Development of a Method to Analyze and Classify Problem Statements in Technology Transfer

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Abstract

This paper reports on the development of a method to analyze and classify the problem statements of requestors of technology transfer assistance through NASA's Marshall Space Flight Center. Without a classification structure for problem statements, those responsible for finding solutions to technology-related problems have been unable to easily determine whether a problem is unique or if a solution has already been determined for similar problems.

A content analysis approach was developed to analyze problem statements from a technology transfer requests database. Results from the analysis were used to build a hierarchical classification structure which categorized the problem statements to three levels of detail. The resulting classification structure was evaluated and validated by an independent expert.

Prior to this study, no method for analysis and classification of problem statements was available to those responsible for providing technology transfer assistance. The research indicates that a useful analysis and classification methodology that should improve the efficiency of the technology transfer process has been developed.

Introduction

For many years the United States Government has pursued a policy of encouraging, even requiring, taxpayer-funded Federal Agencies to aggressively pursue the transfer of appropriate Government and Government contractor-developed technologies to the private sector of the U.S. economy. In 1986, Congress, concerned about the international trade imbalance and anxious that U.S. leadership in science and technology was not translating directly into leadership in the commercial marketplace, passed the Federal Technology Transfer Act.

This Act authorized government-owned, government-operated laboratories to form a cooperative research and development agreement with private-sector partners. The National Competitiveness Technology Transfer Act of 1989 provided further authority and guidance. This Act mandated technology transfer as a mission for federal research laboratories (McCain and Hudson, 1996).

One of the difficulties associated with such a large endeavor is identifying those commercial enterprises that are willing and able to bring government-owned or government-developed technologies to market. Another difficulty is identifying which technologies are most appropriate for commercialization. These two issues are often addressed through a Technology Transfer Agreement (TTA), included as Appendix A, between a government agency and commercial requestor of technology transfer assistance.

Key to the TTA is the technical problem statement that describes (or at least, *should* describe) some sort of technical question that has been raised for inquiry, consideration, or solution. As the number of requests for technology transfer assistance has grown, those responsible for providing technology transfer solutions are repeatedly encountering TTAs that contain problems that are not
(i.e. the problem has been solved in a previous instance) (W. H. Fieselman, personal communication, February 14, 1997). However, there is currently no adequate system in place to assist in identifying problem statements that have been solved as a result of a previous request.

Because technology transfer providers are unable to distinguish whether or not a problem statement is unique, a significant amount of time and effort may be expended to find a solution for a problem that has been previously solved. The research reported upon here describes a method which has been developed specifically to address this shortcoming. The method employs the combination of a unique application of content analysis and outside evaluation to build a classification structure for TTA problem statements. The structure holds the potential to be a useful tool in improving the efficiency of the technology transfer process. Further, the method may be appropriate to engineering and technology researchers as they attempt to better understand other types of problem statements.

The Nature of Problem Solving

A "problem" is an undesirable situation that is significant to and may be solvable by some agent, although probably with some difficulty (Agre, 1982). In the context of technology transfer, the problem definition statement contained within a TTA plays an important role in the determination of which technologies and other resources are available for use in the problem solution.

The technology transfer process is essentially a problem structuring and solving process. The process involves identification of government-developed technologies that are appropriate solutions for private business problems.

Many researchers (Barnhard, 1938; Polya, 1945; Reitman, 1964; Pounds, 1969; Bartee, 1973) have discussed different elements of the problem solving process. Yet, few of these studies yielded definite conclusions and none proposed a comprehensive problem solving methodology or theoretical model. In more recent years, however, researchers have built upon these early works to the point that a general model (Smith 1989, 1988, 1985) and several discipline-specific models of the nature of problem solving for Marketing, MIS, Accounting, and Engineering, among others (Khazanchi and Yadev, 1995; Turban, et al., 1996; McLeod, 1995; Henson and Hughes, 1991; Malhotra, et al., 1987; Zitelli and Tucker, 1991; and Ransom, 1990) appear in the literature. In each of these models, problem identification and definition are considered the first steps in successful problem solving.

Although problem definition appears to be recognized as a key component of problem solving, the problem definition process has been largely ignored in the management science literature (Lyles and Mitroff, 1980) despite Drucker's (1954) statement of problem definition's importance as a critical activity.

