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ABSTRACT

As part of an evaluation of its scientific and technical information program, the National Aeronautics and Space Administration (NASA) conducted a review and analysis of structural, language, and presentation components of its technical report form. The investigation involved comparing and contrasting NASA's publications standards for technical reports with current usage and practice of report preparation, prescriptive standards and criteria for such reports, and findings from the literature specifically concerned with the organization, language, and presentation components of the report. The findings suggest, among other things, that (1) the structure and sequence of a technical report should be flexible enough to accommodate the contents and intended audience; (2) producers of technical reports should develop and adopt an outline containing a sequence of report components that is flexible; (3) summaries and abstracts should be clear and concise; (4) tables and figures should be integrated into the text; (5) in terms of readability, summaries and abstracts should score as less difficult to read than the text; (6) the use of the passive voice should be tempered; (7) a maximum number of multiple plots on a single figure should be established; and (8) the accepted rules of style, grammar, and punctuation used in constructing the prose of the text should be used for mathematics, whether appearing in the text or set off in display. (FL)

NASA Technical Memorandum 84260

The Technical Report: An Analysis of Information Design and Packaging for an Inelastic Market

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THE TECHNICAL REPORT: AN ANALYSIS OF INFORMATION DESIGN AND PACKAGING FOR AN INELASTIC MARKET

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SUMMARY

Economists measure how responsive or sensitive consumers are to change in the price of a product by the concept of *elasticity*. The demand for some products is such that consumers are relatively responsive to price changes; price changes give rise to very considerable changes in the quantity purchased. The demand for such products is said to be *elastic*. For other products, consumers are relatively unresponsive to price changes; that is, price changes result in modest changes in the amount purchased. In such cases demand is *inelastic* (McConnell, 1978).

The demand for scientific and technical information (STI) is considered to be *inelastic* because up to a certain point the consumer will continue to try to obtain the information regardless of moderate increases in cost, either in terms of real dollars or in terms of effort/time required to make the acquisition. On the other hand, the demand for such specific information products as the technical report is considered to be *elastic* because as cost, either in terms of real dollars or in terms of effort/time required to make the acquisition increases, the information consumer is likely to substitute another STI product such as a journal, book, conference/meeting paper, or preprint, assuming the desired information can be found in an alternate product. However, when the desired information is available from only one product, demand becomes *inelastic*.

For many R&D agencies of the federal government, including the National Aeronautics and Space Administration (NASA), the technical report constitutes an information product, a primary means of communicating the results of research to the user (Stohrer and Pinelli, 1981). Studies of STI usage among engineers and scientists indicate varying amounts of use for the technical report (COSATI, 1968). The technical report was preferred by applied technologists while theoretical scientists preferred the refereed journal. Between these two extremes exists what is referred to as the "marginal" user, the engineer or scientist who makes occasional or moderate use of technical reports.

As part of an evaluation of the NASA STI program, a review and analysis of the technical report was conducted. The results, which are contained in NASA Technical Memorandum 83269 (McCullough, Pinelli, et al., 1982), will be used by NASA to evaluate the current design and packaging of its technical reports. This paper highlights the results of the study and focuses on improving the utility of the technical report by marginal users.

INTRODUCTION

The technical report serves as a primary means of communicating the results of NASA's research. Consequently, NASA technical reports must be organized and written to accomplish effective communication. NASA employs uniform publications standards which are designed to ensure clarity, quality, and utility of its technical reports. These standards include a basic report format which defines the report's components and establishes their sequence. The standards address, in a limited sense, language (verbal and visual) and presentation (typography, graphic design, and physical media) components. To date, these standards have not been examined to determine the extent to which they contribute to the effectiveness of the NASA technical report as a product for information dissemination. However, there are no generally accepted standards against which NASA publications standards for technical reports could be compared.

The survey and analysis of the technical report involved comparing and contrasting NASA's publications standards for technical report preparation with current usage and practices for technical report preparation, prescriptive standards and criteria for technical reports, and experimental/theoretical findings from the literature specifically concerned with the organization, the language, and the presentation components of the technical report. Current usage and practices were determined by systematically analyzing technical reports and related material obtained from a survey of technical report producers. Prescriptive standards and criteria were obtained from a review of style manuals, publications guides, and textbooks concerning technical writing and editing, verbal and visual presentation; and typography, graphic design, and physical media. Experimental/theoretical findings were obtained from a survey of the literature. Manual and machine-readable data bases including Defense Technical Information Center (DTIC), Educational Resources Information Center (ERIC), Library and Information Science Abstracts (LISA), National Technical Information Service (NTIS), and NASA's Remote Console (RECON) were searched to obtain the experimental/theoretical findings.

RELATED RESEARCH AND LITERATURE

The historical developments of technical report literature have been presented by Tallman (1962), Boylan (1970), and Auger (1975). The complexity of technical report literature has been described by several authors (Wright, 1963 and Hartas, 1966). Studies by Earle and Vickery (1969) and by Coile (1969) determined the use of technical reports as citations in scientific and technical publications such as books, periodicals, and monographs. Wilson (1958), Fuccillo (1967), and Randall (1959) conducted separate studies to determine the half-life of technical reports. The SATCOM Committee (National Academy of Sciences, National Academy of Engineering, 1969) and the report of the Weinberg Panel (Executive Office of the President, 1963) were concerned with the structure, organization, and transfer of scientific and technical information and the role of the technical report within an STI system. Perhaps the largest and most comprehensive studies devoted to the technical report were conducted by the American Psychological Association (Garvey and Griffith, 1965) and a COSATI Task Group (1968) under the direction of Sidney Passman. Very little definitive research on the technical report has been conducted since the early 1970's.

The technical report was shown to possess characteristics which make it unique as a medium for information transfer. As an information product the report has been criticized and praised. Critics charge that the technical report does not meet the rigors or criteria established for scientific journal publication. Lack of screening or peer review was the characteristic listed most frequently as a major weakness. Proponents saw merit in such features of the technical report as timeliness, comprehensive treatment, and inclusion of ancillary information. Notwithstanding the controversy over its status, the technical report was shown to constitute an important vehicle for disseminating the results of research. Both the technical report and the scientific journal played distinct roles in the communication of scientific and technical information (COSATI, 1968).

Three studies which utilized feedback from users of NASA STI were conducted to help evaluate the NASA STI program (Monge, 1978; Pinelli, 1980; and Pinelli, 1981). This feedback indicated that NASA technical reports were being used and that the perceived prestige of NASA technical reports was high. Specific concerns of the users included consistency in terms of adherence to NASA publications standards, the type of binding used for certain NASA technical reports, detailed summaries and abstracts, development of conclusions, relating the results to previous and/or existing work, absence of grids on graphs, insufficient tabular data, and the exclusion of negative data.

