CRITICAL SUCCESS FACTORS FOR GOVERNMENT R&D CENTERS

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JOSEPH M. GUTWEIN and EARL J. MONTOYA

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ABSTRACT

A study is made of the critical success factors (CSFs) for a number of managers at two Government R&D Centers. The object organizations are the Department of Transportation/Transportation Systems Center (DOT/TSC) at Cambridge, Mass., and, the National Aeronautics and Space Administration/Hugh L. Dryden Flight Research Center (NASA/DFRC) at Edwards Air Force Base, Edwards, Cal. CSFs and measures are identified for the Center Directors (CDs) of both R&D Centers, and form the basis for comparisons of corresponding CSFs with two lower levels of management in a chain of command reporting to the CD of each Center. Comparisons are also made of CSFs for corresponding management levels between the two Centers.

CSFs and measures are found to be manager-specific. Managers feel that priorities among CSFs are temporal, situationally dependent, and vary with the R&D environment. A hierarchical linkage of CSFs and measures is established for a chain of command of three levels of management in each Center. Information and performance measures of the CDs are shown to be subjective and based on non-quantifiable data. The hierarchy of CSFs illustrates a focusing effect with successively lower levels of management dependent on more specific data to assess performance.

An industry set of CSFs is developed by aggregating all manager-specific CSFs and measures for the thirty nine interviews conducted at the two R&D Centers. Twenty four CSFs are identified which cluster into six interrelated critical areas common to the two Centers. The critical success areas are: Purpose and Direction, Resources and Productivity, Product Effectiveness and Value, Control and Accountability, Organizational Unity, and Human Resource Development. The industry set of CSFs enables a comparison between corresponding management levels of the two Centers. Notwithstanding differences in mission, organization and Headquarter relationships, there are more similarities in CSFs than differences for corresponding levels of management of the two R&D Centers. This supports the validity of the industry set and reflects shared concerns of R&D managers in the Government.

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1. INTRODUCTION

Competent executives in successful Government R&D Centers continually search for ways to improve their organization so that it becomes more responsive and productive in fulfillment of its mission. In an environment and economy where R&D resources, both human and dollars, are severely constrained by other social priorities, improving responsiveness and productivity pose difficult challenges to these executives. Essentially, they must achieve their objectives as best they can with what they've got. With a competent "turned-on" staff and modern facilities, productivity benefits from the synergism of a cohesive organization effective in implementing its programs. Responsiveness is achieved by the organization's cognizance of the dynamic environment and the orientation of its staff to recognize and produce what society needs.

In career civil service employee organizations, such as the Government R&D Centers studied in this thesis, the challenge of top management is to achieve a strong sense of common purpose among the management and technical staff through their participative goal setting. Top management strives for goal clarity and congruence in these organizations in the hopes that everyone will pull together and set priorities for personal goals consistent with the best
interests of the organization.

This thesis is addressed to the management control issue of goal setting and accountability for performance by managers in Government R&D Centers. It is believed that the concept of critical success factors, as defined below, forms a basis of performance evaluation against goals, and, is useful for establishing accountability.

Critical success factors are those key variables which "must go right" for an organization to successfully achieve its goals. The critical success factors serve as a focus for management's attention on important dimensions of organizational effectiveness and goal achievement. Measures of critical success factors provide feedback information to management facilitating an overview of performance. The premise is that all members of an organization participate in the generation, collection, and analysis of information about their functional responsibilities. The critical success factor information thus constitutes a basis for management accountability which is often difficult or nebulous to define.

Information about critical success factor measures may be obtained internal or external to the organization. The control that top management can exert in response to this
feedback is mainly via internal mechanisms. The externalities constitute the environment to which the internal organization must adapt. However, events external to the organization provide useful feedback regarding internal performance and behavior.

Measures of critical success factors provide information which may be either objective or subjective. The objective information is usually quantifiable and often lends itself to data processing and information banks, e.g., project cost summary reports or skill bank inventories. Of importance to top management on many matters is the subjective, or non-quantifiable, sources of information feedback, e.g., general attitudes of sponsor or headquarter satisfaction on direction and performance, reactions from the technical or industrial community regarding staff competence, benefits of project results, or, internal crises. Such information is usually perishable, and, moreover, does not lend itself to machine processing. It often must flow by word of mouth thus requiring open lines of communication. (Mintzberg, Ref. 1.1)

The information provided by critical success factors and the associated measures serves different purposes, and varies in content with the environment, and with time, for different levels and functions within the organization. An overview on information needs associated with the critical
success factors and measures by different levels of management in Government R&D Centers is the thrust of this thesis.

The primary objective of this thesis is to identify the critical success factors and important information measures for the Center Directors (CD) of two Government R&D Centers. The object organizations are the Department of Transportation/Transportation Systems Center (DOT/TSC) at Cambridge, Massachusetts, and, the National Aeronautics and Space Administration/Hugh L. Dryden Flight Research Center (NASA/DFRC) at Edwards Air Force Base, Edwards, California. Critical success factors (CSF) are identified for the CDs of each center along with CSFs for the middle levels of management. Of interest is to establish a hierarchical vertical profile relationship for a chain of command from the top echelon to the middle level of management in the two R&D Centers. It is believed that a hierarchical relation among CSFs and their measures is a consequence of the different requirements for information needed by the various levels of management in organizations. Top level management normally devotes much time to planning and strategic decisions. The lower levels of management usually are more involved with operational control. The information requirements at the top may be expected, therefore, to be non-quantifiable while the requirements at the lower levels of management takes on
a specific "hard data" character. In the analysis of the findings in this thesis, an attempt will be made to establish a hierarchy among the CSFs and measures for the two Government R&D Centers.

The purpose of CSFs and their measures is to help managers focus on important performance variables of their organizations. CSFs may provide the basis for improving accountability in Government R&D Centers and may be useful to the CD in evaluating the performance of his management staff. In this regard, CSFs and the associated feedback information could be used as measures of performance in a management-by-objectives (MBO) goal-setting and performance evaluation process. Establishment of a relation between CSFs and the MBO process is beyond the scope of this thesis, but, it is offered as a suggestion for further thought and research in combination with behavioral science studies.

The second objective of this thesis is to evolve a set of CSFs which may be considered an "industry set" for Government R&D Centers. Since data is to be presented on the results of interviews with only two centers, the "industry set" of CSFs will not be offered as a set that is representative of all Government R&D Centers. However, from the set of CSFs which are presented, some conclusions can be drawn relating to a comparison between the two R&D Centers.
Similarities and differences will be identified by comparing CSF profiles for the R&D Centers. The relations between CSFs will be discussed in the context of the unique mission that each Center is fulfilling.

