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(6) SOFTWARE ENGINEERING PROJECT MANAGEMENT

A SURVEY ON THE U.S. AEROSPACE INDUSTRY'S MANAGEMENT:

SOFTWARE DEVELOPMENT PROJECTS. Report Number 2.

(REPORT NR. 2)

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This report contains a copy of the visual aids with accompanying narrative of a presentation given at the American Institute of Aeronautics and Astronautics (AIAA) Conference Computers in Aerospace, 31 Oct-2 Nov 1977. This presentation was part of a session on "Software Management - Development" and based on data gathered during a survey on how the U.S. aerospace industry manages its software engineering projects. This is Report Nr. 2 of a planned series of reports on the data. Report Nr. 1 is contained in the proceedings of the subject conference.

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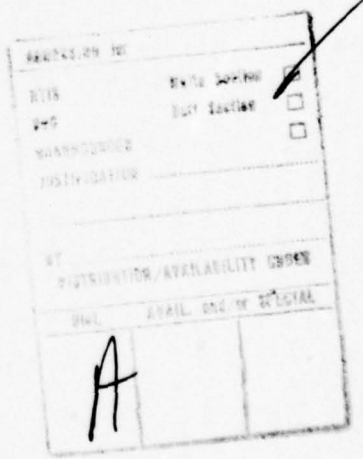
INTRODUCTION

This report contains a copy of the visual aids and accompanying narrative presented at the American Institute of Aeronautics and Astronautics (AIAA) Conference, Computers in Aerospace, 31 Oct-2 Nov 1977 at the International Hyatt House, Los Angeles, California. The presentation was part of a session on "Software Management - Development" chaired by Mr. James P. Chilton, McDonnell Douglas Astronautics Company, Huntington Beach, California.

The presentation was based on data gathered during a survey concerning the U.S. aerospace industry's management of software engineering projects, and represents the second in a planned series of reports on the data. Report Nr.1 is contained in the proceedings of the subject conference.

The survey was conducted through a rather lengthy questionnaire concerning 225 numbered questions. However, through the use of question-packing techniques, approximately 1,328 separate responses were possible. A subset of the survey was devoted to sampling the participants to determine their feelings about specific propositions concerning some of the major issues in software engineering project management, the degree of criticality of these issues, whether or not they were managerial or technical problems, and whether or not solutions could be effected through improvements in management or technology. The survey participants were also asked their opinions on how they did, or would, solve these major issues.

In all, 20 propositions on major issues of software engineering project management were tested. (See Attachment 1 of this report) Because of a limited time at the conference, only three of these issues were selected for presentation and this report concerns those three. (Propositions 1, 9, and 10) The propositions as presented in the survey were rephrased slightly for the conference to make them more easily understood.



THE PRESENTATION

A copy of the visual aids, with accompanying narrative, is provided in Attachment 2. The narrative is based on the presentation given at the conference. In those incidences where the text was almost identical to the slide, it is not repeated and the slides are left to stand on their own.

SUMMARY

This presentation gives a glimpse into some of the major problems of software engineering project management, the feelings of project managers concerning these problems, and whether or not the facts and data gathered in the survey support their beliefs about these propositions. Since this survey was addressed to only a small sample of the U.S. aerospace industry, and in turn, the aerospace industry represents only a portion of all the organizations in the United States doing software development, it could hardly be conclusively stated that the propositions judged true in our survey are true in all cases. However, at least within our sample, the data bears out that the three propositions we have chosen to expound upon are indeed true.

ATTACHMENT 1

MAJOR PROBLEMS/MAJOR ISSUES OF SOFTWARE

ENGINEERING PROJECT MANAGEMENT

INSTRUCTIONS.

Four answers are called for at the end of each of the following propositions. Check one word or phrase to complete each of the first three responses and provide a brief narrative in response to Question d.

PROPOSITIONS.

REQUIREMENTS SPECIFICATIONS.

1. Problem - Performance specifications are frequently incomplete, ambiguous, inconsistent, machine dependent, and/or unmeasurable.

