mathematical topics. The set of questions in this section will be used to learn about your knowledge in this area.

1 I have gained knowledge about **probability** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of an graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by a colleague on a work task
- Taught by a paid consultant on a work task

2 I have gained knowledge about **statistics** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of an graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by a colleague on a work task
- Taught by a paid consultant on a work task

3 I have gained knowledge about **fuzzy logic** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of an graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading

Taught by a colleague on a work task

Taught by a paid consultant on a work task

4 I have gained knowledge about **Bayesian Belief Networks (BBN's)** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of an graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by a colleague on a work task
- Taught by a paid consultant on a work task

5 I have gained knowledge about **TOPSIS** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of an graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by a colleague on a work task
- Taught by a paid consultant on a work task

6 I have gained knowledge about **ELECTRE** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of an graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by a colleague on a work task
- Taught by a paid consultant on a work task

7 I have gained knowledge about **decision trees** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of an graduate level college course that I attended

- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by a colleague on a work task
- Taught by a paid consultant on a work task

8 I have gained knowledge about **influence diagrams** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of an graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by a colleague on a work task
- Taught by a paid consultant on a work task

9 I have gained knowledge about **criteria aggregation methods (e.g, analytical hierarchy process, weighted sum models, etc.)** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of an graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by a colleague on a work task
- Taught by a paid consultant on a work task

10 I have gained knowledge about **explicit tradeoff approaches (e.g, multi-attribute utility theory, SMART, SMARTER, etc.)** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of an graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by a colleague on a work task
- Taught by a paid consultant on a work task

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Decision Analysis Methods in Aerospace Technology Assessment

SECTION 2 - Experience

The set of questions in this section explore your "real world" experience with decision analysis methods that did NOT involve aerospace technology assessment.

Aerospace technology assessment is defined as process for measuring the impact of established or new aerospace related technologies. For this survey, aerospace technology assessment includes "technology assessment" and "technology forecasting" processes.

11 I have the following experience with **decision trees** outside of a classroom environment (check all that apply):

- Model development
- Model input/data collection
- Analysis of model output
- Publication of more than 5 papers on this method
- Usage of this method on more than 5 projects
- Never used this method

12 I have the following experience with **influence diagrams** outside of a classroom environment (check all that apply):

- Model development
- Model input/data collection
- Analysis of model output
- Publication of more than 5 papers on this method
- Usage of this method on more than 5 projects
- Never used this method

13 I have the following experience with **criteria aggregation methods (e.g, analytical hierarchy process, weighted sum models, etc.)** outside of a classroom environment (check all that apply):

- Model development
- Model input/data collection

- Analysis of model output
- Publication of more than 5 papers on this method
- Usage of this method on more than 5 projects
- Never used this method

14 I have the following experience with **explicit tradeoff approaches (e.g, multi-attribute utility theory, SMART, SMARTER, etc.)** outside of a classroom environment (check all that apply):

- Model development
- Model input/data collection
- Analysis of model output
- Publication of more than 5 papers on this method
- Usage of this method on more than 5 projects
- Never used this method

15 My usage of **decision trees** outside of a classroom environment has been primarily as a:

- Facilitator or analyst
- Decision Maker (DM) - participant in decision making process which takes place with the support of an expert analyst/faciltator
- Do-it-Yourself user (both analyst and DM)
- None of the above - never used this method

16 My usage of **influence diagrams** outside of a classroom environment has been primarily as a:

- Facilitator or analyst
- Decision Maker (DM) - participant in decision making process which takes place with the support of an expert analyst/faciltator
- Do-it-Yourself user (both analyst and DM)
- None of the above - never used this method

17 My usage of **criteria aggregation methods (e.g, analytical hierarchy process, weighted sum models, etc.)** outside of a classroom environment has been primarily as a:

- Facilitator or analyst
- Decision Maker (DM) - participant in decision making process which takes place with the support of an expert analyst/faciltator
- Do-it-Yourself user (both analyst and DM)
- None of the above - never used this method

18 My usage of **explicit tradeoff approaches (e.g, multi-attribute utility theory, SMART, SMARTER, etc.)** outside of a classroom environment has been primarily as a:

- Facilitator or analyst
- Decision Maker (DM) - participant in decision making process which takes place with the support of an expert analyst/facilitator
- Do-it-Yourself user (both analyst and DM)
- None of the above - never used this method

19 I have used **decision trees** outside of a classroom environment for a total of the following number of years:

0	1-2	3-4	5-6	7-8	9-10	10+
1	2	3	4	5	6	7

20 I have used **influence diagrams** outside of a classroom environment for a total of the following number of years:

0	1-2	3-4	5-6	7-8	9-10	10+
1	2	3	4	5	6	7

21 I have used **criteria aggregation methods (e.g, analytical hierarchy process, weighted sum models, etc.)** outside of a classroom environment for a total of the following number of years:

0	1-2	3-4	5-6	7-8	9-10	10+
1	2	3	4	5	6	7

22 I have used **explicit tradeoff approaches (e.g, multi-attribute utility theory, SMART, SMARTER, etc.)** outside of a classroom environment for a total of the following number of years:

0	1-2	3-4	5-6	7-8	9-10	10+
1	2	3	4	5	6	7

23 I have used the following software programs for decision analysis outside of classroom environment (check all that apply):

Analytica

DecisionPro

Decision Manager

- ERGO
- Expert Choice
- Expression Tree
- HUGIN
- Logical Decisions
- Precision Tree
- Other, please specify ____________

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Decision Analysis Methods in Aerospace Technology Assessment

SECTION 3 - Technology Development Time

The set of questions in this section explore your typical technology development time.

24 The nature of the R&D projects that I have primarily worked with can best be categorized as:

- Very long term R &D (20+ years before implementation)
- Long term R&D (10-19 years before implementation)
- Medium term R&D (6-9 years before implementation)
- Short term R&D (3-5 years before implementation)
- Very short term R&D (0-2 years before implementation)

25 The majority of the aerospace technology projects that I have worked on can best be described as:

- Aeronautics only
- Mostly aeronautics and some space
- Equally space and aeronautics
- Mostly space and some aeronautics
- Space only

26 In the majority of the aerospace technology projects that I have worked on, I was employed by:

- Government
- Industry
- Academia
- Other

27 In the majority of the aerospace technology projects that I have worked on, I received my funding from:

- Government
- Industry
- Academia
- Other

28 I have worked on aerospace projects in which technology assessments were conducted (check all that apply):

- Annually
- Only prior to the start of the project
- Only at the project mid-point
- Only at the end of the project
- At the project beginning, mid-point and end
- Never
- Other, please specify ____________________

29 Most of my experience with aerospace project planning has been with projects that can best described as:

- Long term (strategic)
- Mid term (tactical)
- Short term (operational)

30 My current project/program is approximately at the following level of completion:

5%	25%	50%	75%	95%
1	2	3	4	5

31 The stability of my current level of research funding is:

- Better than when I began my research career
- About the same as when I began my research career
- Worse than when I began my research career

SUBMIT

Decision Analysis Methods in Aerospace Technology Assessment

SECTION 4 - Decision Analysis Usage for Aerospace Technology Assessment

The set of questions in this section explore your "real world" usage of decision analysis methods for aerospace technology assessment.

Aerospace technology assessment is defined as process for measuring the impact of established or new aerospace related technologies. For this survey, aerospace technology assessment includes "technology assessment" and "technology forecasting" processes.

32 How often have you used **decision trees** for aerospace technology assessment?

Never	Rarely	Sometimes	Frequently	Always
1	2	3	4	5

33 How often have you used **influence diagrams** for aerospace technology assessment?

Never	Rarely	Sometimes	Frequently	Always
1	2	3	4	5

34 How often have you used **criteria aggregation methods** for aerospace technology assessment?

Never	Rarely	Sometimes	Frequently	Always
1	2	3	4	5

35 How often have you used **explicit tradeoff approaches** for aerospace technology assessment?

Never	Rarely	Sometimes	Frequently	Always
1	2	3	4	5

36 How often have you conducted aerospace technology assessments that did not involve any of the 4 types of decision analysis methods previously mentioned?