> *"Indeed, the most common source of mistakes in management decisions is the emphasis on finding the right answer rather than the right question.... The important and difficult job is never to find the right answer, it is to find the right question. For there are few things as useless—if not as dangerous—as the right answer to the wrong question" (Drucker, 1954, 111).*

In his 1989 work on defining managerial problems, Smith theorized a prescriptive framework for problem definition. While Smith's theorized problem definition framework is a positive step forward in the research of problem definition, it is not without its deficiencies. The framework has not been practically applied. Smith recognized that further work is necessary to determine *how* managers and management scientists define problems. The framework has not been validated in either field or laboratory contexts, using problems actually faced by subjects or assigned by experimenters. Also, the framework contains no methodology for analyzing and classifying problem definitions. Without an analysis and classification methodology, the problem definition concept continues to be elusive. Development of such a method, therefore, would appear to offer a significant contribution to researchers and practitioners as they continue to struggle to gain a better understanding of the essence of good problem definition.

The Technology Transfer Process

Technology transfer is the process by which technology, knowledge, and/or information developed in one organization, in one area, for one purpose is applied and utilized in another area or for another reason ("Technology Transfer," 1990). Technology is the practical application of knowledge, especially in a particular area ("Merriam-Webster's...," 1995). NASA, the U.S. Department of Defense (DOD), and the U.S. Department of Energy (DOE) are three of the government agencies most affected by legislation concerning technology transfer. Of these three, NASA's role in technology transfer holds particular significance to this research.

For many years, NASA has had a formal program designed to transfer information about new technologies developed for space application to the commercial sector of the economy. The Technology Transfer Office of NASA's Marshall Space Flight Center (MSFC) is one of the more successful implementations of this program. MSFC has been in the forefront of the development of U.S. industrial assistance programs using technologies developed at the Center. The innovative processes and procedures developed by the MSFC technology transfer program have been used as an informal model for the rest of the NASA technology transfer community ("NASA/Marshall...," 1997).

Marshall's focus concerning technology transfer is on the process of, and results obtained from, moving scientific discoveries and newly developed technologies from a Federal Government Laboratory or Agency to the non-Government industrial community (Craft, 1994). An example of a new technology developed by MSFC and available for transfer to the commercial sector is the Passive Light Exposure Module (PLEM) described in Appendix B.

NASA and its agents use the TTA to identify the most appropriate resources available within NASA to solve technology-related problems. The TTA form contains requests for information about the company requesting technical assistance, a question asking how the company learned that NASA provides technical assistance, a space for definition of the technical problem, a space for listing actions already performed by the company in attempting to solve the problem, a space for listing the desired result(s) associated with the problem solution, and a question asking when the results are needed.

Completed TTAs are administered by the Regional Technology Applications Board (RTAB). The RTAB meets each week to consider the TTAs placed on its agenda. The RTAB examines the technology-related company needs as defined in the TTA and attempts to match those needs with technologies and other resources available through NASA or other government organizations ("Technology transfer agreement services," 1997).

RTAB meetings are conducted via teleconference between the Stennis, Kennedy, and Marshall Space Flight Centers and several other affiliated offices (federal laboratories and university centers). A round-table discussion of the problem and potential solutions is followed by designation of an action and assignment of a Project Engineer (PE). In addition, the Board may come to an agreement to request more information from the company requesting assistance, refer the request to other agencies, or determine that the problem cannot be solved through the technology transfer process. The latter is an absolute last resort after all other possibilities have been exhausted.

Like other technology transfer providers, the RTAB repeatedly encounters non-unique problem statements. The result is that PEs often find themselves "reinventing the wheel" - expending time and effort searching for solutions that have already been found. If the RTAB had a classification structure for TTA problem statements, the Board could use the structure to determine if a like problem had already been considered by the Board in the past. While there has been considerable research into the nature of problem solving (Smith; 1988, 1989) no analysis and classification structure for problem statements has been developed (Harper and Rainer, 2000)

METHOD DEVELOPMENT

Content Analysis as a Research Tool

The aforementioned technology transfer process used by MSFC includes a historical record of the technology transfer assistance requests that have been addressed by the RTAB since its inception. The database was made available to the researcher for analysis. Because of the qualitative and subjective nature of the problem statements contained within the database, content analysis was judged to be a candidate method for analysis of the problem statements.