ANSWERS.*

a. This problem is:

Critical	[ ]	Not important	[ ]
Important	[ ]	No problem	[ ]

b. This is a problem in:

Management	[ ]	Both	[ ]
Technology	[ ]	Neither	[ ]

c. This problem can be solved through improvement in:

Management	[ ]	Both	[ ]
Technology	[ ]	Neither	[ ]

d. How would (did) you solve this problem?

_____

_____

_____

_____

* NOTE: In the actual survey an identical set of choices followed each of the twenty propositions.

SOFTWARE DESIGN.

2. Problem - There are no decision rules for the software engineering project manager to use in selecting the correct software design techniques or tools available within the state-of-the-art.

3. Problem - There is no measure or index of "goodness" of code that can be used as an element of software design, and there is no practical way to guaranty one program is better than another.

TESTING AND RELIABILITY.

4. Problem - There are no decision rules for selecting the procedures, strategies, and tools to be used in testing software.

5. Problem - There is no measurement, or index of reliability that can become an element of design and there is no way to predict software failure; i.e., there is no practical way to guaranty (prove) the delivered software meets a given reliability criteria.

6. Problem - There is no way to guaranty that the delivered software meets the user's requirements.

MAINTENANCE AND MAINTAINABILITY.

7. Problem - There is no measurement or index of maintainability that can become an element of software design; i.e., there is no practical way to guaranty that a given program is more maintainable than another.

8. Problem - No technical discipline exists for the design of maintainable programs.

PROJECT MANAGEMENT/PLANNING.

9. Problem - Planning for software engineering projects is generally poor.

10. Problem - There is an inability to accurately estimate delivery time of a computer program.

11. Problem - The ability to plan for resources, particularly the number of programmers required, is poor.

12. Problem - There is no real quality method of designing a project control plan that will enable project managers to control their project.

13. Problem - There are no decision rules for the selection of management techniques for software engineering project management.

PROJECT MANAGEMENT/STAFFING.

14. Problem - Techniques for the selection of project managers are poor, generally resulting in poorly managed projects.

15. Problem - There is no means of measuring with any degree of accuracy the quality and quantity of code produced by a programmer.

PROJECT MANAGEMENT/ORGANIZATION.

16. Problem - There is a poor accountability structure in most development projects, leaving some question as to who is responsible for various project functions.

17. Problem - There is much consternation in industry concerning how best to organize for the accomplishment of a project (e.g., should the project be organized around the function, the project, or under a new matrix system?).

PROJECT MANAGEMENT/CONTROL.

18. Problem - It is difficult to impossible for a project manager to have the requisite visibility to be able to determine whether the project is on schedule and within cost.

19. Problem - There is a general lack of traceability from the requirements specification to the final code.

20. Problem - There is, in general, an inability to measure the quality of a program.

ATTACHMENT 2

This attachment contains a reproduction of the visual aid (slides) used in the presentation.

Facing each slide is the narrative that accompanied that slide.

SLIDE NO. 1

This presentation concerns Software Engineering Project Management: A State-of-the-Art Report. The reference to "state-of-the-art" is not to imply a discussion of the latest concepts in project management, but rather how software engineering projects are managed today in the "real world".

SLIDE NO. 2

The major purpose of the presentation is to discuss and present the results of a survey on how the U.S. aerospace industry manages its software engineering projects.

#1

SACRAMENTO ALC

SOFTWARE ENGINEERING PROJECT MANAGEMENT
A STATE-OF-THE-ART REPORT

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Report Nr II
1 Nov 1977

2

THE PURPOSE OF PAPER

- TO DISCUSS AND PRESENT THE RESULTS OF A SURVEY ON HOW THE U.S. AEROSPACE INDUSTRY MANAGES ITS SOFTWARE ENGINEERING PROJECTS

SLIDE NO. 3

In constructing the survey it was determined that certain key areas should be addressed. The major questions considered are found on this slide. The survey was divided into three parts: the first, relatively brief, obtaining background data on the firm; the second, very extensive, to provide a detailed, very precise view of individual software engineering projects; and the third, presenting propositions for consideration and comments.