The thesis is organized into eight sections. Section 2 presents background on the critical success factor concept. The information in Section 2 is from a draft report prepared by Dr. John F. Rockart of the Center for Information Systems Research, MIT. An example of Rockart's research in critical success factors is given in Appendix A. A description of the two Government R&D Centers is given in Section 3. The two Centers are described in relation to their Headquarters' affiliations, organization structures, methods of funding, project assignments and responsibilities, type of work and brief descriptions of typical work products.

The approach used in acquiring the interview data is presented in Section 4 along with the methodology for analyzing and interpreting the data. The findings of the thesis are presented in Section 5. Critical success factors and measures are discussed for three levels of management in the two R&D Centers. A vertical profile is established to depict hierarchical relationships as discussed above.

A comparison of the critical success factors for the
Center Directors of the two R&D Centers is made in Section 6. In addition, an industry set of CSFs is developed from which a profile matrix is prepared to compare the critical success factors for different management positions in each organization. The conclusions of the thesis are presented in Section 7 along with recommendations for further study presented in Section 8.
2. BACKGROUND ON CRITICAL SUCCESS FACTORS*

In discussions with the Director of one of the R&D Centers interviewed in this study, he remarked, "I need more timely and accurate information on important activities crucial to the success of the Center. --- I need better bottoms-up feedback.--- The information I rely upon is mainly word of mouth, or reactions that I sense in people from what they say. ---The information I need is not the hard data of an MIS system.---What I need for information cannot be provided by an MIS."

The Director of the other R&D Center also lamented, "Somewhere in the Center useful information stops or gets filtered.---I hear of things through the grapevine faster than I get them from my staff.--- I keep getting surprises on problems. --- I lack information on matters for which I need data in order to make decisions to fix a situation."

In effect, these Directors were expressing the thoughts of many other general managers - and especially chief executive officer's (CEO) - whose needs for information are not as clearly determined as are those of many functional managers and first-line supervisors. Once one gets above the functional level, there is a wide variety of information which

*The material in this section (except for the first two paragraphs) is taken, verbatim from a draft report entitled, "A New Approach to Defining the Chief Executive's Information Needs", April 5, 1978, by John F. Rockart of the Center for Information Systems Research, MIT.
one might possibly need; and, each functional specialty has an interest in "feeding" particular data to a general manager or in not feeding. If fed all the formal data generated in the Center, as the one Director complained, a massive information flow occurs. This syndrome is spelled out with differing emphases by the recent comments of two corporate presidents:

The first thing about information systems that strikes me is that one gets too much information. The information explosion crosses and criss-crosses executive desks with a great deal of data. Much of this is only partly digested and much of it is irrelevant...(2.1)

I think the problem with management information systems in the past in many companies has been that they're overwhelming as far as the executive is concerned. He has to go through reams of reports and try to determine for himself what are the most critical pieces of information contained in the reports so that he can take the necessary action and correct any problems that have arisen (2.2).

It is clear that a problem exists with defining exactly what data the chief executive (or any other general manager) needs. My experience in working with executives for the past decade or more is that the problem is universally felt - with individual frustration levels varying, but most often, high.

In this article, several current major approaches to the definition of managerial information systems needs are first discussed. We then turn to a new approach developed by our research team at M.I.T.'s Sloan School of Management. This last approach stems for some early work done by Daniel and
Anthony and is based on an executive's identifications of his "critical success factors" and the information needs which flow from these factors. Experience in the last year with this approach suggests that it is highly effective in aiding executives to define their significant information needs. Equally important, it has proved efficient in terms of the time needed to explain the method and to zero in on information needs. (For most executives, the time needed totals three to six hours.) Most critical, executive response to the method has been excellent both in terms of the process and its outcome. Until recently, the method had been used only with an organization's top executives, but our current work makes it clear that it is useful for any general manager with multifunctional responsibilities.

2.1 Current Methods of Determining Top Executive Information Needs

In effect there are five current approaches to determine executive information needs. We term these the by-product approach, the null approach, the key indicator method, the total-study method, and, finally, the critical success factor method. Below is a brief synopsis of each of the first four and a discussion of their strengths and weaknesses. The fifth method, the critical success factor approach, and its use in one major case is then described in detail.
The By-Product Method. In this "method," little attention is actually paid to the real information needs of the chief executive. The organization's computer-based information systems development process is centered on the development of operational systems which perform the required paperwork processing for the company. Attention is focused, therefore, on systems which process payroll, accounts payable, billing, inventory, accounts receivable, etc. The information by-products of these transaction-processing systems are often made available to all interested executives, and some of the data (e.g., summary sales reports, year-to-date budget reports, etc.) are passed on to top management. The by-products which reach the top are most often at a heavily aggregated level (budget/actual for major divisions) or they are exception reports of significant interest (e.g., particular jobs now critical by some pre-set standard). All reports, however, are essentially by-products of a particular system initially designed primarily to perform routine paperwork processing.

Where the information sub-system is not computer-based, the reports reaching the top are often typed versions of what a lower level feels is useful. Alternatively, they may be the on-going periodically-forthcoming resultant of a previous one-time request for information concerning a particular matter initiated by the chief executive in the dim past.

Of the five methods discussed, this is probably the predominant method. It leads to the welter of reports noted
in the introductory paragraphs of this article. It has the paperwork-processing tail wagging the information dog.

The approach is, however, understandable. Paperwork must be done and clerical savings can be made by focusing on automating paper-processing systems. It is necessary to develop this class of data processing system to handle day-to-day paperwork. However, other approaches are also necessary to provide more useful management information.

**The Null Approach.** This approach is characterized by statements which might be paraphrased in the following way. "Top executives' activities are dynamic, ever-changing, and therefore, one cannot pre-determine exactly what information will be needed to deal with changing events at any point in time. These executives, therefore, are and must be dependent on future-oriented, rapid assembled, most-often subjective, informal information delivered by word-of-mouth from trusted advisors." Proponents of this approach point to the uselessness of the reports developed under the by-products method noted just above. Having seen (often only too clearly) that (1) the existing reports used by the chief executive are not very useful and that (2) he, therefore, relies very heavily on oral communication, advocates of this approach then conclude that all computer-based reports — no matter how they are developed — will be useless. They look at inadequately designed information systems and curse all computer-based systems.
Proponents of the null approach see managerial use of information as Mintzberg does:

...it is interesting to look at the content of managers' information, and at what they do with it. The evidence here is that a great deal of the manager's inputs are soft and speculative - impressions and feelings about other people, hearsay, gossip, and so on. Furthermore, the very analytical inputs - reports, documents, and hard data in general - seem to be of relatively little importance to many managers. (After a steady diet of soft information, one chief executive came across the first piece of hard data he had seen all week - an accounting report - and put it aside with the comment, "I never look at this.") (2.3).