Content analysis deals with the systematic examination of current records or documents as sources of data (Best, 1977) and is a common technique employed in the social sciences to draw inferences from text (Weber, 1985). It is executed by objectively and systematically extracting attributes from written communications (Carney, 1972) and by analyzing those extracted parts (Budd, Thorp, and Donohew, 1967). This established research methodology has been used for such purposes as

- to describe prevailing practices or conditions;
- to discover the relative importance of, or interest in, certain topics or problems;
- to discover the level of difficulty in publications;
- to analyze the use of symbols; and
- to identify the styles of the communications' authors and evaluate their biases (Best, 1977).

As a mode of observation, content analysis is usually an operation of coding (Babbie, 1979). Communications - oral, written, or other - are coded or classified in terms of some conceptual framework. However, no such conceptual framework exists for technology transfer problems. Historical records of the board contained in the Technology Transfer Utilization Office database were sampled, analyzed, and classified in order to develop the classification system for the problem statements submitted to the RTAB by requestors of technology transfer assistance. Therefore, the researcher started the content analysis with no *a priori* expectations as to which actual classes of problem statements would emerge.

The Research Study Database

The researcher was supplied with an extract of the TTA database that is maintained by CRC Corporation on behalf of NASA's Marshall Space Flight Center Technology Utilization Office. The identity of all requestors of technology transfer assistance is confidential. Therefore, all database attributes containing any company information were excluded from the TTA database used in this study. The attributes included in the study database were:

- a unique alpha-numeric identifier that identified each record and the contact point (i.e. Marshall, Stennis, Kennedy, or others) of the initial request for assistance;
- the TTA problem statement;
- a statement of actions already per formed by the requestor company (if any) in an attempt to solve the problem;
- a statement of the desired results from the solution of the problem;
- Technology Transfer Office closure information (the text of the closure letter sent to the requestor);
- Technology Transfer Office com ments (i.e. what was done to solve the problem, contacts, or actionees); and
- close status (i.e. closed positive, closed negative, referral, out of scope, withdrawn).

Sample Selection

A random statistical sample of 1,000 TTA records was selected from the population of records in the RTAB database using random numbers generated by a computerized spreadsheet application. The database contained 8,232 TTA records, representing every TTA considered by the RTAB since its inception. The sample, therefore, represented 12.15 percent of the database population.

Determination of Classification Structure

Past uses of content analysis as a research method have utilized some sort of theoretical framework as a basis for coding qualitative statements. No such framework exists for problem statements. Therefore, it was necessary to build a classification structure as the problem statements were analyzed.

An important consideration in any classification attempt is how to represent relations between classes. Based upon conversations with the members of the and RTAB concerning their preference for a classification structure, it was determined that the Board preferred a tree-type classification structure of three descending levels, with each level being more detailed than the level above it, because they believed it to be the most functional for their purposes and the purposes of the requestors. In this structure, the top-level class of the structure is a general descriptor of the problem type, the second level class further refines the problem type, and the third, lowest level, allows for grouping of problem types into homogenous classes. The experts in the NASA Technology Transfer Office thought that a two-level structure would not be detailed enough, while a four-level structure was believed to be so detailed that all but a few problem statements would be in their own class. Other structures, such as matrix or network structures, were thought to be too complicated for practical use.

Besides practicality, another important attribute of a classification structure is its ability to represent reality. The problem statements faced by the RTAB often contain multiple dimensions, such as materials, process, personnel, marketing, and/or financial considerations. A tree-type structure does not necessarily capture all of these dimensions in its parent-child structure. Other representation methods, such as plex network, relational, or object-oriented structures may be superior when dealing with such complexities. However, the expertise required to develop and maintain these structures, as well as the difficulties associated with explaining them to individuals who must ultimately internalize and take ownership of the classification system, dictates the use of a more straightforward classification system. Hence, the tree-type structure was deemed to be most appropriate to accomplish the purpose of the study.

Classification Guidelines

Content analysis is a systematic social science research methodology. Because the analysis had no framework as a basis, a set of finite guidelines was developed to ensure consistency in the classification process. Without consistency, accurate classifications that are reliable and valid cannot be made. The following guidelines were developed to ensure consistency in the classes and classification structure resulting from the content analysis.