SLIDE NO. 4

In creating the survey, the following approach was taken. A model of a software engineering project management system was designed. System elements were identified and relationships between and among these elements were proposed. This model formed the basis of the questionnaire, and in some respects, the questionnaire itself became the model. The questionnaire was then used to survey that segment of the U.S. aerospace industry comprising the membership of the AIAA Technical Committee on Computer Systems, the conference host. The committee membership is comprised of senior level ADP managers in many of the major U.S. corporations, individuals in an ideal position to respond. At the completion of the survey the model was validated and a series of reports are now being prepared. This presentation is the second in this series.

#3

THE QUESTIONS

- WHAT ARE THE CURRENT PRACTICES IN SOFTWARE ENGINEERING PROJECT MANAGEMENT TODAY??
- ARE THE NEW DEVELOPMENTS IN MANAGEMENT, I.E., "MODERN" MANAGEMENT TECH OR PROJECT MANAGEMENT TECH, BEING USED??
- WHAT ARE THE TRENDS IN SOFTWARE ENGINEERING PROJECT MANAGEMENT??
- WHAT ARE THE RELATIONSHIPS BETWEEN SOFTWARE ENGINEERING PROJECT MANAGEMENT TECHNIQUES AND SUCCESSFUL DELIVERY OF SOFTWARE??
- WHAT ARE THE RELATIONSHIPS BETWEEN VARIOUS ELEMENTS OF SOFTWARE ENGINEERING PROJECT MANAGEMENT AS A SYSTEM??
- WHAT ARE THE RELATIONSHIPS BETWEEN "MODERN" SOFTWARE ENGINEERING TECHNIQUES AND SOFTWARE ENGINEERING PROJECT MANAGEMENT??

#4

THE APPROACH TO ANSWERING THE QUESTIONS

1. DESIGN A MODEL OF SOFTWARE ENGINEERING PROJECT MANAGEMENT AS A SYSTEM DEFINING ELEMENT AND PROPOSING RELATIONSHIPS AND FORM QUESTIONNAIRE AROUND MODEL.

2. SURVEY A SAMPLE OF U.S. AEROSPACE INDUSTRY AS REPRESENTED BY MEMBERSHIP ON THE AIAA TECHNICAL COMMITTEE ON COMPUTER SYSTEMS.

3. VALIDATE THE MODEL.

4. REPORT THE RESULTS.

SLIDE NO. 5

All the returns are not yet in. Thirty-three companies, representing 70% of the total mailing reporting on fifty-two projects, have responded. Large to very large projects developed under government contract predominate.

SLIDE NO. 6

As previously stated, Part Three of the questionnaire contained propositions (twenty in all) concerning problems and/or major issues in the area of software engineering project management. This presentation discusses three of these propositions and the respondent's position relative to them. The answers to Part Two of the survey (the individual project reports) are then compared to the responses to Part Three to determine whether or not the data submitted in Part Two supports the contentions of Part Three.

#5

THE SURVEY

- 33 COMPANIES (70% RETURNS) ANSWERED 1338 QUESTIONS (72 PAGES) ABOUT HOW THEY OR THEIR COMPANY MANAGE SOFTWARE ENGINEERING PROJECTS.

- 52 PROJECTS WERE REPORTED ON.

- COMPANIES WERE PREDOMINANTELY AEROSPACE FIRMS, WITH GOVERNMENT CONTRACTS, REPORTING ON LARGE TO VERY LARGE PROJECTS.

#6

PROPOSITION (ABOUT PROBLEMS) TO BE TESTED

- PROPOSITION 1: REQUIREMENT SPECIFICATIONS ARE FREQUENTLY INCOMPLETE, AMBIGUOUS, INCONSISTENT, AND/OR UNMEASURABLE

- PROPOSITION 9: PLANNING FOR SOFTWARE ENGINEERING IS GENERALLY POOR

- PROPOSITION 10: THE ABILITY TO ACCURATELY ESTIMATE DELIVERY TIME ON A SOFTWARE DEVELOPMENT IS POOR

SLIDE NO. 7

As we discuss each of these propositions, you may want to ask yourself: Does the proposition reflect a problem that is critical, important, not very important, or no problem at all? If this is considered a problem of some magnitude, is it a problem in management, technology, both, or neither? And, if this is recognized as a problem, is it amenable to solution through improvements in management, technology, both, or neither?