RESEARCH PROCEDURES

The complete research procedure for the review and analysis is contained in NASA Technical Memorandum 83269. An abbreviated procedure is presented for the analysis of the technical reports and related materials, the sequential components, the language components, and the presentation components.

Technical Report Analysis

A sample frame was established to survey and analyze technical reports. The membership of the Society for Technical Communication (STC) and institutions/organizations on NASA's automatic distribution list for technical publications were used for this purpose. Each member of the sample frame was requested to provide (1) copies of technical reports produced by their organization/institution for external distribution, (2) copies of in-house style manuals and publications/productions guides, and (3) information concerning the use of commercially available style manuals and publications guides. The documents received were classified into predetermined categories. Data were extracted and recorded onto eight data cards.

Sequential Components

From an analysis of 99 reports, an exhaustive list of structural components for report organization was prepared. The position of each component was compiled. Six generally accepted and recently published writing and editing textbooks were consulted to determine their recommendations for report organization. Four style manuals and two publications guides used by the survey respondents were analyzed to produce a listing of structural components for report organization. The standards for report preparation contained in the NASA Publications Manual were compared and contrasted with the data from the survey, the data compiled from the writing and editing textbooks, and with the recommendations of the style manuals and publications guides. A suggested outline for report components indicating both placement as front, body, or back matter, and ordering within these divisions was prepared. This outline is included as an appendix. The extent to which tables and figures were integrated into the text was calculated.

Language Components

Three readability tests were used to measure the readability of the survey reports. One hundred word samples were used and, whenever possible, samples were taken from the summary, the text, the headings, and the captions of the reports. The voice (active or passive) and person (first, second, and third) were also determined and recorded for all summary and text samples from the survey reports and the sample NASA report on which readability tests were run. The results were compared with the prescriptive standards/criteria and experimental findings.

Three mathematical style books were consulted to determine general standards against which the guidelines in the NASA Publications Manual and actual usage in the sample NASA report were compared. The survey reports were analyzed for the presence or absence of mathematical material in text and/or in display; but no observations were made concerning punctuation or breaking of equations. For visual language components, the total number of tables and figures in each survey report were counted. Figure-to-page ratios and table-to-page ratios were prepared. The data were compared with the prescriptive standards/criteria and experimental/theoretical findings from the literature and with the guidelines set forth in the NASA Publications Manual.

Presentation Components

The typographical aspects of three report elements were considered. The experimental/theoretical findings were used to develop minimum and maximum acceptable limits for type size, line length, number of characters per line, and line length for a given type size. These parameters, as they appeared in the survey results, the NASA sample report, and the guidelines set forth in the NASA Publications Manual, were compared with the limits of acceptability developed from the experimental/theoretical findings.

Nine aspects of graphic design were tabulated, calculated, and analyzed for the survey reports. These data were compared with the guidelines contained in the NASA Publications Manual and with the experimental/theoretical findings from the literature. The type of paper used in the survey reports was identified. The type of binding used for the survey reports was also recorded. NASA guidelines for the preparation of copy for microfiche were examined relative to other literature recommendations for documents which will be re-imaged. All physical media considerations (paper, type of binding, and guidelines for microfiche) were compared with the NASA publications guidelines, the practice in the sample NASA report, and with the experimental/theoretical findings from the literature.

FINDINGS

The results of the review and analysis were compiled and presented according to the sequential, language, and presentation components of a technical report. The data are discussed in terms of their relationship to the NASA publications standards for technical reports as contained in the NASA Publications Manual - 1974.

Sequential Components

The survey reports showed wide variation in the number, kind, and placement of sequential components. The 99 reports surveyed used 96 different components. Only five components (cover, title page, table of contents, introduction, and appendixes) were common to half or more of the reports; however, strong agreement (82 percent or more) existed in regard to placement of these five components as front, body, or back matter.

The six style manuals and publications guides were not unified in the number of names of components recommended for inclusion in technical reports (see Table A). While 16 of 24 components were recommended by a majority of these sources, unanimous agreement for inclusion existed for only two components: the introduction and the appendixes. The publications guides were even more divided in the recommended sequence of the report components. Actual usage as determined by the analysis provided the most variance in terms of numbers, locations, and descriptions of report components.

The three sources used in the sequential components portion of the study (survey reports, style manuals and publications guides, and textbooks) were compared to produce a list of components recommended for inclusion by 50 percent or more of any of the three sources. This comparison, shown in Table B, is presented to indicate whether each source, as a consensus, advocated that a particular component should be included as a structural component of a technical report. Components recommended by NASA are included for comparison. The survey reports represented the limiting factor in that, as shown previously, only five components were common to more than half of the reports. Considering only the textbooks and style manuals, agreement existed on 12 components: the cover, title page, abstract, contents, list of figures/illustrations, list of symbols, introduction, body (text), bibliography, references, appendix, and glossary. The NASA Publications Manual discussed 10 of these 12, omitting only the list of figures, illustrations, and the glossary.

TABLE A

Summary of Sequential Components

Component	Style manuals and publications guides (n=6)	Textbooks (n=6)	Survey sample (n=99)	NASA
Cover	.50	.83	.68	x
Title page	.83	1.00	.73	x
Foreword	.50	.17	.19	x
Preface	.83	.33	.24	x
Acknowledgement	.33	---	.24	
Letter of transmittal	.17	1.00	---	
Contents	.83	1.00	.71	x
List of figures/ illustrations	.83	1.00	.39	
List of tables	.67	.33	.30	
List of symbols and/or abbreviations	.50	.83	.18	x
Glossary	.83	.33	.23	
Abstract	.50	1.00	.39	x
Introduction	1.00	1.00	.58	x
Body	.67	.83	.35	x
Method	.17	---	.22	
Results (Data)	.33	---	.27	x
Discussion	.17	.50	.11	x
Conclusions	.33	.83	.31	x
Recommendations	.33	.67	.07	
References	.83	.50	.39	x
Appendix	1.00	1.00	.60	x
Index	.83	---	.23	
Bibliography	.50	.83	.15	x
Summary	.17	.50	.30	x

Style manuals--American Psychological Association, Chicago Manual of Style, National Academy of Sciences, and U.S. Geological Survey

Publications manuals--American National Standards Institute and Committee on Scientific and Technical Information

Textbooks--Houp & Pearsall; Lannon; Olsiu, Brusaw & Alfred; Mathes & Stevenson; Mills & Walters, and Pauley

TABLE B.