To some extent, this school of thought is correct. There is a great deal of information used by top executives which must be dynamically gathered as new situations arise. And, most certainly there is data which affects top management which is not computer-based and which must be communicated in informal, oral, subjective conversations.

There is, however, also data which can and should be supplied regularly to the chief executive through the computer system. More significantly, as we note later, it is also important to clearly define what informal (not computer-based) information should be supplied to a top executive on a regular basis.

The Key Indicator/Exception Management Approach. A clear contender today for the fastest growing school of thought concerning the "best" approach to the provision of executive information is what we term the "key indicator"
approach. The approach is increasingly based on three con-
cepts, two of which are necessary and the third of which pro-
vides the glamour (as well as a few tangible benefits).

The first concept is the selection of a set of "key indi-
cators" of the health of the business for which data is coll-
lected. The second principle is "execution reporting" - the
ability to make available to the manager those indicators where
performance is different (with "significant levels" predefined)
than expected results. The executive may thus focus in areas
where performance is significantly different than planned.

The third leg is the expanding availability of cheaper,
and more flexible visual display techniques. These range from
computer consoles (with color displays) to wall-size visual
displays of computer-generated digital or graphical material.

The "key indicator approach" is a school heavily
espoused by some chief executives.

...we want everything condensed down so that we
see the key item bits of information, not the total
reports themselves. For example, we want to see how
well a profit center did compared to plan, current
month, year-to-date ... we want to see the material
exceptions or variances from plan shown by the
reports. (2.4)

What I want from my information system, particular-
ly from my financial information system, is simplici-
ty. I had to design, for my own edification, a "high
spot" statement which gives one a snapshot --- a
statement of what is happening and the key ratios in
all of our affiliates all over the world on a monthly
basis. This is the primary document by which I manage
my business. In other words, what I want the infor-
mation system to throw up to me is the exceptions.
(2.5)
A paradigm of these systems is the one developed at Gould, Inc. under the direction of William T. Ylvisaker, chairman and chief executive officer. As Business Week reports:

Gould is combining the visual display board, which has now become a fixture in may boardrooms, with a computer information system. Information on everything from inventories to receivables will come directly from the computer in an assortment of charts and tables that will make comparisons easy and lend instant perspective.

Starting this week Ylvisaker will be able to tap three-digit codes into a 12-button box resembling the keyboard of a telephone. "SEX" will get him sales figures. "GIN" will call up a balance sheet. "MUD" is the keyword for inventory.

About 75 such categories will be available, and the details will be displayed for the company as a whole, for divisions, for product lines, and for other breakdowns, which will also be specified by simple digital codes. (2.6)

At Gould, this information is displayable on a big four foot by five and a half foot screen in the boardroom. It is also available at computer terminals. Data is available in full, by exception, and graphically if desired.

As in most similar "key indicator" systems we have seen, the emphasis at Gould is on financial data. In an article entitled, "How the President Satisfies his Information Requirements", Daniel T. Carroll, reporting on Gould's system in mid-1976, describes the system's "core report" (2.7). The report, available for each of Gould's 37 divisions provides data on each of the 40 operating factors noted in Table 24.
For each factor, current data is compared with budget and prior year figures on a monthly and year-to-date basis. The report, as noted by the author, is ever-changing, but its orientation toward Profit and Loss and Balance Sheet Data, as well as ratios drawn from this financial data, is evident.

**The Total-Study Method.** A fourth approach to the development of executive information is the "total information needs" approach. In this approach a widespread sample of managers is queried about their information needs and the resultant "needs" are compared with the existing information systems. The subsystems necessary to provide the information currently unavailable are identified and prioritized. This approach, clearly, is a reaction to two decades of data processing during which single systems have been developed for particular uses in relative isolation from each other and with little attention to management information needs. In effect, this approach was developed by IBM and others to counter the "by-product approach" noted above.

The most widely used formal method to accomplish the "total study" is IBM's Business Systems Planning (BSP) methodology. BSP is aimed at a "top-down" analysis of the information needs of an organization. In a two-phase approach, tens of managers are interviewed (usually 40 to 100) to determine their environment, objectives, key decisions, and the resulting information needs. Several IBM-suggested
Table 2.1-1 OPERATING FACTORS
network design methods and matrix notations are used to present the results in an easily visualized manner. The objectives of the process are to develop an overall understanding of the business, the information necessary to manage the business, and the existing information systems. Gaps between information systems which are needed and those currently in place are noted. A prioritized plan for new systems implementation to fill the observed gaps is then developed.

This "total understanding approach" is expensive in terms of manpower, and all-inclusive in terms of scope. Studies we have seen have required several person-years of effort. The amount of data and opinions gathered is staggering. Analysis of all this input is a high art form. It is difficult, at best, to determine the correct level of aggregation of decision-making, data gathering, and analysis at which to work. Yet the study output tends to be highly useful in most cases. The exact focus of the results, however, can be biased towards either top management information, functional management information, or paperwork processing depending on the biases of the study team. We have not seen a BSP study in which top executive information was given priority in the study's output. The design, cleaning up, and extension of the paperwork processing "information network" is too often the focus of the study team.

Some Shortcomings of Existing Approaches. All of the
above approaches have their advantages and disadvantages. The "by-product approach" does focus in on getting paperwork processed inexpensively, but it is far less useful with regard to managerial information. It too often results in a manager's considering data from a single paperwork function (e.g. payroll) in isolation from other data which supplies meaning to it (e.g., factory output versus payroll dollars). The emphasis in this approach simply is toward the completion of necessary paperwork, not toward assisting busy managers to think through their real information needs.

The "null approach" has probably saved many organizations from building useless strategic planning information systems in its single-minded harping on the changeability, diversity, and "soft" environmental information needs of a top executive. It, however, places too much stress on the executive's strategic and person-to-person roles. It overlooks the management control (2.9) role of the chief executive which can be, at least partially, served by means of routine, often computer-based, reporting.

