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Thomas E. Pinelli
NASA Langley Research Center
Hampton, Virginia

Nanci A. Glassman and Linda O. Affelder
Continental Research
Norfolk, Virginia

Laura M. Hecht and John M. Kennedy
Indiana University
Bloomington, Indiana

Rebecca O. Barclay
Rensselaer Polytechnic Institute
Troy, New York

National Aeronautics and Space Administration

Department of Defense

INDIANA UNIVERSITY

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by

Thomas E. Pinelli, Nanci A. Glassman, Linda O. Affelder,
Laura M. Hecht, John M. Kennedy, and Rebecca O. Barclay

ABSTRACT

This paper reports the results of an exploratory study that investigated the influence of technical uncertainty on the use of information and information sources by U.S. industry-affiliated aerospace engineers and scientists in completing or solving a project, task, or problem. Data were collected through a self-administered questionnaire. Survey participants were U.S. aerospace engineers and scientists whose names appeared on the Society of Automotive Engineers (SAE) mailing list. The results support the findings of previous research and the following study assumptions. Information and information-source use differ for projects, problems, and tasks with high and low technical uncertainty. As technical uncertainty increases, information-source use changes from internal to external and from informal to formal sources. As technical uncertainty increases, so too does the use of federally funded aerospace research and development (R&D). The use of formal information sources to learn about federally funded aerospace R&D differs for projects, problems, and tasks with high and low technical uncertainty.

INTRODUCTION

The *NASA/DoD Aerospace Knowledge Diffusion Research Project* attempts to understand, among other things, the information environment in which U.S. aerospace engineers and scientists work and the factors that influence their use of scientific and technical information (STI) (Pinelli, Kennedy, and Barclay, 1991). Such an understanding could (1) lead to the development of practical theory, (2) contribute to the design and development of aerospace information systems, and (3) have practical implications for transferring the results of federally funded aerospace research and development (R&D) to the U.S. aerospace community.

This paper reports the results of an exploratory study that investigated the influence of technical uncertainty on the use of information and information sources by U.S. industry-affiliated aerospace engineers and scientists in completing or solving a project, task, or problem. Several authors have explored relationships among uncertainty and information use (Gifford, Bobbitt, and Slocum, 1979; and Randolph, 1978). Randolph (1978) found that the greater the uncertainty associated with the task, the greater the use of STI. These findings, plus the work of Bodensteiner (1970); Holland, Stead and Leibrock (1976); Atkin (1973); and Kuhlthau (1991), led us to investigate the extent to which the perceived technical uncertainty of a project, task, or problem affected the use of information and information sources by U.S. aerospace engineers and scientists. The work of Paisley (1980), Wilson (1981), Roberts (1982), Dervin (1983), and Taylor (1991) regarding "information use environments" influenced the conceptual framework, underlying assumptions, and direction of this study.

Information on the aerospace information environment is included to help establish a context for the study. The study's methodology is described, and the variables and their measurement are explained. The study's hypotheses, the data used to test the hypotheses, and a discussion of the results are presented.

THE AEROSPACE INFORMATION ENVIRONMENT

Organizations such as aerospace that are involved in innovation are open systems that must deal with complexity and sources of work-related uncertainty (Katz and Kahn, 1966). This proposition traces its origins to, among others, Galbraith (1973) and Duncan (1973), who have conceptualized organizations as information processing systems that must deal with uncertainty. Tyson (1992) and Mowery (1985) state that the aerospace industry, in particular the commercial aviation sector, is characterized by the high degree of systemic complexity embodied in the design and development of its products. Industries such as aerospace must deal with technical and market uncertainty from outside the organization as well as uncertainty concerning problem solving within the organization (Myers and Marquis, 1969; Utterback, 1974). Miller (1971) states that organizations use business and technical information, obtained largely from the external environment, to reduce technical uncertainty and complexity.