Components Included by Half or More of Each Source

Component	Source			
	Included by a majority of survey reports	Included by half or more of style manuals and guides	Included by half or more of textbooks	Listed by NASA Publications Manual
Cover	Yes	Yes	Yes	Yes
Memo/Letter of transmittal	No	No	Yes	No
Title page	Yes	Yes	Yes	Yes
Abstract	No	Yes	Yes	Yes
Contents	Yes	Yes	Yes	Yes
List of figures/ illustrations	No	Yes	Yes	No
List of symbols	No	Yes	Yes	Yes
Introduction	Yes	Yes	Yes	Yes
Summary	No	No	Yes	Yes
Conclusions	No	No	Yes	Yes
Recommendations	No	No	Yes	No
Body (Text)	No	Yes	Yes	Yes
Discussion	No	No	Yes	Yes
Bibliography	No	Yes	Yes	Yes
References	No	Yes	Yes	Yes
Appendix	Yes	Yes	Yes	Yes
Foreword	No	Yes	No	No
Preface	No	Yes	No	Yes
List of tables	No	Yes	No	No
Glossary	No	Yes	Yes	No
Index	No	Yes	No	No

The NASA Publications Manual agreed with the survey reports in both inclusion and placement of the five components for which a consensus existed. NASA included all three components (title page, introduction, and appendixes) recommended unanimously by the style manuals/publications guides. Of the 16 components recommended by half or more of these sources, 11 were mentioned by the NASA standards. The five not included were the foreword, list of tables, list of illustrations/figures, glossary, and index. The NASA Publications Manual included five of the six components recommended by all the textbooks (title page, abstract, contents, appendix, and introduction) and 13 of the 17 components mentioned by three or more of the six textbooks. Components omitted by NASA were the memo/letter of transmittal, list of illustrations/figures, recommendations, and glossary.

NASA's guidelines compared favorably, in general, with the survey usage and the recommendations of the style manuals/publications guides and textbooks where a consensus existed. However, no one recognized structure for the sequential components of technical reports was found to exist. This lack of a single agreed-upon organization is probably due to the wide variations in the content, purpose, and discipline of technical reports and to the varied audiences to which they are directed. Components present in a report, particularly in the body or text, will also be affected by the nature of the report--whether it is informative, analytical, or assertive.

The majority of the prescriptive sources and the experimental/theoretical findings recommended that figures and tables be integrated into the text. Eighty-two percent of the survey reports integrated both figures and tables with the text as illustrated in Figure 1. The NASA Publications Manual (p. 17-18, 37-38) stated that where practical, tables and figures were preferably placed in the body of the report as soon as possible after mention in the text; however, when visuals were of such volume that insertion in the text would impair readability, they should be placed in the back matter, following the appendixes and references. The sample NASA report did not contain any tables. Figures were grouped in the back matter of the report.

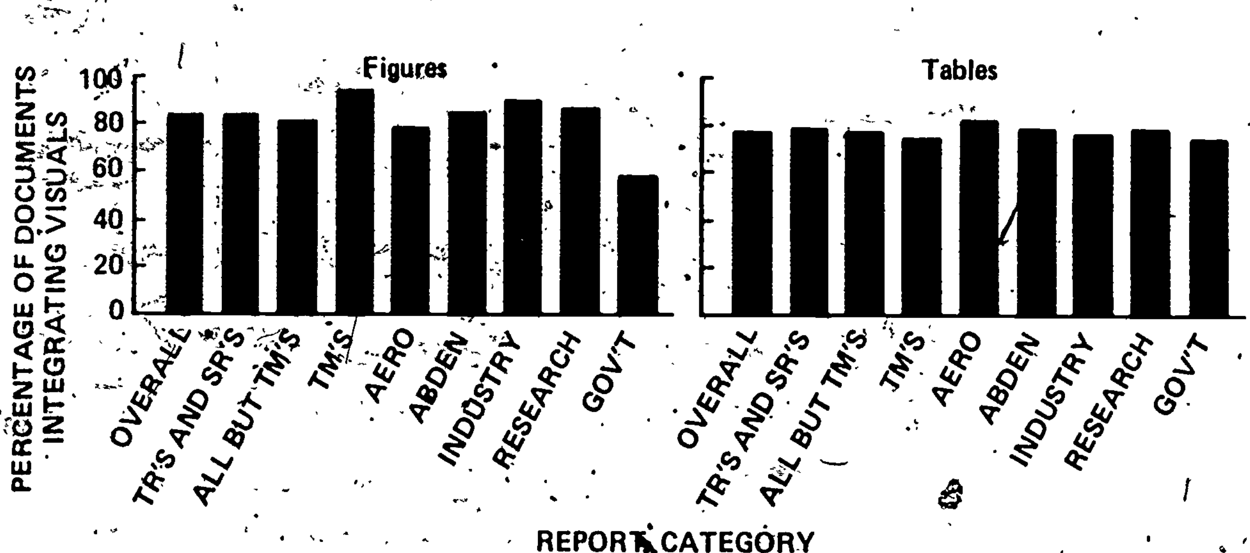

Figure 1.- Percent of survey documents with visuals integrated in text

Language Components

Results of the Flesch (1948), Fog (Gunning, 1952), and Kincaid (Hull, 1979) readability tests on the survey reports and the sample NASA report are shown in Table C. Numbers in parentheses indicate the sample size for each readability level reported. These sample sizes were determined by the availability of 100-word passages in the survey reports.

TABLE C

Readability Results

Report sample	Report section			
	Text	Summary*	Headings	Captions
Fog index (grade level)				
Overall survey	17.7 (50)	19.5 (42)	14.7 (36)	13.5 (10)
ABDEN reports	18.3 (28)	20.1 (27)	15.1 (19)	13.[illegible] (6)
NASA report	17.6 (1)	17.0 (1)	--- (0)	--- (0)
Kincaid index (grade level)				
Overall survey	14.2 (50)	16.7 (42)	12.0 (36)	12.3 (10)
ABDEN reports	15.0 (28)	16.9 (27)	12.4 (19)	12.2 (6)
NASA report	15.3 (1)	16.0 (1)	--- (0)	--- (0)
Flesch formula (grade level)				
Overall survey	19.3 (50)	21.3 (42)	22.4 (36)	22.5 (10)
ABDEN reports	19.9 (28)	21.8 (27)	22.5 (19)	22.6 (6)
NASA report	18.7 (1)	18.7 (1)	--- (0)	--- (0)

*Summary samples were drawn from the introduction, summary, or conclusions sections. This "definition" was used only for readability tests.