SLIDE NO. 8

Proposition 1 pertains to an often heard complaint about requirements: "Requirements specifications are frequently incomplete, ambiguous, inconsistent and/or unmeasurable." Is this proposition true? What type of problem is it? And, how could it be solved?

#7

IS THIS PROPOSITION (PROBLEM):

CRITICAL ?	NOT IMPORTANT ?
IMPORTANT ?	NO PROBLEM ?

THIS IS A PROBLEM IN:

MANAGEMENT ?	BOTH ?
TECHNOLOGY ?	NEITHER ?

THIS PROBLEM CAN BE SOLVED THROUGH IMPROVEMENT IN:

MANAGEMENT ?	BOTH ?
TECHNOLOGY ?	NEITHER ?

#8

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PROPOSITION 1

REQUIREMENT SPECIFICATIONS ARE FREQUENTLY INCOMPLETE, AMBIGUOUS, INCONSISTENT, AND/OR UNMEASURABLE.

SLIDE NO. 9

According to the survey in which 45 project managers reported, 96% said the problem was at least important. (It should be pointed out at this time that these propositions were not placed in any rank order by the authors; however, Propositions 1, 9 and 10 represent the three most critical problems in the opinion of the surveyees.) The majority of the people felt that the propositions were a problem in both management and technology, though a number felt it to be a problem in management alone. The same number felt it could be solved either by management and technology, or management alone.

SLIDE NO. 10

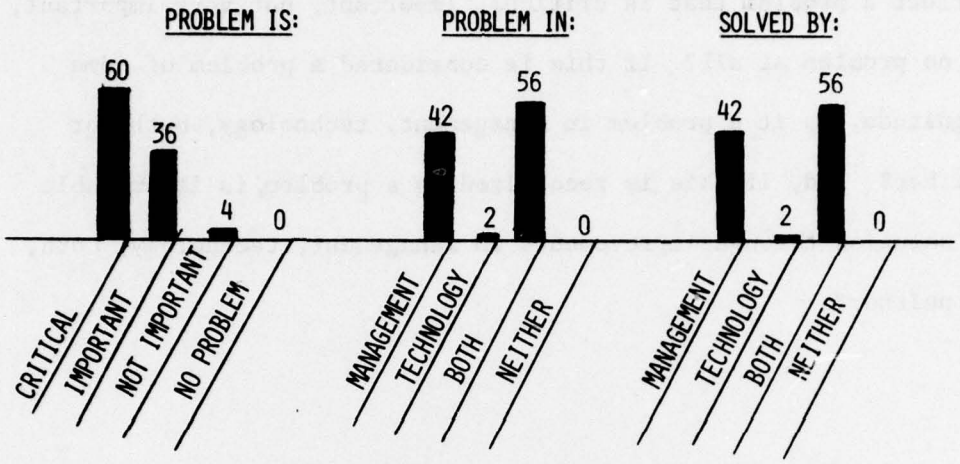
In looking at the results of the survey, it was determined that 67% of the project managers thought it necessary to rewrite specifications before proceeding with the design. Of these, an 43% average rewrite was required. The reasons given were (33 reported): errors, 24%; incompleteness or ambiguity, 33%; change in scope 27%; change in requirements, 24%; either the customer or the developer became smarter, 21%. Two individuals felt that changing requirements were the normal order of things.

In summary, we can conclude that the vast majority of project managers surveyed felt the requirements specifications as originally presented indeed present a serious problem. The results of the individual project surveys bear this out.

9

PROPOSITION 1: REQUIREMENT SPECIFICATIONS ARE FREQUENTLY INCOMPLETE, AMBIGUOUS, INCONSISTENT AND/OR UNMEASURABLE.

SURVEY OPINIONS (45 RPT), VALUES IN %:



10

SURVEY RESULTS

67% OF PROJECT MANAGERS FOUND IT NECESSARY TO REWRITE SPECIFICATIONS BEFORE PROCEEDING WITH DESIGN (51 RPT)

OF THESE, 43% (RANGE 15 TO 100%) OF THE REQUIREMENT SPECIFICATIONS WERE REWRITTEN (32 RPT).