The "key indicator approach" does provide a significant amount of useful information. By itself, however, the "key indicator approach" often results in many, undifferentiated, heavily financial variables' being presented to a management team. It tends to be financially all-inclusive rather than on-target to a particular executive's individual current specific needs. The information provided is objective,
quantifiable, computer-stored data. Thus, in the key indicator approach the perspective of the "information needs" of the executive is a partial one - oriented toward "hard data" needs alone. More significantly, in its "cafeteria" approach to presenting an extensive information base, it provides the assistance to executives in thinking through their real information needs.

The total study approach is comprehensive and can pinpoint missing systems. However, it suffers, as just noted, from all of the problems of "total" approaches. There are problems concerning expense, the bewildering amount of data collected (making it difficult to discern the forest from the trees), and a difficult in devising reporting systems which serve any individual manager well.

The Critical Success Factors Approach. The Critical Success Factor (CSF) approach is an attempt to overcome some of the shortcomings just named. It focuses on individual managers and on each manager's current information needs - both "hard" and "soft". It provides a method - which appears to be logical to the executives with whom we have worked - which zeroes in on information needs in a clear, managerially-meaningful way. Finally, it recognizes fully that information needs will vary from manager to manager and that these needs will change with time for a particular manager.

The approach is based on the concept of the "key variable" or "critical success factor" first discussed in the management
literature by J. R. Daniel in 1961 (2.10). Although a powerful concept in itself for other than information systems thinking, it has been heavily obscured in the outpouring of managerial wisdom in the last two decades. Although it appears somewhat cloudy elsewhere, it has been elevated and clarified to the best of our knowledge only in the writings of Anthony, Dearden, and Vancil (2.11).

2.2 Key Variables

What are "critical success factors?" They are, for any business, the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization. They are the few key areas where "things must go right" for the business to flourish. If results in these few significant areas are good, the business will be successful. If results in these areas are not adequate, the organization's efforts for the period will be less than desired.

As a result, the critical success factors are areas of activity which should receive constant and careful attention from management. The current status of performance in each area should be continually measured, and current status information should be made available.

As Figure 2.2-1 notes, critical success factors support the attainment of organizational goals. Goals represent end points which an organization hopes to reach. The critical success factors, on the other hand, are the areas in which
GOALS

EPS

MARKET SHARE

ROI

NEW PRODUCT SUCCESS

ETC.

CRITICAL SUCCESS FACTORS

"THE KEY AREAS OF THE BUSINESS IN WHICH HIGH PERFORMANCE IS NECESSARY IF THE GOALS ARE TO BE MET."

Figure 2.2-1 RELATIONSHIP OF GOALS AND CRITICAL SUCCESS FACTORS
adequate performance will ensure attainment of the goals. Information on the status of goal attainment is a "score-keeping: activity. If goals are not being met, the particular cause must be established and other action must be taken. Information on the status of a CSF, however, provides data which leads to targeted direct action (or lack of action if all is going well) in a key area.

The Literature. Discussions of the critical success factors concept are few and limited in the information systems literature. The first reference to these factors appears to have been made by Daniel. He observed that many company information systems appeared to be static, while both the company's environment and its organization often changed. A changing business structure, he noted, led - with a static information system - to a wide gap between the information needed to run the business and the information available. Citing three examples of major corporations, Daniel concluded:

...in retrospect, it is obvious that these three companies were plagued by a common problem: inadequate management information. The data were inadequate, not in the sense of there not being enough, but in terms of relevancy for setting objectives, for shaping alternative strategies for making decisions, and for measuring results against planned goals. (2.12)

To draw attention to the information actually needed for these managerial activities, Daniel introduced the concept of critical success factors. He stated:
...a company's information system must be discriminating and selective. It should focus on "success factors." In most industries there are usually three to six factors that determine success; these key jobs must be done exceedingly well for a company to be successful. Here are some examples from several major industries:

- In the automobile industry, styling, an efficient dealer organization, and tight control of manufacturing costs are paramount.*

- In food processing, new product development, good distribution, and effective advertising are the major success factors.

- In life insurance, the development of agency management personnel, effective control of clerical personnel, and innovation in creating new types of policies spell the difference.

The companies which have achieved the greatest advances in information analysis have consistently been those which have developed systems that have (a) been selective and (b) focused on the company's strengths and weaknesses with respect to its acknowledged success factors. By doing this, the managements have generated the kind of information that is most useful in capitalizing on strengths and correcting weaknesses. (2.13)

Daniel also stressed the inadequacy of traditional accounting systems to provide the type of data necessary to monitor critical success factors. In a paragraph worth repeating 15 years later, he states:

In the minds of most executives, the accounting system exists primarily to meet the company's internal data needs; yet this is often an unreasonable and unfulfilled expectation. Accounting reports rarely focus on success factors that are non-financial in nature. Moreover, accounting practices with respect to allocation of expenses, transfer prices, and the like, often obscure rather than clarify the underlying strengths and weaknesses of

*(In 1978, we would also add compliance with energy regulations.)
a company. This inadequacy should not be surprising since the raison d'être of many accounting systems is not to facilitate planning but rather to ensure the fulfillment of management's responsibility to the stockholders, the government, and other groups. (2.14)

Daniel thus introduced the concept and focused on one category of CSFs - those critical success factors which are relevant for any company in a particular industry. We term these industry-based critical success factors (later we discuss other types of CSFs). Fig. 2.2-2 lists the automobile industry CSFs and adds two other sets of industry-based CSFs.

It should be noted that information concerning many of these CSFs is usually not available from the data stored in a formal computer-based information system. In fact, some industry-based CSFs are heavily oriented toward subjective, non-computer-based information. For example, to measure his CSFs, (Figure 2.2-2), the Dean of a Graduate School of Management in a University must track some very subjective information. It is true that one CSF student quality, can be easily and fairly objectively assessed (through entrance examination scores, college grades, etc.). Yet, equally as critical to the success of a Management School are the quality of the faculty and the opinion of the school held by others. These latter two must be measured by a heavily subjective process. If any of the three factors, whether formally or informally measured, however, dips to unacceptable levels, action must be taken - hopefully before the slide
SCHOOL OF MANAGEMENT
  • QUALITY FACULTY
  • QUALITY STUDENTS
  • REPUTATION

GROCERY
  • PRODUCT MIX
  • INVENTORY
  • SALES PROMOTION
  • PRICE

AUTOMOTIVE
  • STYLING
  • QUALITY DEALER SYSTEM
  • COST CONTROL
  • MEETING ENERGY STANDARDS

Figure 2.2-2 INDUSTRY BASED CRITICAL SUCCESS FACTORS
has made much progress.

To the best of our knowledge, written emphasis on the CSF concept lay dormant after Daniel's seminal work until a decade later. It was picked up by Anthony et al in their work on the design of management control systems.