Never	Rarely	Sometimes	Frequently	Always
1	2	3	4	5

SUBMIT

Decision Analysis Methods in Aerospace Technology Assessment

SECTION 5 - Satisfaction with Decision Analysis for Aerospace Technology Assessment

The set of questions on this page explore your satisfaction with using decision analysis methods for aerospace technology assessment.

To what extent do you agree with the following statements?:

37 The aerospace technology assessment process influenced the final outcome of the R&D portfolio

- Strongly influential
- Somewhat influential
- Neutral
- Somewhat not influential
- Not influential at all
- No experience with aerospace technology assessment process

38 Aerospace technology assessments, conducted using **decision trees**, were helpful in developing R&D portfolios

- Strongly agree
- Somewhat agree
- Neither agree or disagree
- Somewhat disagree
- Strongly disagree
- No experience with aerospace technology assessments using decision trees

39 Aerospace technology assessments, conducted using **influence diagrams**, were helpful in developing R&D portfolios

- Strongly agree
- Somewhat agree
- Neither agree or disagree
- Somewhat disagree
- Strongly disagree
- No experience with aerospace technology assessments using influence diagrams

40 Aerospace technology assessments, conducted using **criteria aggregation methods**, were helpful in developing R&D portfolios

- Strongly agree
- Somewhat agree
- Neither agree or disagree
- Somewhat disagree
- Strongly disagree
- No experience with aerospace technology assessments using criteria aggregation methods

41 Aerospace technology assessments, conducted using **explicit tradeoff approaches**, were helpful in developing R&D portfolios

- Strongly agree
- Somewhat agree
- Neither agree or disagree
- Somewhat disagree
- Strongly disagree
- No experience with aerospace technology assessments using explicit tradeoff approaches

42 Aerospace technology assessments, conducted without any of the 4 types of decision analysis methods previously mentioned, were helpful in developing R&D portfolios

- Strongly agree
- Somewhat agree
- Neither agree or disagree
- Somewhat disagree
- Strongly disagree
- No experience with aerospace technology assessments without the 4 specified decision analysis methods

SUBMIT

Decision Analysis Methods in Aerospace Technology Assessment

SECTION 6 - Value of Decision Analysis for Aerospace Technology Assessment

The set of questions in this section explore your perceived value of using decision analysis methods for aerospace technology assessment.

To what extent do you agree with the following statements?:

43 Most aerospace technology assessments completed using decision analysis methods produce results more reliable than those obtained by intuition and experience

- Strongly agree
- Somewhat agree
- Neither agree or disagree
- Somewhat disagree
- Strongly disagree

44 Overall, I believe that I can create a better R&D portfolio if I use aerospace technology assessment techniques

- Strongly agree
- Somewhat agree
- Neither agree or disagree
- Somewhat disagree
- Strongly disagree

45 I believe that I can create a better R&D portfolio if I use aerospace technology assessment techniques with decision analysis methods

- Strongly agree
- Somewhat agree
- Neither agree or disagree
- Somewhat disagree
- Strongly disagree

46 If decision analysis methods are used in the aerospace technology assessment process, I have a basis for arguing or disagreeing with senior managers

- Strongly agree
- Somewhat agree
- Neither agree or disagree
- Somewhat disagree
- Strongly disagree

47 How likely is it that you will use or recommend the following decision analysis methods in future aerospace technology assessments?

	1 Very likely	2 Somewhat likely	3 Neutral	4 Somewhat not likely	5 Not at all likely
Decision trees	1	2	3	4	5
Influence diagrams	1	2	3	4	5
Criteria aggregation methods	1	2	3	4	5
Explicit tradeoff approaches	1	2	3	4	5

48 The sophistication of most decision analysis nethods are beyond the routine use of many R&D managers

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

49 Decision analysis methods help me to predict unanticipated consequences

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

50 I have serious reservations about the way in which decision analysis methods perform their mathematical manipulations

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

51 I believe I can make better decisions if I use decision analysis methods

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

52 Most decision analysis methods are not too complex to use on a regular basis

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

53 Despite R&D being an uncertain activity, it is possible to estimate accurately the inputs required by most decision analysis methods

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

54 I am too busy to spend the time required to use a decision analysis method

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

55 The high costs of acquiring the data/information make most decision analysis methods far too expensive

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

56 Most decision analysis methods require too much quantitative input data, not readily available within the organization

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

57 I don't see how the use of decision analysis methods would help me to reduce some of the uncertainty I feel about our technology selection decisions

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

58 I am not reluctant about using decision analysis methods just because they are based on complex mathematical manipulations

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

59 Decision analysis methods are of little use because people soon learn how to make the system work to their advantage

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

60 It is difficult to apply most decision analysis methods to some of our technologies

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

61 I believe decision analysis methods limit emotional appeals and personal bias

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

62 I believe using decision analysis methods helps explain the selection process to external customers/end users

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

63 I believe that the successful use of decision analysis methods depends on the selection criteria

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

64 I believe that the successful use of decision analysis methods depends on the experience of the person(s) that implements the method

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

65 I believe that I possess the skills to successfully gather reliable input data for most decision analysis methods

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

66 I believe that if given reliable input data, I possess the skill to successfully implement most decision analysis methods

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	2	3	4	5

SUBMIT

Decision Analysis Methods in Aerospace Technology Assessment

SECTION 7 - PERSONAL BACKGROUND

The set of questions in this section will be used to compare your answers with those of other people. All of your answers are strictly confidential

67 The highest degree that I have earned is:

- High school diploma
- Associates
- Bachelors
- Masters
- Doctorate
- Other professional degree (medical, law, etc.)
- None of the above

68 My gender is

- Female
- Male

69 Which of the following most closely describes your current employer:

- Federal Government (civil servant)
- Contractor at Government Facility
- State or Local Government
- Academia
- Private Industry
- Self-Employed
- Retired (Federal Government)
- Retired (Other)
- Other, please specify

70 Which of the following most closely describes your job function:

- Management/Supervisor
- Science or Engineering
- Administrative
- Other, please specify

SUBMIT

B. FINAL SURVEY QUESTIONNAIRE

Decision Analysis Methods in Aerospace Technology Assessment

SECTION 1 - Knowledge/Education/Training

The set of questions in this section will be used to learn about any training or education that you have received in specific decision analysis methods and related mathematical topics

SURVEY VOCABULARY

- **Aerospace Technology Assessment** - a process for measuring the impact of established or new aerospace related technologies
- Bayesian Belief Network
- **Criteria Aggregation Methods** - includes methods such as Analytic Hierarchy Process, Weighted Sum Models (WSM), etc.
- Decision Tree
- ELECTRE
- **Explicit Tradeoff Approaches** - includes methods such as Multi-Attribute Utility Theory, SMART, SMARTER, etc.
- Fuzzy Logic
- Influence Diagram
- Probability
- Statistics

1 I have gained knowledge about **statistics** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of a graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by colleague(s) on a work task
- Taught by paid consultant(s) on a work task
- No experience with this method
- Other, please specify ______

2 I have gained knowledge about **probability concepts and tools** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of a graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by colleague(s) on a work task
- Taught by paid consultant(s) on a work task
- No experience with this method
- Other, please specify ____________

3 I have gained knowledge about **decision trees** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of a graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by colleague(s) on a work task
- Taught by paid consultant(s) on a work task
- No experience with this method
- Other, please specify ____________

4 I have gained knowledge about **influence diagrams** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of a graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by colleague(s) on a work task
- Taught by paid consultant(s) on a work task
- No experience with this method
- Other, please specify ____________

5 I have gained knowledge about **criteria aggregation methods (e.g., analytical hierarchy process, weighted sum models, etc.)** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of a graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by colleague(s) on a work task
- Taught by paid consultant(s) on a work task
- No experience with this method
- Other, please specify

6 I have gained knowledge about **explicit tradeoff approaches (e.g., multi-attribute utility theory, SMART, SMARTER, etc.)** through the following means (check all that apply):

- Topic in or title of an undergraduate level college course that I attended
- Topic in or title of a graduate level college course that I attended
- Topic in or title of training course that I attended
- Do-it-yourself (self-taught) reading
- Taught by colleague(s) on a work task
- Taught by paid consultant(s) on a work task
- No experience with this method
- Other, please specify

7 I have knowledge about the following mathematical concepts and techniques: (check all that apply):

- Fuzzy Logic
- Bayesian Belief Networks (BBN's)
- ELECTRE
- None of the above

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Decision Analysis Methods in Aerospace Technology Assessment

SECTION 2 - Experience

The set of questions in this section explore your "real world" experience with decision analysis methods that did NOT involve aerospace technology assessment.