Three factors (task characteristics, task environment, and task interdependence) combine to influence the degree of technical uncertainty and complexity with which organizations involved in innovation must contend (Tushman and Nadler, 1980). Uncertainty increases as the task becomes more complicated, as the environment becomes more dynamic, and as task interdependence becomes more complex. The greater the technical uncertainty and complexity, the greater the information processing requirements and the greater the need for information external to the organization (Rosenbloom and Wolek, 1970; Allen, 1970).

In a telephone survey (Pinelli, Kennedy, and White, 1992), members of the Society of Automotive Engineers (SAE) were asked how the technical uncertainty of a project affected the need for STI. Most aerospace engineers (71 percent) agreed that technical uncertainty increased the need for STI. About 58 percent strongly agreed that technical uncertainty increased the need for internal STI, and 42 percent strongly agreed that it increased the need for external STI. Non-aerospace engineers (66 percent) also agreed that technical uncertainty increased the need for STI. About 40 percent strongly agreed that technical uncertainty increased the need for internal STI, and about 36 percent strongly agreed that technical uncertainty increased the need for external STI.

However, it is the nature of organizations that are involved in innovation, such as aerospace, to isolate themselves from their external environment and to erect barriers to communication with the external environment (Gerstenfeld and Berger, 1980). This behavior is due, in large part, to the need for organizations to maintain stability and control, and because these organizations are involved in activities of a proprietary nature that involve trade secrets and intellectual property (Fischer, 1980; Allen, 1970). Aerospace organizations are frequently involved in work that may be classified for reasons of national security. As Fischer (1980) points out, however, there is a danger for organizations engaged in innovation to become isolated from their external environment and from information external to the organization. Organizations use a variety of techniques or "boundary-spanning" activities to maintain contact with the external environment and to acquire business and technical information that is external to the organization. The three primary boundary-spanning activities used by organizations involved in innovation fall into two groups—the **informal** that relies on collegial/peer group contacts and gatekeepers/linking agents and the **formal** that relies on librarians and technical information specialists. The more "active" and coordinated these activities, the more effective the boundary-spanning function. The work of Aguilar (1967), Duncan (1972), Keegan (1974), Hambrick (1979), and Auster and Choo (1993) is relevant to this discussion.

Derian (1990) has described the U.S. aerospace industry as a "sheltered" (as opposed to an exposed) culture because of the role played by government in the innovation process and because aerospace operates in both government and private sector markets. He points out that, unlike other U.S. industries, aerospace, principally the commercial aviation sector, has been the beneficiary of federally funded R&D for nearly a century. According to Mowery (1985), "The commercial aircraft industry is virtually unique among U.S. manufacturing industries in that a Federal research organization, the National Advisory Committee for Aeronautics (NACA) and subsequently the National Aeronautics and Space Administration (NASA), has for many years conducted and funded research on airframe and propulsion technologies." The commercial aviation sector has also benefitted from considerable investment, in terms of research and procurement, by the Department of Defense (DoD). "Although not intended to support innovation in any but military airframe and propulsion technologies, [this investment] has, nonetheless, yielded indirect, but very important, technological spillovers to the commercial aircraft industry" (Mowery, 1985).

Derian (1990) states that the aerospace industry is subject to a unique set of *externalities* that result from government intervention which, in turn, change the structure and regulation of the marketplace. Thus, the external environments of sheltered and exposed cultures are distinctive, as is the interaction between the two cultures and the external environment. In the case of the U.S. aerospace industry, the interaction with and isolation from the external environment are moderated somewhat by the "supply-push/demand-pull" effect created by the U.S. government's involvement, primarily through NASA and the DoD, in the aerospace innovation process. From a policy perspective, the U.S. government is both a performer and a dominant purchaser of aerospace R&D, supports precommercial research in civilian and military aircraft technologies, and plays a major role in diffusing the results of that research throughout the aerospace industry.