Anthony and his colleagues pointed out three "musts" of any management control system.

The control system must be tailored to the specific industry in which the company operates and to the specific strategies that it has adopted; it must identify the "critical success factors" that should receive careful and continuous management attention if the company is to be successful; and it must highlight performance with respect to these key variables in reports to all levels of management. (2.15)

While continuing to recognize industry-based CSFs, Anthony et al. went a step further. They placed additional emphasis on the need to tailor management planning and control systems to a company's particular objectives, and its particular managers. That is, the management control system must report on those success factors which are perceived as appropriate to the particular company by the company's managers. In short, CSFs differ from company to company and from manager to manager.

In discussing the CSF concept, Anthony et al stress the need to have "simple measurements" of the critical success factors in the management control system. Like Daniel they emphasize that accounting data by itself is inadequate.
Managers need and use simple measurements of the critical success factors in their business. The designer of a management control system must attempt to supply these data in the most useful form. Frequently, such measurements are physical (the ratio of subscribers renewing) rather than financial or economic. Physical data have the virtue of being both tangible in an operational sense and, in some cases, of being available more frequently and more promptly than accounting information. In such cases, the reporting of key variables should not be delayed until monthly accounting statements are prepared. Special reports on critical physical ratios should be issued on a natural cycle, the frequency of which is determined by the physical activity itself. (2.16)

2.3 The Origin of CSFs

Thus far, we have discussed CSFs which are applicable to any company operating in a particular industry. Yet Anthony et al. suggest that a management control system also must be tailored to the company, its particular objectives, and its particular managers. This suggests that there are other sources of CSFs than the industry alone. And, indeed, there are. In our work thus far, we have isolated four prime sources of critical success factors. These are:

1. The Structure of the Particular Industry. As noted to this point, each industry by its very nature has a set of critical success factors which are determined by the characteristics of the industry itself. Each company in the industry will ignore these factors at its peril, and most of these factors will appear on every CEO's critical success factors list.

2. The Organization's Strategy, Position Within the Industry, and Geographical Location. Each company in an
industry, however, is in an individual situation determined by its history and current competitive strategy. For smaller organizations within an industry dominated by one or two large companies, the competitive actions of the major companies will often produce new and significant problems for the smaller companies. It may mean establishing a new competitive niche, getting out of a product line completely, or merely redistributing resources among various product lines. Thus, for small companies, "competitor x's actions" is often a CSF. For example, in the computer industry, IBM's competitive approach to the marketing of small inexpensive computers is, in itself, a CSF for all minicomputer manufacturers. Just as differences in industry position can dictate CSFs, difference in geographic location and differences in strategies can lead to differing CSFs from one company to another in an industry.

3. **Environmental Factors.** As the gross national product and the economy fluctuate, as political factors change, and as population waxes and wanes, critical success factors can also change for various institutions. At the beginning of 1973, virtually no chief executive in the U.S. would have listed "energy supply availability" as a critical success factor. Following the embargo, however, for a considerable period of time this factor was monitored closely by many executives — since adequate energy was now problematical and vital to organizational bottom-line
performance.

4. **Temporal Organizational Factors.** Internal organizational considerations often lead to "temporal" critical success factors. These are areas of activity that are significant for the success of an organization for a particular period of time because they are below a threshold of acceptability at that point in time (although in general they are "in good shape" and do not merit special attention). As an example, for any organization, the loss of a major group of executives in a plane crash would make the "rebuilding of the executive group" a critical success factor for the organization for the period of time until this was accomplished. Similarly, while inventory control is rarely a CSF for the CEO, a very unusual situation (either for too much or for too little) stock might, in fact, become high level CSF.

The above multiple sources from which critical success factors are generated suggest that a simple list of "industry-based" key variables is not enough for management use in determining information needs. For an organization, its situation will change from time to time, and factors which are dealt with by executives as commonplace at one period of time become "critical success factors" at another time. The key here is for the executive to clearly define at any point in time exactly those factors which are crucial to the success of his particular organization **in the period for**
which he is planning. These success factors will differ from organization to organization, from time period to time period, and from manager to manager as each has differing responsibilities.

An example of differing key variables for similar organizations. One would expect, therefore, that organizations in the same industry would exhibit different CSFs as a result of differences in strategy, geographic location, environmental, and temporal factors. A study by Mooradian (2.17) of the critical success factors as perceived by the top management of three similar medical group practices bears this out. The medical group practices - each a group of participating physicians - were heterogeneous with regard to many of these factors. All, however, were seen to be well-managed with a dynamic and successful administrator in charge.

The CSFs were defined through open-ended interviews with the administrator of each group practice. The managers were asked to define their critical success factors and to order them from most important to least important. To verify the factors selected, the opinion of others in the organization were also obtained.

Table 2.3-1 shows the administrator's key variables for the three group practices. They are ranked in order as perceived by the managers of each institution. It is interesting to note that several of the same variables
Table 2.3-1 CRITICAL SUCCESS FACTORS FOR THREE MEDICAL GROUP PRACTICES
appear on each list. Several variables, however, are unique to each institution.

One can explain the difference in the critical success factors chosen by noting the differences in the stages of growth, location, and strategies of each clinic. The first clinic is a mature clinic which has been in existence for several years, has a sound organization structure, and an assured patient population. It is most heavily concerned with government regulation and temporal or environmental changes (such as rapidly increasing costs for malpractice insurance), which are the only factors which might upset its currently high favorable status quo.

The second group practice is located in a rural part of a major state. It is dependent upon federal funding and also on its ability to offer a type of medical care not available from private practitioners. Its number one CSF, therefore, is its ability to develop a distinctive competitive image for the delivery of quality care and comprehensive care. The final practice is a rapidly growing, new group practice which was - at that point in time - heavily dependent for its near term success on its ability to "set up" an efficient operation and bring on board the correct mix of staff to serve its rapidly growing patient population.

In looking at these three lists, it is noticeable that factors 1 through 4 on Practice #1's list, appear on the
other two lists also. These, it can be suggested, are all-encompassing industry-based factors. The remaining factors, where are particular to one or the other of the practices, but not all, are generated by differences in environmental situation, temporal factors, geographic location, or strategic situation.

2.4 CSFs at All General Manager Levels... And Their Benefits

To this point, we have talked about CSFs from the viewpoint of the top executive of an organization alone. Indeed, that is the major focus of our current work. It is, however, clear from studies now going on that CSFs, as might be expected, can be arrayed hierarchically and used as an important vehicle of communication for management - as well as a design for the construction of useful information systems.