Aerospace technology assessment is defined as a process for measuring the impact of established or new aerospace related technologies. For this survey, aerospace technology assessment includes "technology assessment" and "technology forecasting" processes.

8 I have the following experience with **decision trees** outside of a classroom environment (check all that apply):

- [ ] Model development
- [ ] Model input/data collection
- [ ] Analysis of model output
- [ ] Publication of 2 or more papers on this method
- [ ] Usage of this method on 2 or more projects
- [ ] Never used this method other than for aerospace technology assessment
- [ ] Never used this method at all
- [ ] Other, please specify ______________________

9 I have the following experience with **influence diagrams** outside of a classroom environment (check all that apply):

- [ ] Model development
- [ ] Model input/data collection
- [ ] Analysis of model output
- [ ] Publication of 2 or more papers on this method
- [ ] Usage of this method on 2 or more projects
- [ ] Never used this method other than for aerospace technology assessment
- [ ] Never used this method at all
- [ ] Other, please specify ______________________

10 I have the following experience with **criteria aggregation methods (e.g., analytical hierarchy process, weighted sum models, etc.)** outside of a classroom environment (check all that apply):

- Model development
- Model input/data collection
- Analysis of model output
- Publication of 2 or more papers on this method
- Usage of this method on 2 or more projects
- Never used this method other than for aerospace technology assessment
- Never used this method at all
- Other, please specify

11 I have the following experience with **explicit tradeoff approaches (e.g., multi-attribute utility theory, SMART, SMARTER, etc.)** outside of a classroom environment (check all that apply):

- Model development
- Model input/data collection
- Analysis of model output
- Publication of 2 or more papers on this method
- Usage of this method on 2 or more projects
- Never used this method other than for aerospace technology assessment
- Never used this method at all
- Other, please specify

12 My usage of **decision trees** outside of a classroom environment has been primarily as a:

- Facilitator or analyst
- Decision Maker (DM) - participant in decision making process which takes place with the support of an expert analyst/facilitator
- Do-it-Yourself user (both analyst and DM)
- All of my experience with this method involved aerospace technology assessment
- None of the above - never used this method at all
- Other, please specify

13 My usage of **influence diagrams** outside of a classroom environment has been primarily as a:

- Facilitator or analyst
- Decision Maker (DM) - participant in decision making process which takes place with the support of an expert analyst/facilitator
- Do-it-Yourself user (both analyst and DM)
- All of my experience with this method involved aerospace technology assessment
- None of the above - never used this method
- Other, please specify

14 My usage of **criteria aggregation methods (e.g., analytical hierarchy process, weighted sum models, etc.)** outside of a classroom environment has been primarily as a:

- Facilitator or analyst
- Decision Maker (DM) - participant in decision making process which takes place with the support of an expert analyst/facilitator
- Do-it-Yourself user (both analyst and DM)
- All of my experience with this method involved aerospace technology assessment
- None of the above - never used this method
- Other, please specify

15 My usage of **explicit tradeoff approaches (e.g., multi-attribute utility theory, SMART, SMARTER, etc.)** outside of a classroom environment has been primarily as a:

- Facilitator or analyst
- Decision Maker (DM) - participant in decision making process which takes place with the support of an expert analyst/facilitator
- Do-it-Yourself user (both analyst and DM)
- All of my experience with this method involved aerospace technology assessment
- None of the above - never used this method
- Other, please specify

16 I have used **decision trees** outside of a classroom environment and NOT for aerospace technology assessment for a total of the following approximate number of years:

17 I have used **influence diagrams** outside of a classroom environment and NOT for aerospace technology assessment for a total of the following approximate number of years:

18 I have used **criteria aggregation methods (e.g., analytical hierarchy process, weighted sum models, etc.)** outside of a classroom environment and NOT for aerospace technology assessment for a total of the following approximate number of years:

19 I have used **explicit tradeoff approaches (e.g., multi-attribute utility theory, SMART, SMARTER, etc.)** outside of a classroom environment and NOT for aerospace technology assessment for a total of the following approximate number of years:

SUBMIT

Decision Analysis Methods in Aerospace Technology Assessment

SECTION 3 - Technology Development Time

The set of questions in this section explore your typical technology development time.

20 The nature of the R&D projects that I have primarily worked with can best be categorized as:

- 20+ years before expected implementation (Very long term R &D)
- 10-19 years before expected implementation (Long term R&D)
- 6-9 years before expected implementation (Medium term R&D)
- 3-5 years before expected implementation (Short term R&D)
- 0-2 years before implementation (Very short term R&D)

- Mixed portfolio of two or more of the above types of R&D

21 The majority of the aerospace technology projects that I have worked on can best be described as:

- Aeronautics only
- Mostly aeronautics and some space
- Equally space and aeronautics
- Mostly space and some aeronautics
- Space only
- Other, please specify

22 In the majority of the aerospace technology projects that I have worked on, I was employed by:

- Government
- Industry
- Academia
- Other, please specify

23 In the majority of the aerospace technology projects that I have worked on, I received my funding from:

- Government
- Industry
- Academia
- Other, please specify

24 I have worked on aerospace projects in which technology assessments were conducted (check all that apply):

- Annually
- Only prior to the start of the project
- Only at the project mid-point
- Only at the end of the project
- At the project beginning, mid-point and end
- Unscheduled request(s) from the decision maker/management
- Never
- Other, please specify

25 Most of my experience with aerospace project planning has been with projects that can best be described as:

- Strategic (long term)
- Tactical (mid term)
- Operational (short term)

26 My current primary project/program is approximately at the following level of completion:

5%	25%	50%	75%	95%
1	2	3	4	5

27 The stability of the current level of research funding in my organization is:

- Better than when I began my research career
- About the same as when I began my research career
- Worse than when I began my research career

SUBMIT

Decision Analysis Methods in Aerospace Technology Assessment

SECTION 4 - Decision Analysis Usage for Aerospace Technology Assessment

The set of questions in this section explore your "real world" usage of decision analysis methods for aerospace technology assessment.

Aerospace technology assessment is defined as a process for measuring the impact of established or new aerospace related technologies. For this survey, aerospace technology assessment includes "technology assessment" and "technology forecasting" processes.

28 I have conducted aerospace technology assessments using **decision trees** for the following approximate number of projects:

29 I have conducted aerospace technology assessments using **influence diagrams** for the following approximate number of projects:

30 I have conducted aerospace technology assessments using **criteria aggregation methods** for the following approximate number of projects:

31 I have conducted aerospace technology assessments using **explicit tradeoff approaches** for the following approximate number of projects:

32 I have conducted aerospace technology assessments that did not involve any of the 4 types of decision analysis methods previously mentioned for the following approximate number of projects:

33 The average amount of time that I typically spend on a project conducting an aerospace technology assessment (ATA) using **decision trees** is:

34 The average amount of time that I typically spend on a project conducting an aerospace technology assessment (ATA) using **influence diagrams** is:

35 The average amount of time that I typically spend on a project conducting an aerospace technology assessment (ATA) using **criteria aggregation methods** is:

36 The average amount of time that I typically spend on a project conducting an aerospace technology assessment (ATA) using **explicit tradeoff approaches** is:

37 The average amount of time that I typically spend on a project conducting an aerospace technology assessment (ATA) without any of the 4 types of decision analysis methods previously mentioned is:

SUBMIT

Decision Analysis Methods in Aerospace Technology Assessment

SECTION 5 - Satisfaction with Decision Analysis for Aerospace Technology Assessment

The set of questions on this page explore your satisfaction with using decision analysis methods for aerospace technology assessment.