CONCEPTUAL FRAMEWORK

The conceptual framework is based on the work of Paisley (1968, 1980), Allen (1977), Taylor (1991), and Mick (1979) and represents an extension of Orr's (1970) scheme of the engineer-scientist as an information processor. Information use is central to this concept. It acts to moderate (reduce) uncertainty. Rogers (1982) has stated that the process of innovation involves considerable risk and grappling with unknowns which may be technical, economic, or merely the manifestation of personal and social variables. When faced with technical uncertainty, individuals seek information, which is why information (communication) behavior cannot be ignored in the study of technological innovation.

Three consistent findings emerge from the numerous information use studies that have been conducted over the past 25 years: the reliance of engineers on interpersonal communication (e.g., face-to-face conversations), the proclivity of engineers to use information that is closest in proximity (e.g., personal collection of information) to their work site, and the tendency of engineers not to rely on libraries and the assistance of librarians for obtaining information. Engineers do use written communications. Their use of information is not always limited to their personal collections, however. They do use libraries and seek the assistance of librarians. They tend to use all of these sources presumably until their need for information has been met.

Assumptions

This study is guided by the assumption that information use and patterns of information use by U.S. aerospace engineers and scientists differ with the degree of technical uncertainty (high or low) characteristic of the project, problem, or task at hand. The basic assumptions are: (1) as technical uncertainty increases, the time spent communicating technical information increases; and (2) as technical uncertainty increases, reliance on information from internal, informal sources gives way to the use of information from external, formal sources. Specifically, it is expected that U.S. aerospace engineers and scientists working on projects, problems, and tasks with high technical uncertainty will make greater use of external sources of information. External sources include (1) colleagues outside of the organization and (2) published sources of written information that originate outside of the organization (e.g., conference/meeting papers, journal articles, and technical reports). Further, U.S. aerospace engineers and scientists working on projects, problems, and tasks with high technical uncertainty will make greater use of the formal information process. The formal component of the information structure is defined as (1) the use of the organization's library or technical information center and (2) the use of the organization's librarians and technical information specialists.

This study also assumes that the results of federally funded aerospace R&D are used by U.S. aerospace engineers and scientists in industry to moderate (reduce) technical uncertainty. Federally funded R&D is defined here as information available in NASA or DoD reports. It is expected that

U.S. aerospace engineers and scientists will be more likely to use federally funded R&D reports when working on projects, problems, and tasks that are high in technical uncertainty than on projects characterized by low levels of uncertainty. Finally, it is expected that the use of formal information sources by U.S. aerospace engineers and scientists as a means to learn about federally funded aerospace R&D increases as the technical uncertainty of the project, problem, or task increases.

Hypotheses

This study seeks to understand the influence of technical uncertainty on (1) information production and information use, (2) the use of external information, (3) the use of formal information sources, and (4) the use of federally funded aerospace R&D. The following hypotheses, informed by the assumptions reviewed above, were generated for testing:

Technical Uncertainty and Information Production/Use

H_1 As the technical uncertainty of job-related projects, tasks, or problems increases, the number of hours per week spent communicating technical information in writing increases.

H_2 As the technical uncertainty of job-related projects, tasks, or problems increases, the number of hours per week spent communicating technical information to others orally increases.

H_3 As the technical uncertainty of job-related projects, tasks, or problems increases, the number of hours per week spent working with written technical information received from others increases.

H_4 As the technical uncertainty of job-related projects, tasks, or problems increases, the number of hours per week spent working with technical information received orally from others increases.

Technical Uncertainty and External Information Use

H_5 As the technical uncertainty of job-related projects, tasks, or problems increases, the frequency of use of written technical information (journal articles) produced outside of the organization increases.

H_6 As the technical uncertainty of job-related projects, tasks, or problems increases, the frequency of use of written technical information (conference/meeting papers) produced outside of the organization increases.

H_7 As the technical uncertainty of job-related projects, tasks, or problems increases, the frequency of use of written technical information (U.S. government technical reports) produced outside of the organization increases.

H_8 The technical uncertainty of job-related projects, tasks, or problems is related to the frequency of use of written technical information obtained from colleagues outside of the organization.