REASON FOR REWRITING (33 RPT):

ERRORS	24%	SMARTER	21%
AMBIGUOUS/INCOMPLETE	33%	NORMAL	6%
CHANGES IN SCOPE	27%	OTHER	3%
CHANGES IN REQUIREMENTS	24%		

SLIDE NO. 11

At this point you may wish to compare your attitudes and experience with the survey respondents in answering: Does the proposition reflect a problem that is critical, important, not very important, or no problem at all? If this is considered a problem of some magnitude, is it a problem in management, technology, both, or neither? And, if this is recognized as a problem, is it amenable to solution through improvements in management, technology, both, or neither?

SLIDE NO. 12

Looking at the survey results, of the 44 project managers that reported, 91% of them felt that the problem was at least important. Only 9% felt it to be unimportant or no problem at all. Seventy-three percent felt that it was a problem in management, while 68% felt it could be solved through improvements in management, and another 27% thinking it would take both management and technology to do the trick.

11

SACRAMENTO ALC

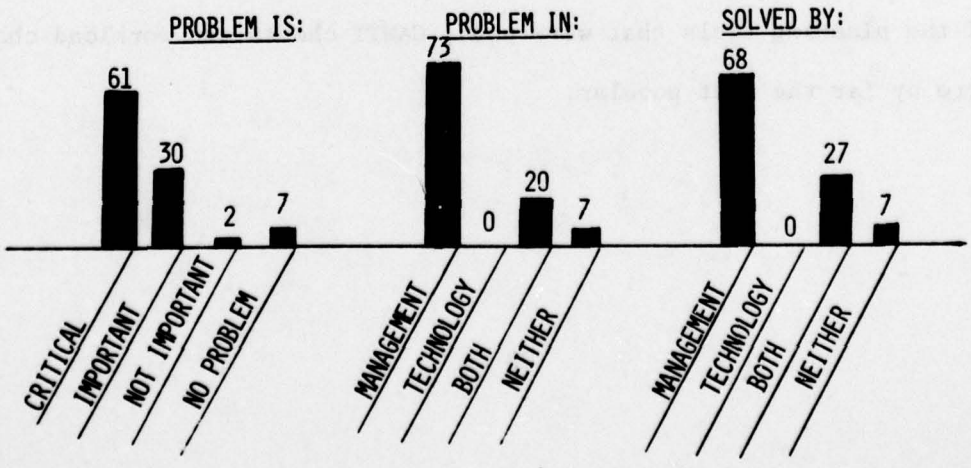
PROPOSITION 9

PLANNING FOR SOFTWARE ENGINEERING PROJECTS IS GENERALLY POOR.

12

PROPOSITION 9: PLANNING FOR SOFTWARE ENGINEERING PROJECTS IS GENERALLY POOR.

SURVEY OPINIONS (44 RPT), VALUES IN %:



SLIDE NO. 13

Before proceeding to determine whether or not the project data bears out both the proposition and beliefs of the project managers, it might be well to provide our definition of planning, which: deciding in advance what to do, how to do it, when to do it, and who is to do it! This is not original definition, having come from Principles of Management: An Analysis of Managerial Functions by Kootz and O'Donnell [1972]. Good planning, as defined by the author, involves planning for all functions (sufficient breadth), in sufficient detail (depth), and with sufficient accuracy. In contrast, poor planning is limited to scope, shallow and inaccurate.

SLIDE NO. 14

By way of background, 22% of the projects used a special planning group for planning, and only 12% of the managers had a formal planning guide furnished either by the company or some other outside organization. Of the planning tools that were used, GANTT charts and workload charts were by far the most popular.

13

DEFINITION PLANNING

PLANNING IS DECIDING IN ADVANCE WHAT TO DO, HOW TO DO IT, WHEN TO DO IT AND WHO IS TO DO IT.

GOOD PLANNING INVOLVES PLANNING FOR ALL FUNCTIONS, IN SUFFICIENT DETAIL AND WITH SUFFICIENT ACCURACY.