The average readability scores of the survey documents ranged from grade 14 to grade 19 for the text and grade 17 to grade 21 for the summary section. Headings and captions scored between grade 12 and grade 15 on the Fog and Kincaid indexes. The text and summary of the NASA report fell within the ranges scored by the survey documents. Survey publications on NASA-related subject areas (ABDEN) scored as more difficult than the overall survey. The NASA sample report generally scored as easier to read (lower grade level) than the ABDEN reports. The levels obtained experimentally (14 to 19) for the texts of survey and NASA reports agreed fairly well with the general level of grade 16--college graduate--reported in the literature for scientific material. Summaries tested as somewhat higher--grades 17 to 21.

The data extracted from survey reports concerning use of person and voice are given in Table D. As can be noted, there was a strong tendency toward use of the third person in the text material (88 percent of reports) and in the summary material (95 percent of reports). The passive voice was used more often than the active voice in both text and summary sections. In the texts, 56 percent of the reports used the passive voice exclusively, 38 percent used the active voice exclusively, and 6 percent used both voices. No data were obtained on the use of person or voice in headings and captions.

TABLE D

Use of Person and Voice by Survey Reports

Report section	Person (No. reports using)				Voice (No. reports using)		
	1st.	2nd.	3rd.	Varied	Active	Passive	Both
Text (n = 50)	2	2	44	2	19	28	3
Summary (n = 42)	1	0	40	1	18	23	1

In the past, a strong tradition existed for use of the passive voice in scientific and technical literature. This is no longer true as was evident from a review of the technical writing/editing textbooks, style manuals, and publications manuals previously cited in Table A, and other literature sources (e.g., Strunk and White, 1978; Stanley, 1975; and Holloway, 1974). A very strong consensus of current thinking indicated that active voice should be used whenever possible because it is usually more direct, natural, and concise. The active voice was favored over the passive voice whenever verbs concern the interaction of inanimate objects and/or the writer wanted to emphasize who or what performed the action. The passive voice was recommended when the writer wanted to emphasize the receiver of the action rather than the doer.

The textbooks, style manuals, and publications guides were more divided on the question of person. Most did not treat the subject of person. The Publication Manual of the American Psychological Association (1974) indicated that experienced writers can use first person without sacrificing objectivity or dominating the communication. (These are the usual arguments against use of the personal pronouns

"I" and "we.") On the other hand, Pauley (1979) stated that the use of first and second persons should be avoided, and Mills and Walter (1978) advocated avoiding first person or using it only sparingly.

The sample NASA report used third person, passive voice in both text and summary sections. The NASA Publications Manual 1974 did not discuss person or voice. However, the current practice in editing branches of the Agency is to encourage use of the active voice whenever possible, while recognizing that the nature of scientific and technical material makes the use of the passive voice necessary or preferable in certain situations. Current NASA practice in regard to person is that third person is preferred, but first person is permitted if the author prefers this form.

The maximum number of data paths plotted on one figure ranged from one to ten for the survey documents, with a median value of four and a mean value of five. The corresponding figure for the sample NASA report was eight. NASA guidelines did not set a maximum number, but eight types of lines (data paths) were presented and an order recommended for their introduction in figures. Literature sources and mean usage in the survey tended to limit multiple plots on a single figure to a lower number than NASA usage (see Table E).

Literature recommendations varied regarding symbols for data points and data paths in multiple plots on single figures. No data were obtained from the survey documents on this subject. The first three data-point symbols recommended by the NASA Publications Manual agreed with those of Harvill (1977), but NASA suggested varying data paths, while Harvill used a straight line for all paths.

TABLE E

Preferred Data Points and Data Paths

SOURCE	DATA POINTS	DATA PATHS
HARVILL (1977)	○ □ △	——————— ——————— ———————
SCHUTZ (1961, II)	+ ○ ▲ ●	- - - + - - - - - - ○ - - - ——— ▲ ——— · · · · · ● · · · · ·
NASA (1974)	○ □ ▷ ◇ [symbol] [symbol] [symbol] [symbol] [symbol] ◁ ◇	——————— - - - - - - - - - — - — - — - — — - - — - - — — - - - — - - - — — — - — — - — — - - - — - - - — - - — - - — -

Presentation Components

Table F contains the results of the analysis of line lengths of survey documents as a function of type size. The mean and median values for all type sizes were above the ranges recommended by Arnold (1972, p. 84-85) and Burt (1959, p. 13-14). The sample NASA report used 11-point type. Its 41-pica longest line exceeded the maximum acceptable length recommendations of Arnold and Burt, and it was also above the mean and median values for survey documents which used 11-point type. NASA guidelines did not discuss line length in terms of type size.

TABLE F

Line Length as a Function of Type Size for Single-Column Survey Documents

Type size (points)	No. of documents	Mean longest-line (picas)	Median longest-line (picas)	Range longest-line (picas)
9	7	39	39	36 - 43
10	17	38	37	34 - 42
11	12	37	38	27 - 42
13	1	39	--	-------

Recommendations from the literature on minimum, maximum, and optimum character counts per line are listed in Table G. All were directed toward general literature rather than scientific/technical documents in particular. Taking the lowest and highest values cited by any sources gives a "most lenient" acceptable range of 50 to 80 characters per line.

The 37 single-column survey documents had a mean count of 74 characters per line and a median value of 72 characters per line. Individual values ranged from 58 to 110 characters per line. No documents were below the minimum limit of 50 characters per line established from Table G. Eight reports, or 28 percent of the one-column publications were above the upper limit of 80 characters per line. No statistics were prepared on the character counts of multi-column publications.

The NASA sample report had an average of 84 characters per line and thus was above the upper limit of 80 characters per line obtained from the literature. The sample NASA report was also above the mean and median values for the survey. The NASA guidelines did not treat the subject of character count.

Spencer (1969, p. 35) explained the underlying basis of the need for line length and character count limits. Short lines tend to increase the number of fixation pauses the eye must make, while long lines tend to increase the number of regressions the eye must make. Both situations decrease reading speed and increase errors in comprehension.