Technical Uncertainty and the Use of Formal Information Sources

H_9 The level of technical uncertainty of job-related projects, tasks, or problems is related to the use (non-use) of technical information obtained from the organization's library.

H_{10} The level of technical uncertainty of job-related projects, tasks, or problems is related to the use (non-use) of technical information obtained from librarians and technical information specialists inside of the organization.

Technical Uncertainty and the Use of Federally Funded Aerospace R&D

H_{11} The level of technical uncertainty of job-related projects, tasks, or problems is related to the use of federally funded aerospace R&D.

H_{12} The level of technical uncertainty of job-related projects, tasks, or problems is related to the reported importance of federally funded aerospace R&D.

H_{13} The level of technical uncertainty of job-related projects, tasks, or problems is related to the use of federally funded R&D found in NASA or DoD technical reports.

H_{14} The level of technical uncertainty of job-related projects, tasks, or problems is related to the use of colleagues outside of the organization to learn about federally funded aerospace R&D.

H_{15} The level of technical uncertainty of job-related projects, tasks, or problems is related to the use of librarians inside of the organization to learn about federally funded aerospace R&D.

H_{16} The level of technical uncertainty of job-related projects, tasks, or problems is related to the use of searches of computerized data bases to learn about federally funded aerospace R&D.

H_{17} The level of technical uncertainty of job-related projects, tasks, or problems is related to the use of publications such as STAR to learn about federally funded aerospace R&D.

METHODOLOGY

This research was conducted as a Phase 1 activity of the *NASA/DoD Aerospace Knowledge Diffusion Research Project*. The study utilized survey research in the form of a self-administered (self-reported) mail questionnaire. Survey participants were U.S. aerospace engineers and scientists whose names appeared on the Society of Automotive Engineers (SAE) mailing list. A total of 946 usable surveys was received by the established cut-off date. Of the 946 respondents, 872 (92.2%) worked in industry, 63 (6.7%) worked in government, 6 (0.6%) worked in academia, and 5 (0.5%) had some other affiliation. The adjusted completion rate for the survey was 67 percent.

A variation of Flanagan's (1954) critical incident technique was used to guide data collection. According to Lancaster (1978), the theory behind the critical incident technique is that it is much easier for people to recall accurately what they did on a specific occurrence or occasion than it is to remember what they do in general. In this study, respondents were asked to categorize the most important job-related project, task, or problem they had worked on in the past 6 months. The categories included (1) education, (2) research, (3) design/development, (4) manufacturing/production, (5) computer applications, (6) management, and (7) other.

Respondents were also asked to rate the amount of technical uncertainty they faced when they started their most important project, task, or problem. Technical uncertainty was measured on 5-point scales (1.0 = little uncertainty; 5.0 = great uncertainty). Survey participants were also asked to indicate whether they worked alone or with others in completing/solving the most important job-related project, task, or problem they had worked on in the past six months.

Technical uncertainty and the importance of federally funded aerospace R&D were measured using ordinal scales. Hours spent communicating and the number of journal articles, conference/meeting papers, and U.S. government technical reports used were measured on an interval scale. Use of formal information sources and federally funded aerospace R&D were measured using a nominal scale. Hypothesis tests were based on responses of the 872 industry-affiliated respondents (total number of respondents = 946). A one-tailed t-test was used to test hypotheses involving the mean number of hours and information products used; Pearson's r was used to test correlations. The chi-square test of independence was used to test hypotheses involving nominal data.

DESCRIPTIVE FINDINGS

The following "composite" participant profile was developed for the industry-affiliated respondents: has a bachelor's degree (52.5%), has an average of 18.7 years of work experience in aerospace, was educated as and works as an engineer (90.7%, 90.8%), and works in design/development (60.4%).