POOR PLANNING IS LIMITED IN SCOPE, SHALLOW AND INACCURATE

14

SURVEY RESULTS

22% OF THE PROJECTS USED A SPECIAL PLANNING GROUP FOR PLANNING (50 RPT)

12% OF THE MANAGERS USED A FORMAL PLANNING GUIDE (49 RPT)

THE FOLLOWING PLANNING TOOLS WERE USED (45 RPT)

PERT	7%	WORKLOAD	65%
MODIFIED PERT	13%	MILESTONE	4%
CPM	4%	OTHER	20%
GANTT	36%	NONE	6%

SLIDE NO. 15

Though perhaps not the ultimate measure of breadth of planning, this chart does show the functions planned for and provides the breakdown, by percent, of time spent on each.

SLIDE NO. 16

As a measure of depth, we referred to the scope and variety of planning documents employed, and the list is fairly impressive.

15

SURVEY RESULTS

15% (RANGE 3 TO 85%) OF THE PROJECTS TIME WAS SPENT PLANNING (42 RPT)

PLANNING ALLOCATED TO (36 RPT):

	RANGE	AVERAGE
MANAGEMENT	10-75%	23%
ORGANIZATIONS	5-50%	15%
STAFF	1-60%	19%
CONTROL PROCEDURES	4-60%	19%
ADMINISTRATION	5-30%	9%
QUALITY ASSURANCE	2-30%	12%
OTHER	5-35%	5%

16

SURVEY RESULTS

THE FOLLOWING PLANNING DOCUMENTS WERE PREPARED (50 RPT)

DOCUMENT	PCT USED
SOFTWARE DEVELOPMENT	76
CHANGE CONTROL	70
TEST	68
DOCUMENTATION	60
ORGANIZATION	56
STAFFING	52
REVIEW AND REPORTING	50
RESOURCE REQUIREMENTS	50
PROJECT MANAGEMENT	50
PHASE AND/OR DELIVERY	46
IMPLEMENTATION	36
TRAINING	24
DATA CONVERSION	6
PRODUCT ASSURANCE	2
CONFIGURATION MANAGEMENT	2
WORK BREAK DOWN STRUCTURE	2
BUDGET	2
NONE	4

SLIDE NO. 17

Breadth and depth do not necessarily add up to accuracy. Forty-seven percent of the projects were, or were expected to be, delivered late. Of these, 37% cited poor planning as a contributing factor. Fifty-three percent of the projects were, or were expected to be, delivered over cost. Of these, 41% cited poor planning as a contributing factor. In answer to one of the questions in Part Two of the survey, 32% of 19 projects responding cited the need for improved planning as a lesson learned, while 39% cited planning as a function they wanted to see improved.

The project managers surveyed believed Proposition 9 to be true, and the results of the survey appear to bear this out.

SLIDE NO. 18

Would you like to compare your findings with those of the experts?

SURVEY RESULTS

47% OF THE PROJECTS WERE, OR EXPECT TO BE, DELIVERED LATE (47 RPT)

37% CITED POOR PLANNING AS A CONTRIBUTING FACTOR (23 RPT)

53% OF THE PROJECTS WERE, OR EXPECT TO BE, DELIVERED OVER COST (45 RPT)

41% CITED POOR PLANNING AS A CONTRIBUTING FACTOR (17 RPT)

32% CITED "IMPROVED PLANNING" UNDER LESSONS LEARNED (19 RPT)

39% CITED PLANNING AS A FUNCTION THEY WANTED TO SEE IMPROVED (28 RPT)

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PROPOSITION 10

THE ABILITY TO ACCURATELY ESTIMATE DELIVERY TIME ON A SOFTWARE DEVELOPMENT IS POOR.