TABLE G

Literature Recommendations for Character Count Per Line

No. of characters per line			Reference
Minimum	Optimum	Maximum	
50	55-60	70	Lee (1965, p. 98)
54	-----	60	Dowding (1957, p. 6)
55	-----	80	*Burt (1959, p. 13-14)
--	60-70	--	Morison (1951, p. 9)
--	60-70	--	Spencer (1969, p. 35)

*Experimental findings

The major cause of varying leading within a report is the presence of stacked fractions in the text. Literature sources (Strawhorn, 1978, p. I.4.5.1; Chaundy, 1954, p. 27; and Swanson, 1971, p. 16) recommended that mathematics in text should be linear. Chaundy (1954, p. 26) stated that linear arrangements of mathematics are more legible, and research by Tinker (1926, p. 465) confirmed this opinion.

Stacked fractions of the form $\frac{a}{b}$ can be expressed linearly as a/b by use of the solidus (/) or as ab^{-1} by use of the negative exponent (Swanson, 1971, p. 16; Chaundy, 1954, p. 26-27; and William Byrd Press, 1954, p. 32, 35).

Swanson (1971, p. 24) stated that radical signs should be avoided whenever possible. She and Chaundy (1954, p. 29) advocated substitution of fractional exponents in the form $a^{1/n}$ for roots of any power.

Seventy-six percent of the survey publications containing mathematics in the text used the solidus to eliminate stacked fractions. No roots of any form were located in the textual passages of these publications; therefore, it was not possible to assess the usage of fractional exponents to replace radicals in the text.

Oxford University (Chaundy, 1954, p. 29) and the American Mathematical Society (Swanson, 1971, p. 16) recommended that the solidus, negative exponents, and fractional exponents be used in displayed mathematics as well as mathematics in the text to replace fractions and roots.

Figure 2 shows the percentages of survey documents which used the solidus and fractional exponents in displayed mathematics. Almost half (45 percent) used the solidus; 35 percent used fractional exponents. A majority of reports published by government agencies and of ABDEN reports employed both conventions.

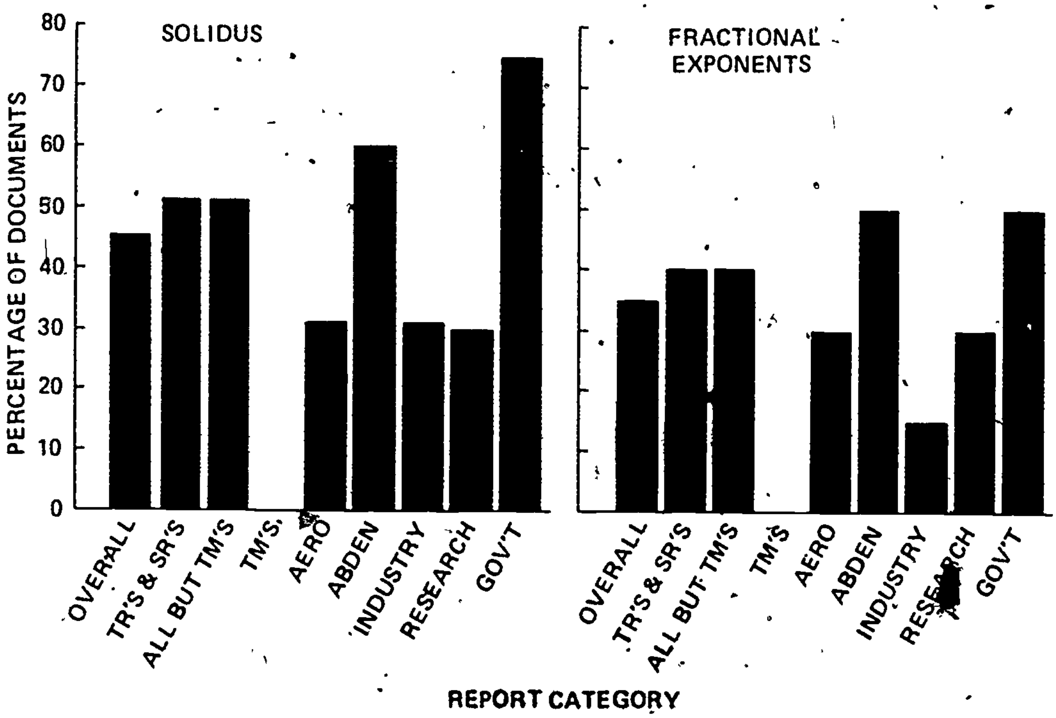

Figure 2. Use of solidus and fractional exponents in displayed mathematics of survey documents

The solidus was not used to replace stacked fractions in the NASA sample report although stacked fractions were present both in text and in display. The NASA Publications Manual 1974 did not include any references to use of the solidus, negative exponents, or fractional exponents for mathematical expressions either in text or in display. The sample NASA report did not contain any roots; therefore, use of fractional exponents to replace radicals in text or display could not be assessed. No data were collected on the use of negative exponents in the survey or in the sample NASA report.

The majority of the overall survey and all categories except technical manuals and reports published by industrial organizations used the same type size, style, and weight for headings as was used for the text. Figure 3 illustrates the data tabulated for this parameter. It is most likely that reports using the same type for text and headings were prepared by some type of "strike-on" typesetting system (typewriter, word processor, computer wheel, or chain printer). Technical manuals and reports from industry tended to use more sophisticated typographic techniques. NASA employed a "strike-on" composing system for the sample report.

Shown in Figure 4 is the percentage use of all capitals versus upper and lower case type for all heading levels in the survey. The ratio of all capitals to upper and lower case was highest in the first level of headings and decreased stepwise in the second and third heading levels. This trend was present in the overall survey and in all document categories. No clear tendency was observed for the fourth and fifth heading levels. Seventy-five percent of the survey used all capitals for first level headings, and fifty percent used all capitals for second level headings.