1. Only TTA problem statements that contained sufficient information for classification were assigned to the three level classification structure. Information was considered sufficient if words or phrases contained in the problem statement explicitly or implicitly indicated the nature, source of, or cause of the problem, and the problem could be characterized by its components to the point that it could be cataloged. This guideline ensured sufficiency of information for classification.

2. Classification at the highest level was required to be based on a tangible entity, not a technology or process. Insisting that the top-level classification was based on a physical *thing* relieves the classification method of two problems that might otherwise confound the process. The first is that requestors are usually looking for a government-developed technology or process as a *solution* to their problem. In virtually all instances, the problem is related in some manner to a good or service, a raw material, a machine, the organization's personnel, or some other form of capital within the organization. Business people often think in terms of these physical resources and will often state their problems in terms of them. A good classification system should be structured in a way to most closely identify with the way the problem is stated.

Also, while a process or technology is often involved within the scope of a problem, a classification structure using all the tangible entities, all the processes, and all the technologies associated with real-world business problems would quickly become unwieldy and so complex that its utility would be diminished. By requiring the highest-level classes to be associated with a physical entity and not with a process or technology, the number of highest-level classes was reduced and the entire structure simplified.

One exception was made to this guideline. General information was determined to be a top-level category even though it is not a tangible entity. However, today's managers recognize information as an important resource within the firm. Although information is conceptual in nature, many of the management techniques that are applied to the physical resources of the organization are also applied to the resource of information as well.

3. Sub-category classifications were required to further refine and describe the problem setting within the overall context of the highest-level classification to which the problem statement had been assigned. While tangible entity classes were desirable at this level also, a process or technology classification was allowed if it was considered superior to a tangible entity classification in further refining the categorization of the problem statement. Problem statement classification is a part of the larger need to have well-defined problem statements. While it can be overdone, specificity in classification is desirable as it helps to narrow the focus of the solution effort. The purpose of this guideline was to ensure that a sub-category was more specific to the problem statement than the top-level category to which the problem statement was assigned.

4. Sub-sub-category classification was required to differentiate the problem statements in a sub-category class to the point that, while not all the problem statements would be the same, the statements shared similar conditions, products, materials, equipment, or other components. The purpose of this guideline was to ensure a certain amount of homogeneity in the problem types that shared a sub-sub-category.

5. Where a problem statement contained more than one potential class, sub-class, or sub-sub-class, a determination of which class best fit the statement was made based upon the *latent content* of the statement, rather than the *manifest content*. Latent content has to do with the underlying meaning of words or passages (what is implied, but not necessarily directly stated), as opposed to manifest content, which describes the concrete terms of text (i.e. word counts). Content analyses based upon latent content have been shown to be more valid than those based upon manifest content. Latent content analysis is better designed for tapping the underlying meaning of communications, allowing the researcher some judgment in determining the context and intent of a statement (Babbie, 1979).

The purpose of this guideline was to establish a standard that allowed pursuit of the most valid classes possible. Because latent content analysis has been shown to be a more valid measure, and because it is necessary to use the method that best attempts to determine the real meaning of each problem statement, latent content analysis appears to be the most appropriate form of content analysis for this study.

Initial Analysis

A "TTA Analysis Form," shown in Figure 1, was developed to aid in documenting the analysis. The form contains six columns. The first column denotes the unique identifier of the TTA. The second column indicates whether the TTA problem statement contains enough information to allow for classification. The next three columns denote the class, sub-class, and sub-sub-class assigned to the problem statement. The final column allocates space for notation of any attributes (i.e. product application, performance specifications, etc.) that might be important in completely defining the problem.

TTA Analysis Form

TTA#	EI/NEI?	Category	Sub-Cat	Sub-Sub-Cat	Other Attribs.

Figure 1 – Example of the TTA Analysis Form

The first step in the analysis process was to determine whether the problem statement contained sufficient information to form a judgment for classification. One reason for this study is that many problem statements are vague, ambiguous, or incomplete. If a problem statement was judged not to contain enough information for classification purposes, the "actions to-date" and "desired results" statements were also analyzed in an attempt to gain enough information to classify the problem. If, after examining all this information, it was determined that there was not enough information to make an informed judgment as to classification, the TTA analysis sheet was marked "N" for no in the "enough information?" column. Otherwise, the column was marked "Y" and the problem statement was classified according to the classification guidelines listed above and its attributes were noted.