To what extent do you agree with the following statements?:

38 Aerospace technology assessments, conducted using **decision trees**, are helpful in developing R&D portfolios

- Strongly disagree
- Somewhat disagree
- Neither agree or disagree
- Somewhat agree
- Strongly agree
- No experience with aerospace technology assessments using decision trees

39 Aerospace technology assessments, conducted using **influence diagrams**, are helpful in developing R&D portfolios

- Strongly disagree
- Somewhat disagree
- Neither agree or disagree
- Somewhat agree
- Strongly agree
- No experience with aerospace technology assessments using influence diagrams

40 Aerospace technology assessments, conducted using **criteria aggregation methods**, are helpful in developing R&D portfolios

- Strongly disagree
- Somewhat disagree
- Neither agree or disagree
- Somewhat agree
- Strongly agree
- No experience with aerospace technology assessments using criteria aggregation methods

41 Aerospace technology assessments, conducted using **explicit tradeoff approaches**, are helpful in developing R&D portfolios

- Strongly disagree
- Somewhat disagree
- Neither agree or disagree
- Somewhat agree
- Strongly agree
- No experience with aerospace technology assessments using explicit tradeoff approaches

42 Aerospace technology assessments, conducted <u>without</u> any of the 4 types of decision analysis methods previously mentioned, are helpful in developing R&D portfolios

- Strongly disagree
- Somewhat disagree
- Neither agree or disagree
- Somewhat agree
- Strongly agree
- No experience with aerospace technology assessments without the 4 specified decision analysis methods

SUBMIT

Decision Analysis Methods in Aerospace Technology Assessment

SECTION 6 - Value of Decision Analysis for Aerospace Technology Assessment

The set of questions in this section explore your perceived value of using decision analysis methods for aerospace technology assessment.

To what extent do you agree with the following statements?:

43 Most aerospace technology assessments completed using decision analysis methods produce results more reliable than those obtained by intuition and experience

- ☐ Strongly disagree
- ☐ Somewhat disagree
- ☐ Neither agree or disagree
- ☐ Somewhat agree
- ☐ Strongly agree

44 If decision analysis methods are used in the aerospace technology assessment process, I am better able to explain my results to senior managers

- ☐ Strongly disagree
- ☐ Somewhat disagree
- ☐ Neither agree or disagree
- ☐ Somewhat agree
- ☐ Strongly agree

45 How likely is it that you will use or recommend the following decision analysis methods in future aerospace technology assessments?

	1 Not at all likely	2 Somewhat not likely	3 Neutral	4 Somewhat likely	5 Very likely
Decision trees	1	2	3	4	5
Influence diagrams	1	2	3	4	5
Criteria aggregation methods	1	2	3	4	5
Explicit tradeoff approaches	1	2	3	4	5

46 The sophistication of most decision analysis methods are beyond the routine use of many R&D managers

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

47 I am concerned about the validity of the mathematics underneath decision analysis methods

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

48 Most decision analysis methods are too complex to use on a regular basis

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

49 Despite the uncertainty in R&D activities, it is possible to estimate accurately the inputs required by most decision analysis methods

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

50 The high costs of acquiring the data/information make most decision analysis methods far too expensive

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

51 Most decision analysis methods require too much quantitative input data, not readily available within the organization

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

52 I believe that the use of decision analysis methods will help me to reduce some of the uncertainty I feel about our technology selection decisions

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

53 I am comfortable using decision analysis methods even though they are based on complex mathematical algorithms

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

54 It is difficult to apply most decision analysis methods to some of our technologies

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

55 I believe decision analysis methods limit emotional appeals and personal bias

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

56 I believe using decision analysis methods helps explain the selection process to external customers/end users

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

57 I believe that the successful use of decision analysis methods depends on the selection criteria in the decision model

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

58 I believe that the successful use of decision analysis methods depends on the experience of the person(s) that implements the method

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

59 I believe that I possess the skills to successfully gather reliable input data for most decision analysis methods

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

60 I believe that if given reliable input data, I possess the skill to successfully implement most decision analysis methods

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

SUBMIT

Decision Analysis Methods in Aerospace Technology Assessment

SECTION 7 - PERSONAL BACKGROUND

The set of questions in this section will be used to compare your answers with those of other people. All of your answers are strictly confidential

61 The highest degree that I have earned is:

- High school diploma
- Associates
- Bachelors
- Masters
- Doctorate
- Other professional degree (medical, law, etc.)
- None of the above

62 My gender is

- Female
- Male

63 Which of the following most closely describes your current employer:

- Federal Government (civil servant)
- Contractor at Government Facility
- State or Local Government
- Academia
- Private Industry
- Self-Employed
- Retired (Federal Government)
- Retired (Other)
- Other, please specify

64 Which of the following most closely describes your job function in the last five years:

- Decision Practitioner
- Management/Supervisor
- Science or Engineering
- Administrative
- Other, please specify

65 How many years experience do you have working in the aerospace field?

SUBMIT

C. REVIEW BOARD LETTERS

National Aeronautics and
Space Administration

Langley Research Center
100 NASA Road
Hampton, VA 23681-2199

April 2, 2009

Sharon Monica Jones
Aeronautics Systems Analysis Branch
NASA Langley Research Center
Mail Stop 442
Hampton, VA 23681-2199

Subject: Decision Analysis Methods in Aerospace Technology Assessments

Ms. Jones,

On April 1, 2009 members of the LaRC IRB reviewed your proposed study, Decision Analysis Methods in Aerospace Technology Assessments. The IRB members determined that the survey was low risk and hereby grant you authority to commence with your study. Any changes to the protocols as approved by the IRB will require additional review prior to implementation.

Review is valid through April 1, 2010.
NASA LaRC IRB MPA Code NASA3082281305HR

Jeffrey S. Hill
Chairman, Institutional Review Board
MS 285, NASA Langley Research Center

Cc:

Patricia G. Cowin, CIH, CSP
Safety and Facility Assurance Office, MS 305

No.: **09-033**

OLD DOMINION UNIVERSITY
HUMAN SUBJECTS INSTITUTIONAL REVIEW BOARD
RESEARCH PROPOSAL REVIEW NOTIFICATION FORM

TO: Rafael Landaeta — *Responsible Project Investigator*

DATE: April 9, 2009 — *IRB Decision Date*

RE: A Study of Decision Analysis Methods in Aerospace Technology Assessments (**NASA LaRC IRB MPA Code NASA 308228130HR)(ODU IRB # 09-033)**
Name of Project

Please be informed that your research protocol has received approval by the Institutional Review Board. Your research protocol is:

__X_ Approved (expedited review)
___ Tabled/Disapproved
_ _ Approved, contingent on making the changes below*

________________________ April 9, 2009
IRB Chairperson's Signature — *date*

Contact the IRB for clarification of the terms of your research, or if you wish to make ANY change to your research protocol.
The approval expires one year from the IRB decision date. You must submit a Progress Report and seek re-approval if you wish to continue data collection or analysis beyond that date, or a Close-out report. You must report adverse events experienced by subjects to the IRB chair in a timely manner (see university policy).

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* Approval of your research is CONTINGENT upon the satisfactory completion of the following changes and attestation to those changes by the chairperson of the Institutional Review Board. Research may not begin until after this attestation.

Attestation

As directed by the Institutional Review Board, the Responsible Project Investigator made the above changes. Research may begin.