There are several significant benefits of taking the necessary time to think through - and to record - the critical success factors for each general manager in an organization. These are:

- First, it helps the manager to determine those factors on which s/he should focus management attention. The process helps insure that these significant factors will receive careful and continuous management scrutiny.

- Second, the process forces the manager to develop
good, adequate measures for each of these critical factors and to seek reports on each of these measures.

- Third, the identification of critical success factors allows a clear definition of the amount of information which must be collected by the organization and tends to limit the costly collection of more data than is necessary.

- Fourth, the identification of CSFs tends to move an organization away from the trap of building its reporting and information system primarily around data that is "easy to collect." Rather, it focuses attention on that data which might otherwise not be collected, but which is significant for the success of the particular management level involved.

- Fifth, the process acknowledges that some factors are "temporal" and that CSFs are manager-specific. This suggests that the information system should be in constant flux with new reports being developed as needed to accommodate changes in the organization's strategy, environment, or organization structure. Rather than changes in an information system being looked upon as an indication of "inadequate design," they must be viewed as "right and inevitable."

- Finally, the process provides a simple four-step sequence for the development of information systems
as shown in Figure 2.4-1. This is a "top-down" approach starting with the definition of CSFs. The second step is the recognition of those measures which indicate progress (or lack of it) with regard to particular CSFs. The third step is the design of reports which will provide information on the current status of each measure to the manager. Finally, only at this point, does one concern oneself with "The MIS" - which, after all, is only a system for gathering and transforming data. Unfortunately, the current process for the development and design of most reporting systems is exactly the opposite. Starting from the bottom up, an MIS group designs a transaction processing system to do billing, payroll, etc. and then asks executives what data "they need" from this system. This backwards approach leads to the outcomes noted in the first part of this paper.*

*At this point, the reader is referred to Appendix A which reports on the results of a case study of the CSF concept. The material in Appendix A is a continuation of the referenced report by Rockart.
Figure 2.4-1  TOP EXECUTIVE REPORTING NEED ANALYSIS
3. DESCRIPTION OF THE GOVERNMENT R&D CENTERS

The object organizations for this thesis are two Government R&D Centers: the Department of Transportation/Transportation Systems Center (DOT/TSC), at Cambridge, Massachusetts, and the National Aeronautics and Space Administration/Hugh L. Dryden Flight Research Center (NASA/DFRC) at Edwards Air Force Base, Edwards, California. Both centers are remotely located from their respective Headquarter Offices in Washington, D.C., but closely coupled in a technical, programmatic, and administrative sense. The DOT and NASA have other R&D and test centers in the country but these were not considered in this study.

In this section we describe the organizational relationships of each center with respect to their parent organizations. We also outline briefly the following: the organizational structures for each center; the mission, role and work content; the method of funding and project assignment relationships with their respective headquarters; and, a brief account of the type of R&D work each center carries out.

3.1 Department of Transportation/Transportation Systems Center (DOT/TSC)

The overall organizational structure for the Department of Transportation (DOT) is shown in Fig. 3.1-1. The Secretary of Transportation is a cabinet position to the President.
Figure 3.1-1 U.S. DEPARTMENT OF TRANSPORTATION
Under the Secretary are office staff positions, assistant secretarial posts, the Research and Special Programs Directorate (RSPD), and seven transportation Modal Administrations identified on the bottom of Figure 3.1-1. TSC reports through RSPD but performs R&D work for all the modes. The sections below describe how TSC fulfills its mission.

3.1.1 DOT/TSC History*

On July 1, 1970, the President of the United States approved the transfer of the NASA/Electronics Research Center (ERC) from NASA to DOT to form the new Transportation Systems Center. This redeployment of a Federal R&D facility involved a transfer of about 400 people from the then existing NASA staff of over 800. The initial technical capability of the Center, as redeployed from NASA, was predominately in the areas of sensors, navigation, communications, satellites, controls, data processing and displays, and systems analysis leading to design, fabrication and test of air and space transportation systems. At the outset, TSC sought to develop strong capabilities to design, develop, test, and evaluate complete transportation systems. The intention was that the modes, in pursuing their R&D programs, would capitalize upon TSC expertise to improve technical content of their programs.

*The material in Section 3.1.1 to 3.1.5 was extracted and edited from the DOT/TSC Long Range Plan in preparation at the time this thesis was written.
The Department of Transportation viewed the acquisition of TSC as a landmark event in its early phase of development** in forming a professional nucleus of highly trained scientists and engineers.

TSC, as an organizational element in DOT, has been a partner with the Office of the Secretary of Transportation (OST) and the Modal Administrations in pursuit of these goals since its acquisition by the DOT from the National Aeronautics and Space Administration (NASA). In 1977 the Transportation Systems Center became an element of the new Research and Special Programs Directorate (RSPD), an organization in the DOT at the same level as the Modal Administrations (Fig. 3.1-1). TSC operates under the executive direction of the Director, RSPD, whose main mission is to plan, develop, initiate, and manage programs in all fields of transportation research and development (Fig. 3.1-2).

RSPD derives its mission from that of the Department, and accordingly sets technology policy, priorities and administers all research and technology programs to insure that research, development and demonstration objectives are consistent with DOT objectives and priorities. The TSC program is an integral part of this responsibility.

** DOT was established by the Congress in the Fall of 1966 by consolidation of the Modal Agencies and transferring the U.S. Coast Guard from the Treasury Dept. to DOT.
Figure 3.1-2 RESEARCH AND SPECIAL PROGRAMS DIRECTORATE
3.1.2 TSC's Mission and Organization

TSC is the Department's multi-modal research, analysis and development resource. TSC conducts research on a wide variety of high-priority technological and socio-economic programs for the Office of the Secretary and the Modal Administrations. The Center provides the multi-modal perspective which enables transfer of technology and capability across traditional modal lines. TSC maintains a close relationship with all of the Modal Administrations, as well as industry groups, and professional societies. Continually focusing its work on key issues and decisions the Department must address, TSC contributes to the advancement of the state-of-the-art with particular emphasis in policy analysis, systems engineering, research and development, planning, technology information dissemination, and data base management.