Example TTA Analysis

The Marshall Space Flight Center TTA #6365 may be used as an example of how the analysis process was applied to TTAs. MSFC-6365 includes the following problem statement:

> *Porcelain coating is sprayed on steel and fused to steel via high tem (700-1000 degree) baking. The thin porcelain coating on steel is very brittle. Whenever the porcelain develops micro cracks due to impact, the steel underneath begins to rust. Therefore, we need a protective clear coating for porcelain that would stick to the porcelain.*

The previous actions section of the TTA states:

> *Clear acrylic, polyurethane and epoxy coatings have been tried - none of them stick to the porcelain.*

The desired results section of the TTA states:

> *The coating should 1) be clear, 2) be hard, 3) be scratch-resistant, 4) be stain resistant, 5) must stick to the porcelain, and 6) be repairable/recoatable.*

For this example, an initial reading of the problem statement indicated that there was sufficient information for classification available to the researcher. The TTA was classified in the *materials* class, the *coatings* sub-class, and the *protective* sub-sub-class, indicating that the problem statement concerned a protective coating materials technology.

Second Analysis

Once all of the sample problem statements had been content analyzed, the entire sample was subjected to a second analysis using the same methods and guidelines as were used in the first analysis. There were two reasons for this second pass at the data. First, the researcher has a business-related background and education. The engineering and physical sciences fields contain many concepts and phrases that are foreign to him. As the researcher progressed through the problem statements, he experienced an incremental learning process that yielded a better understanding of the terms, materials, devices, etc. that are inherent to the technology transfer process. Therefore, the researcher believes that, while the incremental learning process helped considerably in classifying the problem statements in the latter part of the sample, the analysis of the earlier statements in the sample was performed without this benefit.

The second reason for analyzing the data a second time is that many, if not most, of the statements contained words and ideas that spanned more than one category or sub-category. The second analysis gave the researcher an opportunity to revisit his justification for the problem statement class assignments and to reclassify the statements, if appropriate.

Once the second analysis of all of the problem statements in the sample had been completed, the resulting classified TTA problem statements were summarized. Each TTA that had been classified was listed in its appropriate sub-sub-class. The number of TTAs assigned to each class, sub-class, and sub-sub-class were tallied and indicated on the form.

Tests for Classification Consistency and Utility

Once the tree-structure of problem classes had been developed, content validity was tested by two means. First, an additional 100 item random sample was drawn from the TTA database. No previously analyzed problem statements were included in this additional sample. Each of the TTA problem statements were analyzed to determine if they "fit" within one of the three level classifications established by the content analysis.

Second, the tree-structure of problem statement classification was presented to an independent expert with expertise in the high-technology government-contracting environment, particularly in the area of space exploration technologies. A Registered Professional Engineer, Kenneth J. Graves, with over 30 years' experience in the high-technology government-contracting environment, was invited to evaluate the classification structure developed as a result of the content analysis of the sample of problem statements from past TTAs. After a presentation to Mr. Graves concerning the purpose and scope of the research study and the methodology employed, Mr. Graves and the researcher discussed each class, sub-class and sub-sub-class obtained through the content analysis.

The purpose of this part of the evaluation was to obtain Mr. Graves' frank opinions concerning whether the classes, sub-classes, and sub-sub-classes were a reasonable and consistent representation of problem statements in the technology transfer process. Discussion centered on how classification titles were determined and whether the relationships between the classes, sub-classes, and sub-sub-classes were correct and consistent with commonly applied principles in the engineering field.

For example, a lengthy discussion concerning the name of the sub-class Polymers/Plastics of the Materials class focused on whether Polymers was a more appropriate title for the class, with Plastics becoming a sub-sub-class under Polymers. A review of the problem statements associated with this classification, however, satisfied Mr. Graves that the distinction was not necessary to serve the purpose of the classification structure. Although plastics are indeed a type of polymer, it was agreed that the combined name would not cause confusion to users of the classification structure and that a plastics sub-sub-class would not be as useful as the more specific sub-sub-classes developed in the study.