________________________ April 9, 2009
IRB Chairperson's Signature — *date*

D. SURVEY RESULTS SUMMARY CHARTS

DAMATA_Final

Results Overview

zoomerang

Date: 8/5/2009 1:30 PM PST
Responses: Completes
Filter: No filter applied

SECTION 1 - Knowledge/Education/Training The set of questions in this section will be used to learn about any training or education that you have received in specific decision analysis methods and related mathematical topics

SURVEY VOCABULARY Aerospace Technology Assessment - a process for measuring the impact of established or new aerospace related technologies Bayesian Belief Network Criteria Aggregation Methods - includes methods such as Analytic Hierarchy Process, Weighted Sum Models (WSM), etc. Decision Tree ELECTRE Explicit Tradeoff Approaches - includes methods such as Multi-Attribute Utility Theory, SMART, SMARTER, etc. Fuzzy Logic Influence Diagram Probability Statistics

1. I have gained knowledge about statistics through the following means (check all that apply):

Topic in or title of an undergraduate level college course that I attended	59	60%
Topic in or title of a graduate level college course that I attended	41	41%
Topic in or title of training course that I attended	36	36%
Do-it-yourself (self-taught) reading	59	60%
Taught by colleague(s) on a work task	35	35%
Taught by paid consultant(s) on a work task	8	8%
No experience with this method	2	2%
Other, please specify	5	5%

2. I have gained knowledge about probability concepts and tools through the following means (check all that apply):

Topic in or title of an undergraduate level college course that I attended	47	47%
Topic in or title of a graduate level college course that I attended	36	36%

Topic in or title of training course that I attended	37	37%
Do-it-yourself (self-taught) reading	55	56%
Taught by colleague(s) on a work task	38	38%
Taught by paid consultant(s) on a work task	15	15%
No experience with this method	3	3%
Other, please specify	3	3%

3. I have gained knowledge about decision trees through the following means (check all that apply):

Topic in or title of an undergraduate level college course that I attended	11	11%
Topic in or title of a graduate level college course that I attended	19	19%
Topic in or title of training course that I attended	30	30%
Do-it-yourself (self-taught) reading	42	42%
Taught by colleague(s) on a work task	31	31%
Taught by paid consultant(s) on a work task	10	10%
No experience with this method	14	14%
Other, please specify	1	1%

4. I have gained knowledge about influence diagrams through the following means (check all that apply):

Topic in or title of an undergraduate level college course that I attended	7	7%
Topic in or title of a graduate level college course that I attended	12	12%

Topic in or title of training course that I attended	15	15%
Do-it-yourself (self-taught) reading	27	27%
Taught by colleague(s) on a work task	18	18%
Taught by paid consultant(s) on a work task	5	5%
No experience with this method	47	47%
Other, please specify	3	3%

5. I have gained knowledge about criteria aggregation methods (e.g., analytical hierarchy process, weighted sum models, etc.) through the following means (check all that apply):

Topic in or title of an undergraduate level college course that I attended	7	7%
Topic in or title of a graduate level college course that I attended	15	15%
Topic in or title of training course that I attended	19	19%
Do-it-yourself (self-taught) reading	41	41%
Taught by colleague(s) on a work task	29	29%
Taught by paid consultant(s) on a work task	9	9%
No experience with this method	24	24%
Other, please specify	3	3%

6. I have gained knowledge about explicit tradeoff approaches (e.g., multi-attribute utility theory, SMART, SMARTER, etc.) through the following means (check all that apply):

Topic in or title of an undergraduate level college course that I attended	3	3%
Topic in or title of a graduate level college course that I attended	7	7%

Topic in or title of training course that I attended	5	5%
Do-it-yourself (self-taught) reading	19	19%
Taught by colleague(s) on a work task	12	12%
Taught by paid consultant(s) on a work task	5	5%
No experience with this method	67	68%
Other, please specify	2	2%

7. I have knowledge about the following mathematical concepts and techniques: (check all that apply):

Fuzzy Logic	47	47%
Bayesian Belief Networks (BBN's)	42	42%
ELECTRE	1	1%
None of the above	43	43%

SECTION 2 - Experience The set of questions in this section explore your "real world" experience with decision analysis methods that did NOT involve aerospace technology assessment. Aerospace technology assessment is defined as a process for measuring the impact of established or new aerospace related technologies. For this survey, aerospace technology assessment includes "technology assessment" and "technology forecasting" processes.

8. I have the following experience with decision trees outside of a classroom environment (check all that apply):

Model development	28	28%
Model input/data collection	25	25%
Analysis of model output	28	28%
Publication of 2 or more papers on this method	7	7%
Usage of this method on 2 or more projects	20	20%
Never used this method other than for aerospace technology assessment	20	20%
Never used this method at all	34	34%

Other, please specify	3	3%

9. I have the following experience with influence diagrams outside of a classroom environment (check all that apply):

Model development	14	14%
Model input/data collection	16	16%
Analysis of model output	19	19%
Publication of 2 or more papers on this method	4	4%
Usage of this method on 2 or more projects	10	10%
Never used this method other than for aerospace technology assessment	15	15%
Never used this method at all	60	61%
Other, please specify	2	2%

10. I have the following experience with criteria aggregation methods (e.g., analytical hierarchy process, weighted sum models, etc.) outside of a classroom environment (check all that apply):

Model development	23	23%
Model input/data collection	24	24%
Analysis of model output	29	29%
Publication of 2 or more papers on this method	6	6%
Usage of this method on 2 or more projects	20	20%
Never used this method other than for aerospace technology assessment	17	17%
Never used this method at all	42	42%
Other, please specify	1	1%

11. I have the following experience with explicit tradeoff approaches (e.g., multi-attribute utility theory, SMART, SMARTER, etc.) outside of a classroom environment (check all that apply):

Model development	9	9%
Model input/data collection	11	11%
Analysis of model output	14	14%
Publication of 2 or more papers on this method	3	3%
Usage of this method on 2 or more projects	6	6%
Never used this method other than for aerospace technology assessment	6	6%
Never used this method at all	72	73%
Other, please specify	1	1%

12. My usage of decision trees outside of a classroom environment has been primarily as a:

Facilitator or analyst		18	18%
Decision Maker (DM) - participant in decision making process which takes place with the support of an expert analyst/facilitator		11	11%
Do-it-Yourself user (both analyst and DM)		15	15%
All of my experience with this method involved aerospace technology assessment		26	26%
None of the above - never used this method at all		27	27%
Other, please specify		2	2%
	Total	99	100%

13. My usage of influence diagrams outside of a classroom environment has been primarily as a:

Facilitator or analyst	10	10%

Decision Maker (DM) - participant in decision making process which takes place with the support of an expert analyst/facilitator	5	5%
Do-it-Yourself user (both analyst and DM)	11	11%
All of my experience with this method involved aerospace technology assessment	12	12%
None of the above - never used this method	61	62%
Other, please specify	0	0%
Total	99	100%

14. My usage of criteria aggregation methods (e.g., analytical hierarchy process, weighted sum models, etc.) outside of a classroom environment has been primarily as a:

Facilitator or analyst	14	14%
Decision Maker (DM) - participant in decision making process which takes place with the support of an expert analyst/facilitator	8	8%
Do-it-Yourself user (both analyst and DM)	14	14%
All of my experience with this method involved aerospace technology assessment	20	20%
None of the above - never used this method	42	42%
Other, please specify	1	1%
Total	99	100%

15. My usage of explicit tradeoff approaches (e.g., multi-attribute utility theory, SMART, SMARTER, etc.) outside of a classroom environment has been primarily as a:

Facilitator or analyst	5	5%
Decision Maker (DM) - participant in decision making	6	6%

process which takes place with the support of an expert analyst/facilitator			
Do-it-Yourself user (both analyst and DM)		9	9%
All of my experience with this method involved aerospace technology assessment		5	5%
None of the above - never used this method		73	74%
Other, please specify		1	1%
	Total	99	100%

16. I have used decision trees outside of a classroom environment and NOT for aerospace technology assessment for a total of the following approximate number of years:

0	54	55%
less than 1	10	10%
1	5	5%
2	6	6%
3	0	0%
4	1	1%
5	8	8%
6	2	2%
7	0	0%
8	1	1%
9	2	2%
10	2	2%
11	0	0%
12	0	0%
13	0	0%
14	0	0%
15	2	2%
16	0	0%
17	1	1%
18	0	0%
19	0	0%
20	2	2%
21	0	0%

22	0	0%
23	1	1%
24	0	0%
25	2	2%
26	0	0%
27	0	0%
28	0	0%
29	0	0%
30	0	0%
31	0	0%
32	0	0%
33	0	0%
34	0	0%
35	0	0%
36	0	0%
37	0	0%
38	0	0%
39	0	0%
40	0	0%
41	0	0%
42	0	0%
43	0	0%
44	0	0%
45 or more	0	0%
Total	99	100%

17. I have used influence diagrams outside of a classroom environment and NOT for aerospace technology assessment for a total of the following approximate number of years:

0	75	76%
less than 1	4	4%
1	3	3%
2	2	2%
3	3	3%
4	1	1%
5	5	5%
6	0	0%
7	0	0%
8	1	1%