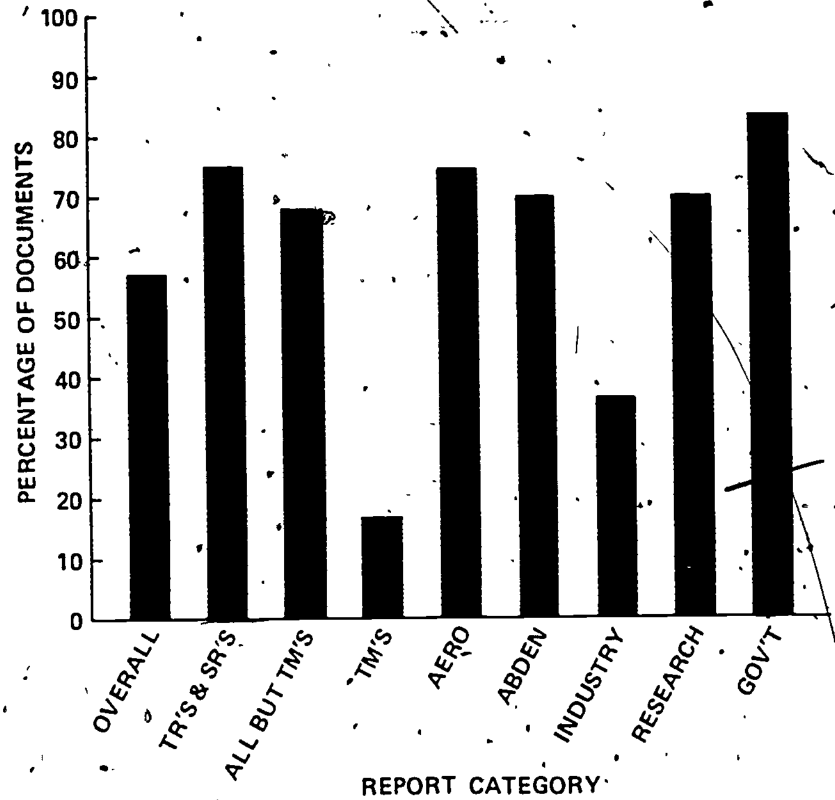

Figure 3. Percent of survey reports in which headings were the same type size, style, and weight as the text

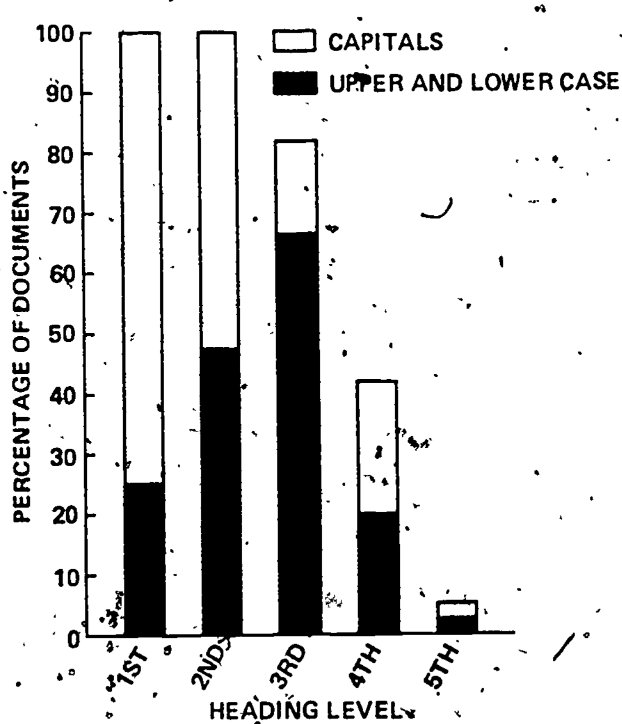

Figure 4. Use of capitals compared with upper and lower case type for headings in the survey reports

Literature sources (e.g., Harvill, 1977, p. 17) strongly advocated that figures and tables be aligned with the text so that the reader does not have to rotate the publication to use them. Hartley (1974, p. 20) and Strawhorn (1978, p. I.3.5.2) stated that if there are a large number of tables and figures and it is not feasible to reduce them to fit the page, it may be preferable to alter the format and orientation of the entire publication.

Analysis of the survey showed that these recommendations were not observed in practice. The majority of the survey publications contained one or more tables or figures placed perpendicular to the rest of the text (see Figure 5). This observation held true for all survey categories except technical manuals and reports from industry. All government publications had at least one visual placed sideways. Only once had a report format been altered to accommodate oversized tabular material while maintaining text and table alignment.

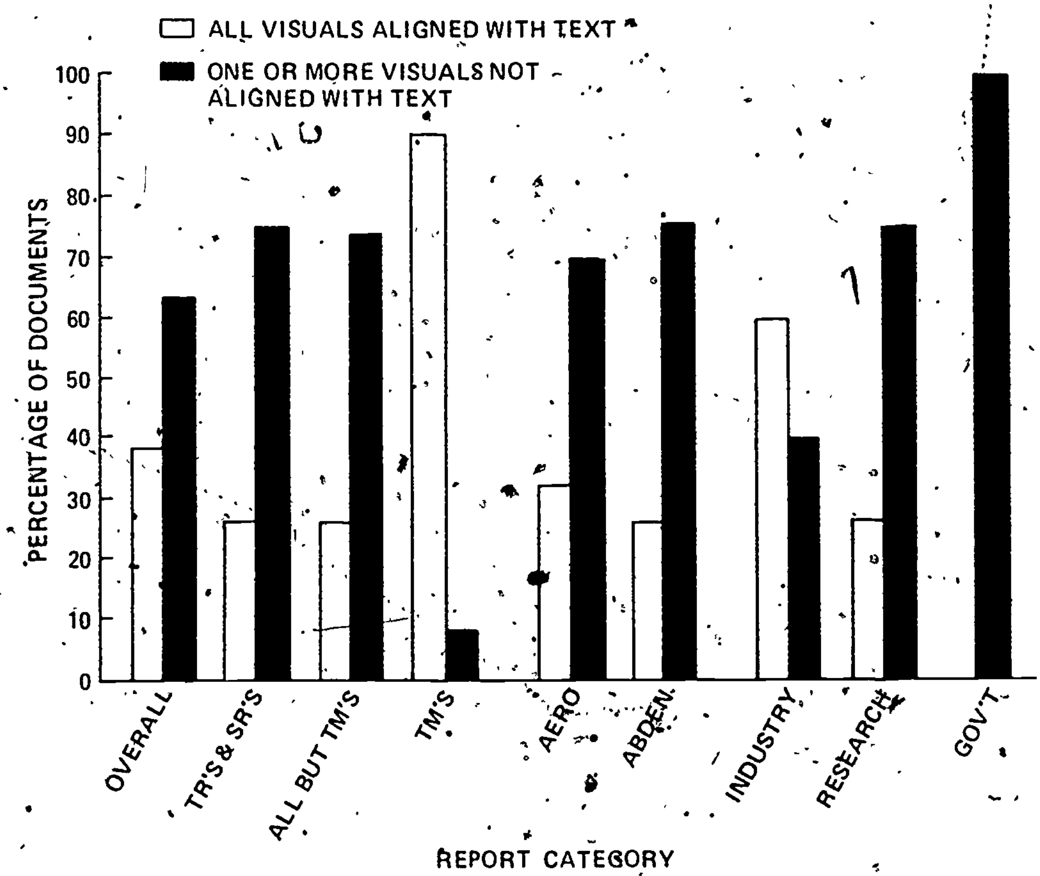

Figure 5. Orientation of tables and figures in the survey reports

21

The frequency of use of various methods to bind survey documents is illustrated in Figure 6. For the survey as a whole, perfect binding was used most often (28 percent of publications), followed by saddle stitching (22 percent), and side-wire stitching ([illegible] percent). All perfect bound documents used hot melt or glue; none were sewn. The most noticeable trend was the frequent use of ring binders for technical manuals ([illegible] percent of category).