Another example of a sub-class that Mr. Graves initially questioned is the sub-class Insulation within the Materials class. Mr. Graves asked if classification might be more appropriate by listing insulation as a sub-sub-class under the material from which the insulation was made (i.e. fiberglass, rubber, stainless steel). After considerable discussion and review of the applicable problem statements, however, it was concluded that insulation was an important enough topic to have its own sub-category. As a result of this part of the expert's evaluation, one sub-class and five sub-sub-class titles were reworded.

Mr. Graves was also asked to content analyze and classify a small sample (12) of randomly selected problem statements from the initial sample. Later, the expert's classifications were compared to the researcher's classifications of the same problem statements. Of the twelve statements, 11 (91.6 percent) were classified the same by both individuals. One statement was classified differently. Upon further review, the researcher agreed with Mr. Graves' classification of the statement and made the appropriate revision to the classification in the study records. The problem statement in question related to a need for wheels for a specialized beach cart that was to be constructed of plastic and capable of negotiating uneven, soft terrain. The researcher had classified the problem in a Materials-Polymers/Plastics-PVC category. However, Mr. Graves classified the problem in the Devices/Appliances-Mechanical-Wheels category.

At the conclusion of the evaluation, Mr. Graves expressed agreement with the make up of the classification structure. He further stated that he believed the structure would be useful and easy to use by the RTAB.

FINDINGS

The intention of the design and execution of the study was to develop an analysis and classification method for problem statements in technology transfer assistance requests. A content analysis method was developed that allowed for analysis and classification of a random sample of TTAs from the Marshall Technology Transfer Utilization Office database population. The TTAs that contained sufficient information for classification were subjected to a unique form of content analysis that resulted in the problem statements being classified in a tree-type, three level structure. Table 1 represents the upper two levels of the classification structure developed using the analysis and classification methodology described here. The numbers listed to the right of the Classes and Sub-classes indicate frequencies within the original sample of 1,000.

Additionally, the study utilized a second random sample to determine whether the classification structure was sufficiently inclusive of most of the problem statements. The second sample conformed completely to the class and sub-class categories as developed in the initial analysis. In addition, this phase included testing of the reasonableness of the classification structure by an expert in the field and a test of the consistency of the classification structure. The analysis and classification method was deemed a reasonable and consistent system, which yielded a useful structure.

CONCLUSIONS AND IMPLICATIONS

The research study was undertaken in response to a stated need of the RTAB for better problem statements from reqestors of technology transfer assistance. Specifically, the project developed and tested a method for analysis and classification of problem statements associated with technology transfer requests.

The method developed here has allowed for formal documentation of the technology transfer process, as employed by the Marshall Space Flight Center Technology Transfer Office and the associated Regional Technology Applications Board. In addition, the shortcomings associated with the current problem statements and problem definition process used to request technology transfer assistance have been placed into context with what is formally known about the problem solving and problem definition processes.

Previously, no method for analysis and classification of problem statements had been documented. Problem statements can be analyzed and classified. The method executed here has been used to analyze and classify the problem statements included in technology transfer assistance requests received by the RTAB.

TTA problem statements can be ex-

Class	Sub-class	Count
Devices/Appliances (156)		
	Circuitry	2
	Computer Hardware	12
	Containers	8
	Diapers	1
	Directional	3
	Energy	4
	Fasteners	5
	Filtration	2
	Heating	2
	Imaging	3
	Injection	6
	Machining	10
	Measurement/Analysis	24
	Mechanisms	3
	Medical	7
	Motors/Engines	20
	Pumps	3
	Sensors/Detectors	24
	Signal Transmission	5
	Sprayers	2
	Transport	6
	Valves	5
General Information (143)		
	CAR Packages	69
	Data Search	54
	Presentations	7
	Publications	8
	Research Studies	5
Liquids (10)		
	Chemicals	5
	Oils	1
	Water	4
Software (103)		
	Applications	16
	Artificial Intelligence	1
	System Interfaces	2
	User Interfaces	2
	Virtual Reality	1
Materials (152)		
	Alloys	5
	Aluminum	7
	Asphalt	1
	Cloth	8
	Coatings	35
	Compounds/Composites	6
	Concrete	1
	Conductors	3
	Edible	1
	Gold	1
	Graphite	1
	Insulation	23
	Lead	2
	Paper	1
	Polymers/Plastics	14
	Resins	15
	Rubber	7
	Stainless Steel	5
	Steel	12
	Tin	2
	Titanium	1
Personnel (3)		
	NASA	2
	Training	1
Plans and Drawings (10)		
	Architectural	4
	Diagrams/Schematics	6
Plants (5)		
	Dried	1
	Harvesting	2
	Indoor	1
	Leaves	1
Structures (3)		
	Boat Slips	1
	Buildings	1
	Walls	1
Waste (22)		
	Liquid	7
	Smoke, Gasses, & Mists	5
	Solid	10