9	0	0%
10	0	0%
11	0	0%
12	1	1%
13	0	0%
14	0	0%
15	2	2%
16	0	0%
17	0	0%
18	0	0%
19	0	0%
20	1	1%
21	0	0%
22	0	0%
23	1	1%
24	0	0%
25	0	0%
26	0	0%
27	0	0%
28	0	0%
29	0	0%
30	0	0%
31	0	0%
32	0	0%
33	0	0%
34	0	0%
35	0	0%
36	0	0%
37	0	0%
38	0	0%
39	0	0%
40	0	0%
41	0	0%
42	0	0%
43	0	0%
44	0	0%
45 or more	0	0%
Total	99	100%

18. I have used criteria aggregation methods (e.g., analytical hierarchy process, weighted sum models, etc.) outside of a classroom environment and NOT for aerospace technology assessment for a total of the following approximate number of years:

0	63	64%
less than 1	5	5%
1	5	5%
2	4	4%
3	5	5%
4	3	3%
5	1	1%
6	4	4%
7	1	1%
8	0	0%
9	0	0%
10	1	1%
11	0	0%
12	0	0%
13	1	1%
14	0	0%
15	3	3%
16	0	0%
17	0	0%
18	0	0%
19	0	0%
20	2	2%
21	0	0%
22	0	0%
23	0	0%
24	0	0%
25	1	1%
26	0	0%
27	0	0%
28	0	0%
29	0	0%
30	0	0%
31	0	0%
32	0	0%
33	0	0%
34	0	0%

35		0	0%
36		0	0%
37		0	0%
38		0	0%
39		0	0%
40		0	0%
41		0	0%
42		0	0%
43		0	0%
44		0	0%
45 or more		0	0%
	Total	99	100%

19. I have used explicit tradeoff approaches (e.g., multi-attribute utility theory, SMART, SMARTER, etc.) outside of a classroom environment and NOT for aerospace technology assessment for a total of the following approximate number of years:

0	78	79%
less than 1	3	3%
1	1	1%
2	2	2%
3	4	4%
4	1	1%
5	2	2%
6	2	2%
7	0	0%
8	0	0%
9	0	0%
10	3	3%
11	0	0%
12	0	0%
13	0	0%
14	0	0%
15	2	2%
16	0	0%
17	0	0%
18	0	0%
19	0	0%
20	1	1%
21	0	0%

22		0	0%
23		0	0%
24		0	0%
25		0	0%
26		0	0%
27		0	0%
28		0	0%
29		0	0%
30		0	0%
31		0	0%
32		0	0%
33		0	0%
34		0	0%
35		0	0%
36		0	0%
37		0	0%
38		0	0%
39		0	0%
40		0	0%
41		0	0%
42		0	0%
43		0	0%
44		0	0%
45 or more		0	0%
	Total	99	100%

SECTION 3 - Technology Development Time The set of questions in this section explore your typical technology development time.

20. The nature of the R&D projects that I have primarily worked with can best be categorized as:

20+ years before expected implementation (Very long term R &D)	11	11%
10-19 years before expected implementation (Long term R&D)	34	34%
6-9 years before expected implementation (Medium term R&D)	16	16%

3-5 years before expected implementation (Short term R&D)		5	5%
0-2 years before implementation (Very short term R&D)		3	3%
Mixed portfolio of two or more of the above types of R&D		30	30%
	Total	99	100%

21. The majority of the aerospace technology projects that I have worked on can best be described as:

Aeronautics only		42	42%
Mostly aeronautics and some space		29	29%
Equally space and aeronautics		10	10%
Mostly space and some aeronautics		12	12%
Space only		5	5%
Other, please specify		1	1%
	Total	99	100%

22. In the majority of the aerospace technology projects that I have worked on, I was employed by:

Government		77	78%
Industry		11	11%
Academia		4	4%
Other, please specify		7	7%
	Total	99	100%

23. In the majority of the aerospace technology projects that I have worked on, I received my funding from:

Government		93	94%
Industry		5	5%
Academia		0	0%
Other, please specify		1	1%
	Total	99	100%

24. I have worked on aerospace projects in which technology assessments were conducted (check all that apply):

Annually	36	36%
Only prior to the start of the project	30	30%
Only at the project mid-point	9	9%
Only at the end of the project	11	11%
At the project beginning, mid-point and end	29	29%
Unscheduled request(s) from the decision maker/management	52	53%
Never	4	4%
Other, please specify	4	4%

25. Most of my experience with aerospace project planning has been with projects that can best be described as:

Strategic (long term)	52	53%
Tactical (mid term)	36	36%
Operational (short term)	11	11%
Total	99	100%

26. My current primary project/program is approximately at the following level of completion:

5%	21	21%
25%	37	37%
50%	24	24%
75%	11	11%
95%	6	6%
Total	99	100%

27. The stability of the current level of research funding in my organization is:

Better than when I began my research career	13	13%
About the same as when I began my research career	43	43%

Worse than when I began my research career		43	43%
	Total	99	100%

SECTION 4 - Decision Analysis Usage for Aerospace Technology Assessment The set of questions in this section explore your "real world" usage of decision analysis methods for aerospace technology assessment. Aerospace technology assessment is defined as a process for measuring the impact of established or new aerospace related technologies. For this survey, aerospace technology assessment includes "technology assessment" and "technology forecasting" processes.

28. I have conducted aerospace technology assessments using decision trees for the following approximate number of projects:

Never		41	41%
1		16	16%
2		14	14%
3		5	5%
4		4	4%
5		11	11%
6		1	1%
7		0	0%
8		1	1%
9		0	0%
10 or more		6	6%
	Total	99	100%

29. I have conducted aerospace technology assessments using influence diagrams for the following approximate number of projects:

Never		69	70%
1		9	9%
2		7	7%
3		2	2%
4		0	0%
5		7	7%
6		3	3%
7		0	0%
8		0	0%
9		0	0%
10 or more		2	2%
	Total	99	100%

30. I have conducted aerospace technology assessments using criteria aggregation methods for the following approximate number of projects:

Never	54	55%
1	9	9%
2	9	9%
3	11	11%
4	3	3%
5	8	8%
6	1	1%
7	1	1%
8	0	0%
9	0	0%
10 or more	3	3%
Total	99	100%

31. I have conducted aerospace technology assessments using explicit tradeoff approaches for the following approximate number of projects:

Never	61	62%
1	7	7%
2	8	8%
3	3	3%
4	2	2%
5	5	5%
6	1	1%
7	0	0%
8	0	0%
9	0	0%
10 or more	12	12%
Total	99	100%

32. I have conducted aerospace technology assessments that did not involve any of the 4 types of decision analysis methods previously mentioned for the following approximate number of projects:

Never	39	39%
1	11	11%
2	7	7%
3	8	8%
4	4	4%
5	8	8%

6	3	3%
7	1	1%
8	0	0%
9	0	0%
10 or more	18	18%
Total	99	100%

33. The average amount of time that I typically spend on a project conducting an aerospace technology assessment (ATA) using decision trees is:

Never used this method for ATA	45	45%
1 day	4	4%
2 days	3	3%
3 days	4	4%
4 days	1	1%
5 days	8	8%
6 days	0	0%
7 days	1	1%
8 days	1	1%
9 days	0	0%
10 days	7	7%
11 days	0	0%
12 days	0	0%
13 days	0	0%
14 days	1	1%
15 days	0	0%
16 days	0	0%
17 days	0	0%
18 days	0	0%
19 days	1	1%
20 days	2	2%
21 days	0	0%
22 days	0	0%
23 days	0	0%
24 days	0	0%
25 days	0	0%
26 days	0	0%
27 days	0	0%
28 days	1	1%

29 days		0	0%
1 month		3	3%
2 months		1	1%
3 months		2	2%
4 months		1	1%
5 months		0	0%
6 months		7	7%
7 months		0	0%
8 months		0	0%
9 months		0	0%
10 months		0	0%
11 months		0	0%
12 months		3	3%
13 months		0	0%
14 months		0	0%
15 months		0	0%
16 months		0	0%
17 months		0	0%
18 months		0	0%
19 months		0	0%
20 months		0	0%
21 months		0	0%
22 months		0	0%
23 months		0	0%
24 months		2	2%
25-30 months		0	0%
31-35 months		0	0%
3 years		0	0%
More than 3 years		1	1%
	Total	99	100%