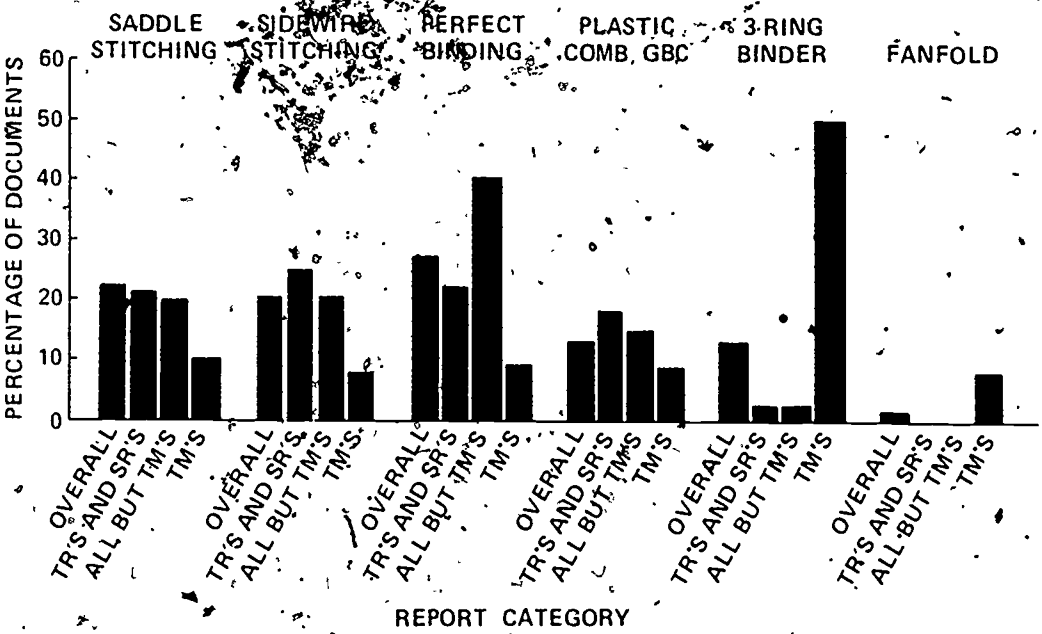

Figure 6. Binding methods used for the survey documents

Many of the same factors that apply to normal typographic considerations of legibility are also factors which govern how well a recopied document can be read. Hawken (1966, p. 30, 34-35, 83) mentioned type size, brightness, height of the lower case "x," counters, and space. Erdmann (1968, p. 108) concluded that size was an accurate predictor of legibility for digitally reproduced characters. Hawken (1966, p. 34-35) stated that the height of the lower case "x" and not the absolute size of the type was the factor influencing reproducibility. He also cited the ratio of thin stroke width to thick stroke width in a letterform as one of the most important factors affecting legibility, with an even stroke ratio, 1:1, being the ideal for reproducibility. Hawken also stated that this ratio becomes more critical as the overall type size decreases. NASA guidelines (Technical Publications Program, A Working Guide, 1979, p. 15) stated that type size should be 10 points (approximately 3.5 mm) or larger.

The results of the typographic degradation study reported herein agreed with Erdmann's conclusions. As shown in Table H, the "most legible" documents had larger average type sizes than the documents deemed "least legible" subjectively and by error count in reading. The "most legible" documents also had higher average values for all other variables measured and reported in Table H, except that there was virtually no difference in the ratio of lower case "x" height to capital letter height between "least" and "most legible" type. The NASA sample type was in the mid-range for most typographic characteristics, between most and least legible documents, except that the thin stroke width of NASA's type was very low. This also resulted in a low thin stroke to thick stroke width ratio.

TABLE H

Average Typography Characteristics of Survey Documents Which Scored as Most and Least Legible After Degradation

Characteristic	Least legible documents	Most legible documents	NASA sample report
Type size, mm	3.20	3.53	3.30
Capital letter height, mm	2.36	2.67	2.54
Lower case "x" height, mm	1.70	1.96	1.91
"x" height / capital height	0.72	0.73	0.75
Thin stroke width, mm	0.203	0.279	0.127
Thick stroke width, mm	0.279	0.355	0.381
Thin stroke width / Thick stroke width	0.73	0.79	0.33

RECOMMENDATIONS FOR CHANGE

Producers of technical reports can increase their potential use as an information product, by making certain changes to the sequential, language, and presentation components. These improvements, which affect the overall design and packaging of the product, are discussed below. These improvements are not, however, without economic consideration. For this reason, cost factors should be calculated to ensure that benefits to the user and/or increased utility will outweigh the cost to the producer.

The structure and sequence of a technical report must be flexible enough to accommodate the contents presented and the intended audience. However, the overwhelming variety of components and the numerous positions of placement can place severe cost penalties, in terms of time and effort, on the user who must review large numbers of reports to obtain needed data. Therefore, it is concluded that uniformity, concise organization, and clearly defined report components would promote clarity and utility. Consequently, technical reports which display these features would be considered an asset and would be perceived as helpful by information users as well as information "specialists." It is further suggested that improvements to the design and packaging of technical reports would ultimately increase their use by marginal users.

Producers of technical reports should develop and adopt an outline containing a sequence of report components which is flexible and can be adapted to the type of material presented (content), the message to be conveyed, and the audience to be reached. Doing so may be complicated by the fact that there appears to be no single, recognized, and agreed upon organization and structure for sequential components of a technical report. The outline should be "tested" using a reader preference survey conducted among technical report producers and users. The results of the survey would be used to modify or finalize the outline. The outline should be incorporated into a style and/or publications manual. A system of review would then be initiated to foster and ensure consistent application of the publication standards contained within the guide. This guide would be periodically reviewed and updated.

Summaries and abstracts should be clear and concise. Descriptive abstracts are preferable to informative abstracts. The abstract should provide an overall description of the research while the summary should contain the essence of the findings or results.