Table 1 – TTA Problem Statement Classes and Sub-classes

amined through the use of content analysis. This analysis, in turn, can lead to classification of the problem, if the problem statement contains sufficient information for identification of the primary considerations associated with that problem.

The hierarchical problem statement classification structure created here provides a vehicle for problem statement assignment, thereby lending additional organization to the problem definition process. Problem statements with comparable elements are grouped together, while problem statements with dissimilar qualities are knowingly isolated. The structure also allows for assessment of the relative similarity of two or more problem statements. For example, two problem statements that share the same subclass, yet are classified in different sub-sub-classes, possess more similarity to each other than two problem statements from different classes or two problem statements sharing the same class that are assigned different sub-classes.

Implications

Through the analysis and classification method reported on here, important elements of the problem statement have been identified to three levels of detail. Such identification can assist the RTAB and the actionee assigned to find a solution in focusing their efforts to technologies that are appropriate to a problem, thereby increasing the efficiency of the solution effort. The method developed through this project may be applicable to other uses of problem statements in scientific, engineering, or technology-related fields.

Although this method has allowed for analysis and classification of problem statements related to technology transfer requests, the classification structure, as developed, has not been reviewed and evaluated by the RTAB. Although the Mr. Graves' review was positive, additional input from members of the RTAB would lend further insight into the validity and utility of the structure. Further, although the method may be appropriate for problem statements in other fields, it has not been applied outside of the context of technology transfer.

Actual use of the problem statement classification structure would be helpful in determining its utility and place within the problem definition context. It is possible that, if all problem statements were classified at the time of the initial request for technology transfer assistance, the classification structure could enforce improved problem statement. If, for example, a requestor was furnished with a listing of the classifications and asked to classify his or her problem within the structure, a clearer picture of the problem might be developed.

Finally, a problem statement classification structure is not, in itself, a sufficient solution to good problem definition. The content analysis of past TTA problem statements indicated that many problem statements included minimum performance specifications within which a solution must work, as well as various attributes associated with the application of the problem entity. While this work contributes to problem definition by creating an analysis and classification structure, much work remains to be done before a full understanding of this concept is gained.

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About the Author

Jeff Harper is the Gongaware Assistant Professor of Management Information Systems and Research Fellow for the School of Business at Indiana State University. He holds the Ph.D. in Management Information Systems from Auburn University, as well as degrees in the management of technology, accounting, and business administration. Dr. Harper’s research and consulting interests include aligning information technology (IT) with strategic intent and technology transfer. He has recently been named an Innovation Fellow for the Center for an Innovative Economy at the Rose-Hulman Institute of Technology. His research has appeared in academic publications such as the Journal of Information Technology Management, the Journal of Technology Transfer, the Case Research Journal, the Journal of Computer Information Systems, and the Journal of the International Academy for Case Studies. He has served as an IT consultant to many organizations, including NASA, the U.S. Justice Department, the Department of the Navy, and BellSouth Corporation. Dr. Harper is currently working on his first book, *Contemporary Case Studies in Management Information Systems*. He may be contacted via email at *JeffHarper@indstate.edu*.

TECHNOLOGY TRANSFER AGREEMENT
Technology Transfer Office, LA01
Marshall Space Flight Center, Alabama 35812

phone: (205) 544-8295 or fax: (205) 544-3151

NASA

Help us understand your company...

Company Name: ____________________

Address: ____________________

____

____

Company Contact: ____________________

Age of Company: ____________________

Estimated Annual Sales: ☐ <1M ☐ 1-5M ☐ 5-25M ☐ >25M

Phone: ( ) ____________________

FAX: ( ) ____________________

Primary SIC (if known): ____________________

Main Product(s): ____________________

Number of Employees:

Locally ☐ <25 ☐ 25-100 ☐ 100-500 ☐ >500

Company wide ☐ <25 ☐ 25-100 ☐ 100-500 ☐ >500

Problem Title: ____________________

Definition of Problem: (background, context, description)

Action to date: (What have you already done to solve the problem?)