TSC is staffed with professional technical personnel possessing the skills, competence and expertise necessary for addressing and resolving the wide range of national transportation problems confronting government and industry. At the end of 1977, the Center had 631 full-time employees plus over 200 in-house support contract personnel. The TSC professional staff includes engineers and scientists of all disciplines, as well as economists, community planners, sociologists, mathematicians, psychologists and transportation legal experts.
More formally stated, the mission of TSC in support of the Department is as follows:

1. Operational, analytical, and research support to the Office of the Secretary (OST) and the operating administrations;

2. Project management and technological support for the program of OST and the operating administrations;

3. Research on transportation systems and the social and economic impacts of transportation systems, including the development and maintenance of the DOT Transportation information base;

4. The sharing of technical, social and economic understanding with the transportation community.

TSC's success in carrying out its mission of conducting needed research and directing a nationwide transportation research effort depends largely on its ability to fit its efforts into the total Department of Transportation program. Doing so, requires that TSC maintain close working relationships with RSPD, the Office of the Secretary, the Modal Administrations, other Federal agencies, contractors, supporting industrial firms, universities, and other segments of the transportation community. The structure of this complex and interdependent network of relationships requires a broad case of competence and constant awareness to developing needs and transportation problems.
TSC has the autonomy to establish direct working relationships with all elements of DOT. A major segment of the work of TSC, therefore, has been in direct support of the seven Modal Administration R&D efforts. TSC also works closely with other organizations of the Federal government; state and local governments; educational, public, industrial and foreign entities involved in the field of transportation after coordination with the appropriate DOT office. TSC's role within the Department, specifically, and throughout the transportation community, in general, keeps pace with the accelerating demands of the Federal Government in the area of transportation.

The present organization of TSC (see Fig. 3.1-3) reflects a functional organizational concept blended to most efficiently respond to the Department's needs: operational, policy and legislative matters, safety matters, and quality of the environment. TSC has four operating directorates and an administration directorate to provide the necessary support for DOT. The technical directorates are modal in their orientation: the Office of Air and Marine Systems supports the Federal Aviation Administration, the Coast Guard, and the Saint Lawrence Seaway Development Corporation; the Office of Ground Systems supports the Federal Railroad Administration and the Urban Mass Transportation Administration; and the Office of Energy and Environment supports the energy conservation efforts in the automotive field of the National Highway
Figure 3.1-3 TRANSPORTATION SYSTEMS CENTER
Traffic Safety Administration. The Office of Systems Research and Analysis is a focal point for socio-economic research, analysis of the supply and demand for transportation, and for transportation information and statistics. While the socio-economic work can be cross- or multi-modal, its primary customer is the Urban Mass Transportation Administration.

3.1.3 TSC Funding

Since its inception in 1970, the Transportation Systems Center's funds have been derived from a complex financing mechanism involving TSC, the Modal Administrations, and OST. This mechanism is a Consolidated Working Fund (C.W.F.) which is administered by the Office of the Secretary. OST, through the C.W.F., receives and disburses funds in agreement with the contractual and reimbursable arrangements in accordance with General Working Agreements (GWA) executed with each of the Modal Administrations and the Office of the Secretary. The C.W.F. is a project-oriented, accounting mechanism for the pooling of funds from the Office of the Secretary, the Modal Administrations, and, is intrinsically temporary. The C.W.F. does not require legislative action. It is often employed in construction projects, which are temporary, and especially where there are multiple sources for a single effort.
Under the General Working Agreement, which is a binding document, work performed by TSC for DOT sponsoring organizations is stated in broad terms and in which there is negotiated concurrence. The individual projects and tasks, which make up the GWA and are defined therein, are documented in finer detail in separate documents, the Project Plan Agreements (PPAs), which define the technical projects and resources allocated. The GWA is fundamentally an "umbrella" document between TSC and the sponsor (FAA, OST, UMTA, etc.) which defines general scope and funding ceilings for one fiscal year.

While this is the structure of the funding since the origin of TSC, it was the clear intention of the Secretary of Transportation in 1970 to have a separate legislative appropriation for TSC in future budgets. At the time DOT assumed responsibility for TSC, an agreement was made with the Office of Management and Budget (OMB) for the use of the Consolidated Working Fund as an "interim" measure only. Since that time the subject of a permanent technique of funding for TSC has been raised and pursued but the present C.W.F. method is still in effect. Indications are that in FY 1978, the Working Capital Fund will be introduced as the financial system for TSC; however, this should involve no significant difference from the present modus operandi except for the funding responsibility.
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<td>117.5</td>
<td>119.9</td>
<td>128.0</td>
<td>121.3</td>
<td>114.3</td>
<td>94.5</td>
<td>73.7</td>
</tr>
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<td>35.8</td>
<td>29.1</td>
<td>25.6</td>
<td>23.9</td>
<td>19.1</td>
<td>33.1</td>
<td>26.6</td>
</tr>
<tr>
<td>HW</td>
<td>13.1</td>
<td>9.2</td>
<td>9.6</td>
<td>6.3</td>
<td>6.4</td>
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<td>3.0</td>
</tr>
<tr>
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<td>70.6</td>
<td>105.2</td>
<td>102.4</td>
<td>105.5</td>
<td>121.3</td>
<td>114.9</td>
<td>77.3</td>
<td>78.3</td>
</tr>
<tr>
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<td>32.2</td>
<td>40.9</td>
<td>50.6</td>
<td>77.5</td>
<td>73.5</td>
<td>70.4</td>
</tr>
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<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
</tr>
<tr>
<td>UM</td>
<td>301.1</td>
<td>644.3</td>
<td>72.2</td>
<td>76.5</td>
<td>97.0</td>
<td>99.9</td>
<td>99.5</td>
<td>96.4</td>
</tr>
<tr>
<td>VV</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
<td>.0</td>
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<td>2390.0</td>
<td>358.8</td>
<td>370.9</td>
<td>396.7</td>
<td>444.8</td>
<td>441.1</td>
<td>397.2</td>
<td>372.5</td>
</tr>
</tbody>
</table>

Table 3.1-1  HISTORY OF PROJECT PLAN AGREEMENTS (PPAs) BY MODE
In 1970, TSC was mainly supported from research appropriations of the Office of the Secretary and the Federal Aviation Administration. The initial work, therefore, was in support of the development of advanced systems to increase the capacity of the Nation's airways and airports systems. The new Center quickly established its importance to the OST and Modal Administrations by responding with invaluable overall support to the Department. As Table 3.1-1 shows, the funding from most of the modes grew dramatically as the competence of the center evolved. Prominent among the newest supports are UMTA, FRA, and NHTSA. Although the original capability redeveloped from the NASA-ERC was largely electronic supporting initially the FAA programs, over the years, TSC has expanded its staff by adding significant mechanical and civil engineering skills. The results have been a shift from a heavily FAA communications and traffic control-oriented program mix to one with significant efforts for UMTA, FRA, and NHTSA in the automotive energy area, along with continued support to FAA.