Survey participants were asked to categorize the most important job-related project, task, or problem they had worked on in the past six months. A majority of the job-related projects, tasks, and problems (56.4%) were categorized as design/development. About 11 percent and 14 percent of the job-related projects, tasks, and problems were categorized as manufacturing/production and management, respectively. Most respondents (82.7%) worked with others (did not work alone) in completing their most important job-related project, task, or problem. On average, respondents worked with 2.75 groups; each group contained an average of 6.7 members. A majority of respondents (72%) performed engineering duties while working on their most important job-related project, task, or problem. About 24 percent performed management duties.

TESTS OF THE HYPOTHESES

Technical Uncertainty and Information Production/Use

Hypotheses H_1 through H_4 state that as the technical uncertainty of job-related projects, tasks, or problems increases, the number of hours per week spent in the past six months communicating information increases. Technical uncertainty was initially measured using a 5-point scale (1 = little uncertainty; 5 = great uncertainty). Job-related projects, tasks, or problems were sorted into two categories for hypothesis testing: "low uncertainty" (technical uncertainty = 1, 2) and "high uncertainty" (technical uncertainty = 3, 4, 5). The mean number of hours per week spent (1) communicating technical information to others, both written and orally, and (2) working with information, both written and oral, received from others was calculated for each uncertainty group. T-tests were used to determine whether a significant relationship exits between the amount of time spent communicating technical information and the level of technical uncertainty associated with the project, task, or problem in question. Results of these tests follow:

Communicating Technical Information: To Others: (Output)	Uncertainty Group	($\bar{X}$)	(n)	Significant Difference of Group Means?
In Writing:	Low	8.35	217	Yes*
	High	9.11	618	
Orally:	Low	10.26	220	No
	High	10.85	613	

Working With Technical Information: Received From Others: (Input)	Uncertainty Group	($\bar{X}$)	(n)	Significant Difference of Group Means?
In Writing:	Low	6.66	223	Yes*
	High	8.18	635	
Orally:	Low	6.17	213	Yes*
	High	7.42	606	

*$p \leq 0.05$.

The differences between the group means for communicating written information to others and working with technical information received from others (both written information and communicating orally) are statistically significant. These results provide support for hypotheses H_1, H_3, and H_4: as the technical uncertainty of job-related projects, tasks, or problems increases, the number of hours per week spent communicating technical information to others and working with technical information received from others, both written and oral, increases. The difference between the group means for communicating technical information to others orally is not statistically significant. Thus H_2, which states that the number of hours per week spent working with information received orally from others increases as the uncertainty of the project, task, or problem increases, was not supported.

Technical Uncertainty Rating and Information Use—Products Used

Hypotheses H_5 through H_7 state that as the technical uncertainty of job-related projects, tasks, or problems increases, the mean number of externally produced information products used increases. Again, technical uncertainty scores were sorted into the categories "low uncertainty" and "high uncertainty." Means were calculated for these two groups with regard to the number of journal articles, conference/meeting papers, and U.S. government technical reports (NASA and DoD reports) used in the past six months. Hypotheses H_5 through H_7 were tested by calculating (1) correlations between the number of externally produced information products used in the past 6 months (Pearson's r) with technical uncertainty and (2) performing t-tests to determine whether a significant relationship exists between the number of externally produced products used and the level of technical uncertainty of the project, task or problem. Results of these tests follow:

Technical Uncertainty Rating and Information Products Used:

	r
Journal Articles	.1097**
Conference/Meeting Papers	.0688
U.S. Government Technical Reports	.0862*

* $p \leq 0.01$.
** $p \leq 0.001$.

	Uncertainty Group	$(\bar{X})$	(n)	Significant Difference of Group Means?
Journal Articles**	Low	4.81	231	Yes*
	High	7.46	641	
Conference/Meeting Papers**	Low	2.70	231	Yes*
	High	4.10	641	
U.S. Government Technical Reports**	Low	2.70	231	Yes*
	High	4.10	641	

*$p \leq 0.05$.
** Item non-responses coded as 0.

The t-tests indicate that the differences in the mean number of externally produced information products used by the two uncertainty groups (low and high) are statistically significant. These results support the hypotheses which collectively state that as technical uncertainty increases, the frequency of use of externally produced information products increases.