Tables and figures should be integrated into the text. Only when tables and figures are of such volume that insertion in the text would impair readability, should they be placed as back matter. Integration of tables and figures should help overcome the difficulties associated with the use of microfiche.

In terms of readability, summaries and abstracts should score as less difficult to read than the text. This is significant because readability scores are more accurate predictors of readership and reader concepts of suitability of material than they are predictors of comprehension. This becomes extremely important to the information user who must read numerous summaries and abstracts to determine if further analysis is necessary or if the actual report should be obtained. The information specialist, who is often engaged in the preliminary acquisition and screening of related literature prior to the undertaking of a research effort, would also find considerable merit to this improvement.

The strong tradition of using the passive voice in technical report preparation should be tempered. The active voice should be used to develop a more direct, natural, and concise presentation. The active voice is favored over the passive voice whenever verbs concern the interaction of inanimate objects and/or the writer wanted to emphasize who or what performed the action. The passive voice is recommended when the writer wants to emphasize the receiver of the action rather than the doer.

A maximum permissible number of multiple plots on a single figure should be established. Doing so should help to reduce some of the problems associated with graphs; namely too much data and grid use/nonuse. These problems become more pronounced when technical reports are microfiched and facsimile copies are produced.

Realizing that the "physical" appearance of an information product influences the users "mind set" regarding the value of the material, standards for composition should be developed which take into account the findings from the experimental/theoretical literature. The standards should cover such factors as type size and style, image area, line length and character density, and gutter width.

The accepted rules of style, grammar, and punctuation used in constructing the prose of a text should also be used for mathematics, whether appearing in the text or set off in display. The solidus and fractional exponents should be used to replace stacked fractions and fractional exponents should be used to eliminate radicals both in the text and in display.

Figures and tables should be aligned with the text so that the reader does not have to rotate the report. If there are a large number of tables and figures and it is not feasible to reduce them to fit on the page, it may be preferable to alter the format and orientation of the entire publication.

The type of binding used should be determined in part by how the report will be used. Ring binders should be used for material which is updated. Perfect binding should be used for large publications, usually more than 140 pages in length, which have a relatively long shelf life. Binding which does not permit a publication to lie flat when opened should be avoided.

Re-imaging technologies, which involve duplication, reproduction, and micrographics, and alter the traditional views of the printed report, necessitate the development of guidelines for copy preparation. A photocopy of a technical report will no longer be on the same paper, nor will it be bound in the same manner. If the report has been converted to microfiche, it may later appear as either a positive or negative image. Re-imaging degrades the report either at the loss of original data (especially when tables, figures, and graphs are concerned) or by the addition of extraneous information.

CONCLUDING REMARKS

Improving the packaging of a product is generally recognized to be one way of increasing the absolute number of units which can be sold. By extension, this paper has attempted to show that improvements in terms of the sequential, language, and presentation components will improve the utility of the technical report. It was further stated that increased utility would have its greatest effect on the marginal user.

In terms of elasticity of demand there would be increased demand by the user and there would also be increased costs to the producer. These two factors would have to be compared and analyzed to determine if the increased cost per unit would be justified by the increased utility.

There are instances where improvements could not be justified because increased utilization would not be the primary concern of the producer. This would most likely be the case for publications that are characterized by intentionally restricted circulation, contained volatile data, or have extremely limited distributions and/or specialized contents. However, when the producer is charged with making the data available to the widest possible audience (as many government agencies including NASA must) or finds it desirable to seek the widest possible dissemination of data, then the increased cost of production may well be justified.

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APPENDIX

SUGGESTED OUTLINE FOR SEQUENTIAL COMPONENTS

The following outline of front, body, and back matter components was developed after consideration of the recommendations of style manuals, publications guides, and textbooks; practices of the surveyed reports; and the general literature review. Not all of the headings listed would be necessary or even appropriate to each technical report; however, this list includes most headings which might occur so that it could be consulted for component name and placement in preparing more involved reports requiring many components. The outline includes more components than those on which a consensus existed among the sources consulted because majority agreement existed on too few components to yield a useful guide for reference use in report preparation. The assumption was made in preparing the outline that tables and figures were integrated with the text.

- Front Matter
  - Cover
  - Title page
  - Disclaimers
  - Notices (including copyright)
  - COSATI standard title page (NTIS Bibliographic Data Sheet)
  - Distribution lists
  - Table of contents
  - List of figures/illustrations
  - List of tables/charts
  - Abstract
  - Foreword
  - Acknowledgement
  - Preface
- Body Matter
  - Summary
  - Introduction
  - Text*
    - Methods
    - Assumptions
    - Procedures
    - Results
    - Discussion
    - Conclusions
    - Recommendations
    - Applications
- Back Matter
  - References
  - Bibliography
  - Appendixes (including lengthy mathematical derivations; descriptions of novel techniques; and procedures and equipment not essential to the main purpose of the report)
  - Glossary (including list of abbreviations, acronyms, or symbols)**

*Related research should be included in the text portion of the report, either where appropriate or in a separate section.

**Alternate recommended placement is in the front matter following the locator components. In either case, the assumption was made that each item was defined at first use in the report.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM-84260		

4. Title and Subtitle	5. Report Date
The Technical Report: An Analysis of Information Design and Packaging For An Inelastic Market*	June 1982
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Thomas E. Pinelli,[**] Robert McCullough,[+] and Virginia M. Cordle[#]	
	10. Work Unit No.
9. Performing Organization Name and Address NASA Ames Research Center Moffett Field, California 94035	11. Contract or Grant No.

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
National Aeronautics and Space Administration Washington, DC 20546	Technical Memorandum
	14. Sponsoring Agency Code

15. Supplementary Notes

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16. Abstract

As part of an evaluation of the NASA STI program, a review and analysis of the technical report was conducted. The results, which are contained in NASA TM-83269 (McCullough, Pinelli, et. al., 1982), will be used by NASA to evaluate the current design and packaging of its technical reports. The results of this study are highlighted.

Producers of technical reports can increase the potential use of the technical report, as an information product, by making certain changes to the sequential, language, and presentation components. These improvements, which effect the overall design and packaging of the product, are discussed. These improvements are likely to have their greatest impact on the marginal technical report user. However, these improvements are not without economic consideration. For this reason, cost factors should be calculated to ensure that benefits to the user and/or increased utility will outweigh the cost to the producer.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Economics of Information Elastic/Inelastic Demand Technical Reports Information Design and Packaging	Unclassified - Unlimited Subject Category - 82

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