Desired Result: (e.g., data search, analysis, design recommendation, process info.)

When do you need the results? ____________ ____________

NOTES:

1. Provide brief, stand-alone explanation and background; use additional sheets, if necessary.
2. Use this form to address problems with technical, rather than administrative or managerial solutions.
3. Avoid problems which place NASA in competition with private consultants, or with providers of commercial products or services.
4. Do not include problems calling for comparative evaluation of competing commercial products or services.
5. Action on this request is subject to review and acceptance by the MSFC Technology Applications Board.
6. Within six months after providing you with an answer, we will ask you to give us feedback about the effectiveness of our help.

NASA USE ONLY:
CONTACT ____________
TAA# ____________

SIGNED: ____________________ DATE: ____________
(Company Contact)

MSFC Form 4237 (November 1994)

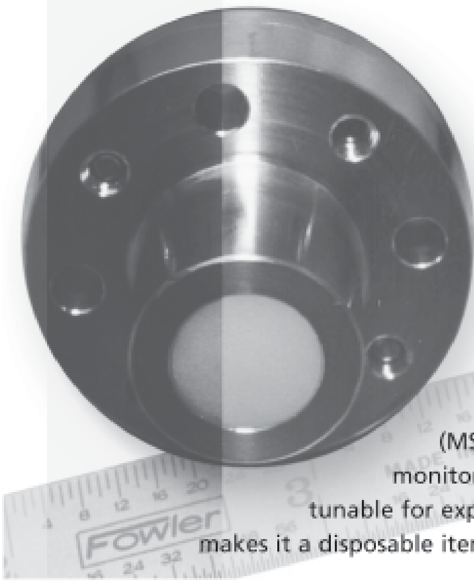
APPENDIX A
The Technology Transfer Agreement Form

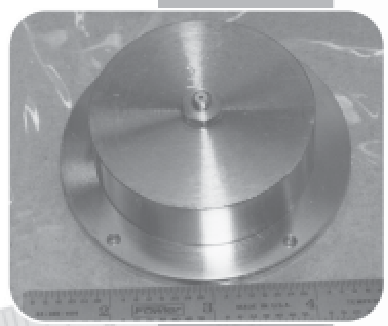
TECHNOLOGY *Opportunity*

OPTICS TECHNOLOGY

Low-Cost, Passive Light Exposure Monitor

NASA offers companies a handheld device for accurate light exposure readings.





NASA Marshall Space Flight Center (MSFC) has produced a passive light exposure monitor that is small, reusable, highly accurate, and tunable for exposure and wavelength—all at a price that makes it a disposable item.

Benefits

MSFC s passive light exposure monitor represents a breakthrough for users of large and expensive light exposure equipment. This invention is:

- ***Handheld***—Is smaller than current light exposure equipment
- ***Passive***—Requires no batteries, power supply, or communication link
- ***Inexpensive***—Costs only $15 in small prototype quantities
- ***Accurate***—Compared favorably to expensive meters in NASA s space experiments
- ***Flexible***—Can be engineered for various wavelengths and exposure times
- ***Reusable***—Can be reset with accompanying equipment

Commercial Applications

MSFC s passive light exposure monitor can be designed for specific wavelengths of light and for varying amounts of total exposure. This flexibility, along with the low cost, makes a variety of applications possible. The device can be used to monitor:

- Sun exposure tests for consumer products, materials, and chemicals
- Material tests in space
- Ultraviolet (UV) applications, including curing processes, electronics data erasing
- Light output over time from solar simulators
- Sunlight over a large area

Versions also can be easily configured for:

- Month- or year-long sun exposure readings for climate studies
- UV-only monitoring for studying ozone layer depletion

National Aeronautics and Space Administration

APPENDIX B

Example of New Technology Developed at MSFC
"Passive Light Exposure Monitor (PLEM)"

(from: "Technology Transfer Opportunities" http://www.nasasolutions.com/tech_ops/plem.pdf)