34. The average amount of time that I typically spend on a project conducting an aerospace technology assessment (ATA) using influence diagrams is:

Never used this method for ATA	68	69%
1 day	2	2%
2 days	1	1%
3 days	2	2%
4 days	3	3%

5 days	4	4%
6 days	0	0%
7 days	1	1%
8 days	0	0%
9 days	0	0%
10 days	2	2%
11 days	0	0%
12 days	0	0%
13 days	0	0%
14 days	0	0%
15 days	1	1%
16 days	0	0%
17 days	0	0%
18 days	0	0%
19 days	0	0%
20 days	0	0%
21 days	0	0%
22 days	0	0%
23 days	0	0%
24 days	0	0%
25 days	1	1%
26 days	0	0%
27 days	0	0%
28 days	1	1%
29 days	0	0%
1 month	2	2%
2 months	1	1%
3 months	2	2%
4 months	1	1%
5 months	0	0%
6 months	2	2%
7 months	0	0%
8 months	0	0%
9 months	0	0%
10 months	0	0%
11 months	0	0%
12 months	3	3%
13 months	0	0%

14 months	0	0%
15 months	0	0%
16 months	0	0%
17 months	0	0%
18 months	0	0%
19 months	0	0%
20 months	0	0%
21 months	0	0%
22 months	0	0%
23 months	0	0%
24 months	1	1%
25-30 months	1	1%
31-35 months	0	0%
3 years	0	0%
More than 3 years	0	0%
Total	99	100%

35. The average amount of time that I typically spend on a project conducting an aerospace technology assessment (ATA) using criteria aggregation methods is:

Never used this method for ATA	56	57%
1 day	2	2%
2 days	2	2%
3 days	0	0%
4 days	1	1%
5 days	4	4%
6 days	0	0%
7 days	1	1%
8 days	0	0%
9 days	0	0%
10 days	3	3%
11 days	0	0%
12 days	0	0%
13 days	0	0%
14 days	3	3%
15 days	0	0%
16 days	0	0%
17 days	0	0%
18 days	0	0%

19 days	0	0%
20 days	1	1%
21 days	0	0%
22 days	0	0%
23 days	0	0%
24 days	1	1%
25 days	0	0%
26 days	0	0%
27 days	0	0%
28 days	2	2%
29 days	0	0%
1 month	3	3%
2 months	2	2%
3 months	8	8%
4 months	1	1%
5 months	0	0%
6 months	3	3%
7 months	0	0%
8 months	0	0%
9 months	0	0%
10 months	0	0%
11 months	1	1%
12 months	4	4%
13 months	0	0%
14 months	0	0%
15 months	0	0%
16 months	0	0%
17 months	0	0%
18 months	0	0%
19 months	0	0%
20 months	0	0%
21 months	0	0%
22 months	0	0%
23 months	0	0%
24 months	1	1%
25-30 months	0	0%
31-35 months	0	0%
3 years	0	0%

More than 3 years	0	0%
Total	99	100%

36. The average amount of time that I typically spend on a project conducting an aerospace technology assessment (ATA) using explicit tradeoff approaches is:

Never used this method for ATA	65	66%
1 day	0	0%
2 days	1	1%
3 days	2	2%
4 days	1	1%
5 days	2	2%
6 days	0	0%
7 days	1	1%
8 days	0	0%
9 days	1	1%
10 days	2	2%
11 days	0	0%
12 days	0	0%
13 days	0	0%
14 days	0	0%
15 days	1	1%
16 days	0	0%
17 days	0	0%
18 days	0	0%
19 days	0	0%
20 days	3	3%
21 days	0	0%
22 days	0	0%
23 days	0	0%
24 days	0	0%
25 days	0	0%
26 days	0	0%
27 days	0	0%
28 days	0	0%
29 days	0	0%
1 month	3	3%
2 months	1	1%
3 months	8	8%

4 months	2	2%
5 months	0	0%
6 months	3	3%
7 months	0	0%
8 months	0	0%
9 months	0	0%
10 months	0	0%
11 months	0	0%
12 months	1	1%
13 months	0	0%
14 months	0	0%
15 months	0	0%
16 months	0	0%
17 months	0	0%
18 months	0	0%
19 months	0	0%
20 months	0	0%
21 months	0	0%
22 months	0	0%
23 months	0	0%
24 months	1	1%
25-30 months	0	0%
31-35 months	0	0%
3 years	0	0%
More than 3 years	1	1%
Total	99	100%

37. The average amount of time that I typically spend on a project conducting an aerospace technology assessment (ATA) without any of the 4 types of decision analysis methods previously mentioned is:

Never used this method for ATA	34	34%
1 day	3	3%
2 days	2	2%
3 days	4	4%
4 days	1	1%
5 days	2	2%
6 days	1	1%
7 days	4	4%
8 days	1	1%

9 days	0	0%
10 days	7	7%
11 days	0	0%
12 days	0	0%
13 days	0	0%
14 days	3	3%
15 days	1	1%
16 days	0	0%
17 days	0	0%
18 days	0	0%
19 days	0	0%
20 days	0	0%
21 days	1	1%
22 days	0	0%
23 days	0	0%
24 days	0	0%
25 days	0	0%
26 days	0	0%
27 days	0	0%
28 days	2	2%
29 days	0	0%
1 month	8	8%
2 months	4	4%
3 months	7	7%
4 months	0	0%
5 months	0	0%
6 months	6	6%
7 months	0	0%
8 months	1	1%
9 months	0	0%
10 months	1	1%
11 months	0	0%
12 months	4	4%
13 months	0	0%
14 months	0	0%
15 months	0	0%
16 months	0	0%
17 months	0	0%

18 months	1	1%
19 months	0	0%
20 months	0	0%
21 months	0	0%
22 months	0	0%
23 months	0	0%
24 months	1	1%
25-30 months	0	0%
31-35 months	0	0%
3 years	0	0%
More than 3 years	0	0%
Total	99	100%

SECTION 5 - Satisfaction with Decision Analysis for Aerospace Technology Assessment The set of questions on this page explore your satisfaction with using decision analysis methods for aerospace technology assessment. To what extent do you agree with the following statements?:

38. Aerospace technology assessments, conducted using decision trees, are helpful in developing R&D portfolios

Strongly disagree	3	3%
Somewhat disagree	4	4%
Neither agree or disagree	8	8%
Somewhat agree	29	29%
Strongly agree	25	25%
No experience with aerospace technology assessments using decision trees	30	30%
Total	99	100%

39. Aerospace technology assessments, conducted using influence diagrams, are helpful in developing R&D portfolios

Strongly disagree	2	2%
Somewhat disagree	0	0%
Neither agree or disagree	10	10%
Somewhat agree	22	22%
Strongly agree	13	13%
No experience with aerospace technology	52	53%

assessments using influence diagrams		
Total	99	100%

40. Aerospace technology assessments, conducted using criteria aggregation methods, are helpful in developing R&D portfolios

Strongly disagree	4	4%
Somewhat disagree	2	2%
Neither agree or disagree	6	6%
Somewhat agree	26	26%
Strongly agree	18	18%
No experience with aerospace technology assessments using criteria aggregation methods	43	43%
Total	99	100%

41. Aerospace technology assessments, conducted using explicit tradeoff approaches, are helpful in developing R&D portfolios

Strongly disagree	0	0%
Somewhat disagree	4	4%
Neither agree or disagree	9	9%
Somewhat agree	19	19%
Strongly agree	19	19%
No experience with aerospace technology assessments using explicit tradeoff approaches	48	48%
Total	99	100%

42. Aerospace technology assessments, conducted without any of the 4 types of decision analysis methods previously mentioned, are helpful in developing R&D portfolios

Strongly disagree	5	5%
Somewhat disagree	9	9%
Neither agree or disagree	17	17%
Somewhat agree	27	27%
Strongly agree	15	15%

No experience with aerospace technology assessments without the 4 specified decision analysis methods		26	26%
	Total	99	100%

SECTION 6 - Value of Decision Analysis for Aerospace Technology Assessment The set of questions in this section explore your perceived value of using decision analysis methods for aerospace technology assessment. To what extent do you agree with the following statements?:

43. Most aerospace technology assessments completed using decision analysis methods produce results more reliable than those obtained by intuition and experience

Strongly disagree		10	10%
Somewhat disagree		3	3%
Neither agree or disagree		29	29%
Somewhat agree		34	34%
Strongly agree		23	23%
	Total	99	100%

44. If decision analysis methods are used in the aerospace technology assessment process, I am better able to explain my results to senior managers

Strongly disagree		7	7%
Somewhat disagree		2	2%
Neither agree or disagree		21	21%
Somewhat agree		33	33%
Strongly agree		36	36%
	Total	99	100%

45. How likely is it that you will use or recommend the following decision analysis methods in future aerospace technology assessments?