Technical Uncertainty and External Information Use—Colleagues Outside of the Organization

Hypothesis H_8 states that the use/non-use of technical information obtained from colleagues outside of the organization is related to the level (high or low) of technical uncertainty of job-related projects, tasks, or problems. This hypothesis was tested by cross-tabulating low and high technical uncertainty with the use/non-use of colleagues outside of the organization. The chi-square analysis follows. The chi-square test of independence revealed that information obtained from colleagues outside of the organization is related to the technical uncertainty of the job-related project, task, or problem. The chi-square statistic is significant at $p \leq 0.05$. Hypothesis H_8 (technical uncertainty is related to the use of colleagues outside of the organization) is supported.

Use of Colleagues Outside of the Organization

	Count / Row Pct / Col Pct / Residual	Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	0	91 37.4% 39.4% 26.6	152 62.6% 23.7% -26.6	243 27.9%
Use	1	140 22.3% 60.6% -26.6	489 77.7% 76.3% 26.6	629 72.1%
	Column Total	231 26.5%	641 73.5%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	20.77192	1	.00001*

* $p \leq 0.05$.
** Item non-responses coded as 0.

Technical Uncertainty and the Use of Formal Information Sources

Hypotheses H_9 and H_{10} state that the technical uncertainty of job-related projects, tasks, and problems is related to (1) the use of information obtained from a librarian/technical information specialist inside the organization and (2) the use of information obtained from the organization's library. The technical uncertainty associated with the most important job-related project, task, or problem is categorized as low uncertainty or high uncertainty. The level of uncertainty is then cross-tabulated with (1) the use/non-use of a librarian/technical information specialist inside the organization and (2) the use/non-use of technical information obtained from the organization's library. The chi-square statistic is used to test for a significant relationship.

Use of a Librarian/Technical Information Specialist Inside the Organization

	Count / Row Pct / Col Pct / Residual	Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	0	150 29.6% 64.9% 16.0	356 70.4% 55.5% -16.0	506 58.0%
Use	1	81 22.1% 35.1% -16.0	285 77.9% 44.5% 16.0	366 42.0%
	Column Total	231 26.5%	641 73.5%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	6.15629	1	.01309*

* $p \leq 0.05$.
** Item non-responses coded as 0.

Use of Information Obtained From the Organization's Library

	Count / Row Pct / Col Pct / Residual	Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	0	117 36.2% 50.6% 31.4	206 63.8% 32.1% -31.4	323 37.0%
Use	1	114 20.8% 49.4% -31.4	435 79.2% 67.9% 31.4	549 63.0%
	Column Total	231 26.5%	641 73.5%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	24.95292	1	.00000*

* $p \leq 0.05$
** Item non-responses coded as 0.

The chi-square test of independence revealed that a relationship exists between (1) the use of a librarian/technical information specialist inside the organization and the level (low or high) of technical uncertainty or a project, task or problem and (2) the use of technical information obtained from the organization's library and the level (low or high) of technical uncertainty of a project, task, or problem. Hypotheses H_9 and H_{10} are therefore supported.

Technical Uncertainty and the Use of Federally Funded Aerospace R&D

Hypotheses H_{11} through H_{17} state that the technical uncertainty of job-related projects, tasks, or problems is related to the use of federally funded aerospace R&D. Specifically, the seven hypotheses state that job-related projects, tasks, or problems characterized by high technical uncertainty are related to (1) the use of federally funded R&D, (2) the use of federally funded aerospace R&D found in NASA or DoD technical reports, (3) the reported importance of federally funded aerospace R&D, (4) the use of colleagues outside of the organization to find out about the results of federally funded aerospace R&D, (5) the use of librarians/technical information specialists inside the organization to find out about the results of federally funded aerospace R&D, (6) the use of computerized data bases to find out about the results of federally funded aerospace R&D, and (7) the use of publications such as *STAR* to find out about the results of federally funded aerospace R&D. The results of the chi-square analyses follow:

Use of Federally Funded Aerospace R&D

Count / Row Pct / Col Pct / Residual		Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	.00	206 / 31.5% / 89.2% / 32.8	448 / 68.5% / 69.9% / -32.8	654 / 75.0%
Use	1.00	25 / 11.5% / 10.8% / -32.8	193 / 88.5% / 30.1% / 32.8	218 / 25.0%
Column Total		231 / 26.5%	641 / 73.5%	872** / 100.0%

	Value	DF	Significance
Pearson Chi-Square	33.68742	1	.00000*

* p ≤ 0.05
** Item non-responses coded as 0.

Use of Federally Funded Aerospace R&D found in NASA or DoD Technical Reports

Count / Row Pct / Col Pct / Residual		Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	.00	213 / 29.0% / 92.2% / 18.6	521 / 71.0% / 81.3% / -18.6	734 / 84.2%
Use	1.00	18 / 13.0% / 7.8% / -18.6	120 / 87.0% / 18.7% / 18.6	138 / 15.8%
Column Total		231 / 26.5%	641 / 73.5%	872** / 100.0%

	Value	DF	Significance
Pearson Chi-Square	15.22424	1	.00010*

* p ≤ 0.05
** Item non-responses coded as 0.

The Importance of Federally Funded Aerospace R&D

Reported importance (1 = very unimportant; 5 = very important) of federally funded R&D used to complete or solve job-related projects, tasks, or problems was correlated with the level of technical uncertainty. Technical uncertainty was also correlated with the use of 1) colleagues outside of the organization, 2) librarians/technical information specialists inside the organization, 3) computerized data bases, and 4) publications such as *STAR* to find out about the results of federally funded aerospace (1 = never used; 4 = frequently used). Pearson's r correlation coefficients follow:

Technical Uncertainty Rating and Sources Used

	r
Importance of Federally-Funded R&D	.2354*
Use of:	
Colleague Outside the Organization	.2241*
Librarian/Technical Information Specialist Inside the Organization	.2089*
Computerized Data Base	.2354*
STAR	.1600*

* $p \leq 0.001$.

Use of Colleagues Outside of the Organization

Count / Row Pct / Col Pct / Residual		Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	.00	179 / 33.0% / 77.5% / 35.2	364 / 67.0% / 56.8% / -35.2	543 / 62.3%
Use	1.00	52 / 15.8% / 22.5% / -35.2	277 / 84.2% / 43.2% / 35.2	329 / 37.7%
Column Total		231 / 26.5%	641 / 73.5%	872** / 100.0%

	Value	DF	Significance
Pearson Chi-Square	30.98700	1	.00000*

* p ≤ 0.05
** Item non-responses coded as 0.

Use of Librarians/Technical Information Specialists Inside the Organization

Count / Row Pct / Col Pct / Residual		Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	.00	194 / 32.0% / 84.0% / 33.5	412 / 68.0% / 64.3% / -33.5	606 / 69.5%
Use	1.00	37 / 13.9% / 16.0% / -33.5	229 / 86.1% / 35.7% / 33.5	266 / 30.5%
Column Total		231 / 26.5%	641 / 73.5%	872** / 100.0%

	Value	DF	Significance
Pearson Chi-Square	31.11160	1	.00000*

* p ≤ 0.05
** Item non-responses coded as 0.

Searches of Computerized Databases

Count Row Pct Col Pct Residual		Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	.00	194 32.6% 84.0% 36.1	402 67.4% 62.7% -36.1	596 68.3%
Use	1.00	37 13.4% 16.0% -36.1	239 86.6% 37.3% 36.1	276 31.7%
	Column Total	231 26.5%	641 73.5%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	35.50518	1	.00000*

* p ≤ 0.05
** Item non-responses coded as 0.