SLIDE NO. 19

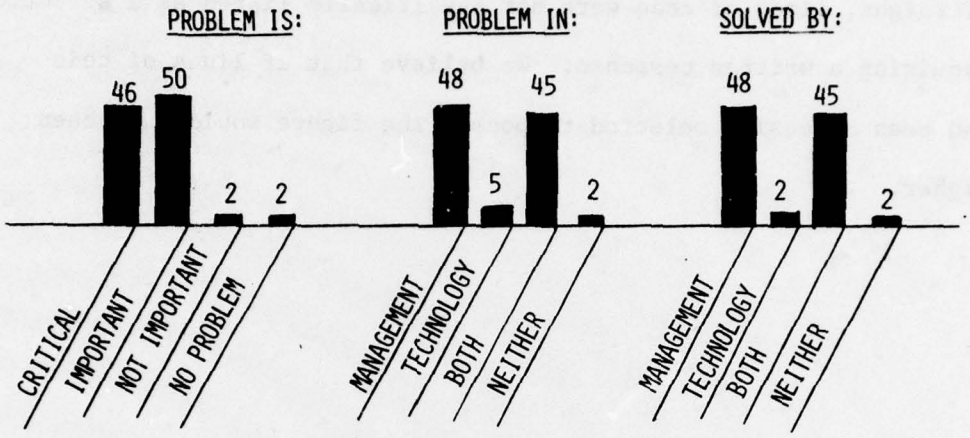
The project managers surveyed concurred with this proposition with 96% feeling this proposition was at least important. As to just what type of problem this was, opinion divided almost evenly between exclusively a management problem, and both a management and technological problem.

SLIDE NO. 20

A quick tally on this slide gives you 166%, which only means that some projects employed more than one estimating technique. Intuition appears to rank high, for though "knack" at 12% must be purely intuitive, few of the other procedures stray too far from that educated guess.

PROPOSITION 10: THE ABILITY TO ACCURATELY ESTIMATE DELIVERY TIME ON A SOFTWARE DEVELOPMENT IS POOR.

SURVEY OPINIONS (42 RPT), VALUE IN %:



SURVEY RESULTS

THE FOLLOWING METHODS WERE USED IN ESTIMATED COST AND SCHEDULE FOR THE PROJECT (50 RPT)

ESTIMATE BASED ON SIMILAR PROJECT	66%
FORMULA	42%
COST AND/OR SCHEDULE DICTATED	20%
ESTIMATED BY SOMEBODY WHO HAS A KNACK FOR ESTIMATING CORRECTLY	12%
CRYSTAL BALL (OR SIMILAR MEANS)	12%
BOTTOM UP	2%
OTHER	12%

SLIDE NO. 21

This slide lists the factors that went into determining costs and schedule. They ranged from program complexity, 57%, down to key-punch, 17%. Lines of code were used by 26%. However, through an oversight, lines of code were not specifically listed as a selection requiring a written response. We believe that if lines of code had been an easily selected response, the figure would have been higher.

SLIDE NO. 22

As previously stated, 47% of the projects were delivered late. Whether or not the project was delivered late or on time, it was compared to the evaluation technique. This slide indicates with reasonable accuracy that it does not matter what type of technique you use in estimating delivery schedule, the chance of being delivered on time or late is approximately the same; leaving us to conclude that the data does bear out that the ability to accurately estimate delivery time on software development is poor.

21

SURVEY RESULTS

IN DETERMINING COST AND SCHEDULE, THE FOLLOWING ELEMENTS WERE CONSIDERED (35 RPT):

PROGRAM COMPLEXITY	57%
DOCUMENTATION	51%
NUMBER OF MODULES	46%
COMPUTER TIME	37%
PROGRAMMER PROFICIENCY	34%
RATIO OF OVERHEAD TO PROGRAMMERS	31%
LINES OF CODE	26%
FACILITIES, SUPPLIES, EQUIPMENT	26%
TRAVEL	26%
TRAINING	23%
TESTER PROFICIENCY	20%
KEYPUNCH	17%
OTHER	20%
NONE	31%

22

SURVEY RESULTS

47% OF THE PROJECTS WERE DELIVERED LATE (47 RPT)

EVALUATION OF TECHNIQUE USED

TECHNIQUE	DEL ON TIME	DEL LATE
ESTIMATE BASED ON SIMILAR PROJECT (30 RPT)	53%	47%
FORMULA (19 RPT)	58%	42%
COST AND/OR SCHEDULED DICTATED (9 RPT)	33%	67%
ESTIMATE BY SOMEBODY WITH KNACK (7 RPT)	57%	43%
CRYSTAL BALL (5 RPT)	40%	60%
LINES OF CODE (9 RPT)	67%	33%
PROGRAM COMPLEXITY (19 RPT)	53%	47%
NUMBER OF MODULES (15 RPT)	47%	53%
PROGRAMMER PROFICIENCY (11 RPT)	36%	64%