Top number is the count of respondents selecting the option. Bottom % is percent of the total respondents selecting the option.	Not at all likely	Somewhat not likely	Neutral	Somewhat likely	Very likely
Decision trees	13 13%	6 6%	28 28%	28 28%	24 24%
Influence diagrams	16 16%	10 10%	38 38%	22 22%	13 13%
Criteria aggregation methods	17 17%	4 4%	32 32%	23 23%	23 23%

Explicit tradeoff approaches	17 17%	7 7%	34 34%	19 19%	22 22%

46. The sophistication of most decision analysis methods are beyond the routine use of many R&D managers

Strongly disagree	3	3%
Disagree	17	17%
Neutral	31	31%
Agree	35	35%
Strongly agree	13	13%
Total	99	100%

47. I am concerned about the validity of the mathematics underneath decision analysis methods

Strongly disagree	15	15%
Disagree	34	34%
Neutral	22	22%
Agree	19	19%
Strongly agree	9	9%
Total	99	100%

48. Most decision analysis methods are too complex to use on a regular basis

Strongly disagree	10	10%
Disagree	36	36%
Neutral	29	29%
Agree	20	20%
Strongly agree	4	4%
Total	99	100%

49. Despite the uncertainty in R&D activities, it is possible to estimate accurately the inputs required by most decision analysis methods

Strongly disagree	7	7%
Disagree	21	21%
Neutral	36	36%
Agree	30	30%
Strongly agree	5	5%
Total	99	100%

50. The high costs of acquiring the data/information make most decision analysis methods far too expensive

Strongly disagree	6	6%
Disagree	26	26%
Neutral	47	47%
Agree	14	14%
Strongly agree	6	6%
Total	99	100%

51. Most decision analysis methods require too much quantitative input data, not readily available within the organization

Strongly disagree	5	5%
Disagree	19	19%
Neutral	35	35%
Agree	33	33%
Strongly agree	7	7%
Total	99	100%

52. I believe that the use of decision analysis methods will help me to reduce some of the uncertainty I feel about our technology selection decisions

Strongly disagree	2	2%
Disagree	9	9%
Neutral	22	22%
Agree	51	52%
Strongly agree	15	15%
Total	99	100%

53. I am comfortable using decision analysis methods even though they are based on complex mathematical algorithms

Strongly disagree	3	3%
Disagree	4	4%
Neutral	27	27%
Agree	49	49%
Strongly agree	16	16%
Total	99	100%

54. It is difficult to apply most decision analysis methods to some of our technologies

Strongly disagree	6	6%

Disagree		20	20%
Neutral		28	28%
Agree		37	37%
Strongly agree		8	8%
	Total	99	100%

55. I believe decision analysis methods limit emotional appeals and personal bias

Strongly disagree		5	5%
Disagree		17	17%
Neutral		18	18%
Agree		46	46%
Strongly agree		13	13%
	Total	99	100%

56. I believe using decision analysis methods helps explain the selection process to external customers/end users

Strongly disagree		0	0%
Disagree		5	5%
Neutral		19	19%
Agree		52	53%
Strongly agree		23	23%
	Total	99	100%

57. I believe that the successful use of decision analysis methods depends on the selection criteria in the decision model

Strongly disagree		0	0%
Disagree		1	1%
Neutral		9	9%
Agree		62	63%
Strongly agree		27	27%
	Total	99	100%

58. I believe that the successful use of decision analysis methods depends on the experience of the person(s) that implements the method

Strongly disagree		0	0%
Disagree		1	1%
Neutral		9	9%

Agree		57	58%
Strongly agree		32	32%
	Total	99	100%

59. I believe that I possess the skills to successfully gather reliable input data for most decision analysis methods

Strongly disagree		3	3%
Disagree		17	17%
Neutral		30	30%
Agree		38	38%
Strongly agree		11	11%
	Total	99	100%

60. I believe that if given reliable input data, I possess the skill to successfully implement most decision analysis methods

Strongly disagree		5	5%
Disagree		10	10%
Neutral		23	23%
Agree		49	49%
Strongly agree		12	12%
	Total	99	100%

SECTION 7 - PERSONAL BACKGROUND The set of questions in this section will be used to compare your answers with those of other people. All of your answers are strictly confidential

61. The highest degree that I have earned is:

High school diploma		0	0%
Associates		1	1%
Bachelors		21	21%
Masters		59	60%
Doctorate		18	18%
Other professional degree (medical, law, etc.)		0	0%
None of the above		0	0%
	Total	99	100%

62. My gender is

Female		24	24%
Male		75	76%
	Total	99	100%

63. Which of the following most closely describes your current employer:

Federal Government (civil servant)		71	72%
Contractor at Government Facility		8	8%
State or Local Government		0	0%
Academia		3	3%
Private Industry		9	9%
Self-Employed		5	5%
Retired (Federal Government)		2	2%
Retired (Other)		0	0%
Other, please specify		1	1%
	Total	99	100%

64. Which of the following most closely describes your job function in the last five years:

Decision Practitioner		7	7%
Management/Supervisor		22	22%
Science or Engineering		69	70%
Administrative		0	0%
Other, please specify		1	1%
	Total	99	100%

65. How many years experience do you have working in the aerospace field?

0	0	0%
less than 1	1	1%
1-5	6	6%
6-10	9	9%
11-15	9	9%
16-20	18	18%
21-25	17	17%
26-30	19	19%

31-35		11	11%
36-40		5	5%
41 or more		4	4%
	Total	99	100%

VITA

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EDUCATION

- M.E., Systems Engineering, University of Virginia, 1990, Charlottesville, VA
- B.A., Mathematics (Highest Honors, Departmental Honors), 1987, Hampton University, Hampton, VA

EXPERIENCE

NASA Langley Research Center, Hampton, Virginia 5/90 – present
Aerospace Engineer. Aviation safety and cost specialist. Developed and evaluated computer vision algorithms for telerobotic tasks in previous position.

Lockheed Engineering & Sciences Co., Hampton, Virginia 7/89 – 5/90
Computer Programmer Associate. Provided computer vision support.

NASA Langley Research Center, Hampton, Virginia 6/87 – 8/87
Langley Research Summer Scholars Program (LARSS) Participant. Used mathematical programming techniques to modify robot vision computer software.

IBM, Manassas Virginia 5/85 – 8/86
Cooperative Education Program Participant. Built complex hardware models into even larger networks for testing bus protocols. Modified computer program that operated an AEHR robotic arm.

AWARDS

- Exceptional Service Medal, 2008, NASA
- Certificate of Distinguished Performance, 2007, NASA Langley
- Individual Award, 2004, 2003, 2002 and 2001, NASA Langley
- Turning Goals into Reality NASA Administrator's Award, 2000, NASA
- Superior Accomplishment Award, 1996 and 1995, NASA Langley
- Certificate of Outstanding Performance, 2005, 1998, 1997, 1996, NASA Langley

CLUBS, ORGANIZATIONS AND BOARDS

- Senior Member, American Institute of Aeronautics and Astronautics (AIAA)
- Member, Joint Implementation Measurement and Data Analysis Team (JIMDAT) for the Commercial Aviation Safety Team (CAST)
- Co-Chair 2004 Annual FAA/NASA International Workshop on Risk Analysis and Safety Performance Measurement in Aviation
- Former Executive Board Member, Air Transportation Research International Forum (ATRIF)