Use of Publications Such as *STAR*

Count Row Pct Col Pct Residual		Technical Uncertainty: Low .00	High 1.00	Row Total
Don't Use	.00	196 29.9% 84.8% 22.2	460 70.1% 71.8% -22.2	656 75.2%
Use	1.00	35 16.2% 15.2% -22.2	181 83.8% 28.2% 22.2	216 24.8%
	Column Total	231 26.5%	641 73.5%	872** 100.0%

	Value	DF	Significance
Pearson Chi-Square	15.60333	1	.00008*

* p ≤ 0.05
** Item non-responses coded as 0.

The chi-square test of independence revealed that an association exists between the technical uncertainty of job-related projects, tasks, and problems and (1) the use of federally funded aerospace R&D, (2) the use of federally funded aerospace R&D found in NASA or DoD technical reports, (3) the importance of federally funded aerospace R&D, (4) the use of colleagues outside of the organization to find out about the results of federally funded aerospace R&D, (5) the use of librarians/technical information specialists inside the organization to find out about the results of federally funded aerospace R&D, (6) the use of computerized data bases to find out about federally funded aerospace R&D, and (7) the use of publications such as *STAR* to find out about the results of federally funded aerospace R&D. Therefore, hypotheses H_{11} through H_{17} are supported.

<u>Summary</u>

Seventeen hypotheses concerned with technical uncertainty and (1) information production/use, (2) external information use, (3) the use of formal information sources, and (4) the use of federally funded aerospace R&D were tested. The results of the tests follow:

Technical Uncertainty and—

	Not Accepted	Accepted
Information Production/Use		
Information Written to Others		X
Communicating Orally to Others	X	
Written Information from Others		X
Oral Communication from Others		X
External Information Use		
Journal Articles		X
Conference/Meeting Papers		X
U.S. Government Technical Reports		X
Colleagues Outside the Organization		X
Use of Formal Information Sources		
Librarian/Technical Information Specialist		X
Technical Information Obtained from the Organization's Library		X
Use of Federally Funded Aerospace R&D		
Use of Federally Funded Aerospace R&D		X
Use of NASA or DoD Technical Reports		X
Importance of Federally Funded Aerospace R&D		X
Colleagues Outside the Organization		X
Librarian/Technical Information Specialist		X
Computerized Data Base		X
Publications Such as *STAR*		X

SUMMARY AND DISCUSSION OF THE RESULTS

An exploratory study was conducted that investigated the influence of technical uncertainty on the use of information and information sources by U.S. industry-affiliated aerospace engineers and scientists in completing or solving a project, task, or problem. The results support the findings of previous research. The results also support the following study assumptions.

1. Information use and information-source use patterns differ for industry-affiliated U.S. aerospace engineers and scientists working on projects, problems, and tasks with high and low technical uncertainty.

2. As technical uncertainty increases, information-source use changes from **internal** to **external** and from **informal** to **formal**. Specifically, industry-affiliated U.S. aerospace engineers and scientists working on projects, problems, and tasks with high technical uncertainty make greater use of **external** sources of information such as (1) colleagues outside their organization, (2) published sources of written information originating outside their organization (e.g., conference/meeting papers, journal articles, and technical reports), and (3) **formal** information sources including the organization's library or technical information center and the organization's librarian/technical information specialist.

3. The use of federally funded aerospace R&D is different for industry-affiliated U.S. aerospace engineers

and scientists working on projects, problems, and tasks with high and low technical uncertainty.

4. As technical uncertainty increases, so too does the use of federally funded aerospace R&D, thereby supporting the assumption that the results of federally funded aerospace R&D are used by U.S. aerospace engineers and scientists in industry to moderate (reduce) technical uncertainty.

5. The use of formal information sources to learn about federally funded aerospace R&D differs for industry-affiliated U.S. aerospace engineers and scientists working on projects, problems, and tasks with high and low technical uncertainty.

Given the limited purposes of this exploratory study and the research design, the results help explain but cannot be used to predict information use. A more rigorous research design and methodology is needed before any such claims of prediction could be made. Certain scales of measurement used in this study would have to be changed and Flanagan's critical incident technique followed more closely.

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