3.1.4 Current TSC Expertise

The Department of Transportation's functions, supported by TSC projects, are shown in Figure 3.1-4, apportioned by estimated FY'78 funding. The programs represent legislated authorities of the Department, such as administering grants, controlling air and marine traffic (operations), and regulating
Figure 3.1-4  DOT OBJECTIVES SUPPORTED BY TSC
transportation service industries. As the Figure shows, the largest part of TSC's current efforts support the DOT role to perform research, analysis, development and demonstrations (RD&D). These efforts are essentially directed toward development of technologies which are needed by the transportation community in advancing the quality and quantity of transportation services. Equally important effort is directed toward the development of a sound technological data base for use on safety, environmental, energy and socio-economic matters. Still another major part is applied to developing improved systems for use by the Federal Aviation Administration, the U.S. Coast Guard and the Saint Lawrence Seaway Development Corporation, as they conduct their operating missions. The "Advise, Coordinate, and Communicate" segment of TSC's effort involves supporting the Department's leadership role in coordinating intergovernmental and industry programs and disseminating the results of DOT sponsored research, development, and demonstrations to local decision-makers. Through the grant process, the DOT exercises a degree of flexibility in stimulating the academic community involvement into research on all areas of transportation.

TSC's work falls into the general categories shown in Figure 3.1-5, with about one half oriented toward physical transportation "Equipment and Systems Designs" and their components and the balance oriented toward the needs of decision-makers. The sections on "Evaluations and Findings"
Figure 3.1-5 DISTRIBUTION OF TSC'S FY78 FUNDING BY TYPE OF PRODUCT
and on "Policy Recommendations" generally involve programs which focus on specific problems and issues, while "Support and Information Services" activities emphasize developing and disseminating more generalized information. Fundamentally, these efforts are in response to the needs and demands of the sponsoring organizations at DOT Headquarters.

The products of TSC's efforts vary with the program and with the sponsor. In the socio-economic area, the product is most often reports based on TSC research which advance the state of knowledge on the subject of particular interest to the sponsor. Often these reports evaluate the impacts of alternative actions or assess the costs and benefits of implementing a specific transportation system. In many cases, TSC produces specifications for system or component improvements related either to transportation systems such as rapid transit cars or rail; or to the communications or navigation systems used in guiding or controlling transportation systems. Typical of the products from TSC are:

- Reports (note: for FY'76 TSC produced 150 reports; in FY'77 it doubled that to 300 reports)
- Specifications
- Data Bases
- Hardware
- Software
- Industry Briefings
- Information Sharing
- Conference/Workshops/Seminars
The Center is the DOT's sole multi-modal resource for pursuing high priority technological and socio-economic research, analysis and development; correspondingly, DOT relies on TSC's results, be they reports or demonstrations, to fulfill this role, accurately and effectively, in partnership with DOT Headquarter elements and Modal Administrations as they face major national decisions.

3.1.5 Operating Constraints

TSC is a unique government R & D center in the Department. There is no other organization which can, or does, look at transportation from a multi-modal perspective. TSC works for all modes and has the ability to assimilate and transfer technology and experience from one mode to another. In particular, TSC has a unique combination of skills which can be applied to a variety of transportation problems. TSC has developed several sophisticated laboratory facilities which are unique in the Department; compared to most of the Modal Administrations and offices in DOT, TSC has a large technical staff--nearly 500 professionals; the skills of that staff range from economics to mechanical engineering, from generalists to those with very specialized skills. Many of the staff have worked on a variety of transportation tasks for different modes, or for intermodal issues. Some of the staff also bring the unique perspective of non-transportation technical backgrounds.
which may lead to a fresh approach to the solution of transportation problems.

While the unique character of TSC, its mission, and its staff are important factors which allow TSC to flexibly respond to DOT requirements, the personnel ceiling and funding mechanism for TSC constrain the full realization of TSC's potential. Unlike a contractor, TSC cannot hire new personnel to staff a particular job and then layoff others when a project is completed. The ceiling restricts the number of technical personnel, and the skills which the staff, in the aggregate, has. Thus, TSC may be unable to accept all sponsors requests for a certain type of work because the skills which would be employed are fully occupied on other projects. In this sense, it is almost a "feast or famine" situation. TSC often has the skills desired but they are fully committed while other skills stand idle. Some staff retraining may be possible, but there is no question that this constrains TSC's ability to respond.

3.2 National Aeronautics and Space Administration/Dryden Flight Research Center (NASA/DFRC)

The National Aeronautics and Space Administration's overall organizational structure is shown on Figure 3.2-1. This figure represents the organization as of September, 1977. Some Headquarters reorganization, internal to the offices shown, has occurred since this diagram was made. The structure is believed to still be representative of NASA today.
Figure 3.2-1 NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
The Administrator is appointed by the President. There are three major offices under the Administrator: Office of Associate Administrator, Office of Space Flight and the Office of Associate Administrator for Center Operations. As shown, Dryden Flight Research Center (DFRC) is directly under the Office of Associate Administrator for Center Operation. DFRC obtains institutional, management and support (IMS) funds through this Office. Research and development funds are obtained primarily from the Office of Aeronautics and Space Technology shown on the left side of Figure 3.2-1. The history, research goals and objectives, organization, funding, and current technical activities of the Dryden Flight Research Center are discussed in the following sections.

3.2.1 NASA/DFRC History*

The NASA Dryden Flight Research Center, originally established in 1947 as the National Advisory Committee for Aeronautics' (NACA) High Speed Flight Research Station, has been a focal point for flight testing of research aircraft. It traces its beginning back to a joint USAF-NACA test program which led to the historic breakthrough into the supersonic speed era on October 14, 1947. On that day the rocket-propelled X-1 airplane was flown faster than the speed of sound by Air Force Captain Charles Yeager. Only 44 years after the Wright Brothers made their first flight, the era of high speed flight.

*The material in Section 3.2.1 was extracted and edited from the NASA/DFRC Visitor Information booklet printed Aug. 1976.
had arrived. Over the next ten years this research effort would include investigations of transonic and supersonic flights during the X-1, X-3, D-558, X-4, and X-5 programs.

The Center has proven to be an ideal site for flight testing. It is located on the edge of Rogers Dry Lake, a very large natural runway, and enjoys clear flying weather nearly every day of the year. It is isolated from the problems of large populations and yet is close enough to a major metropolitan area to keep transportation and similar problems to a minimum.

Ten years after Captain Yeager's first supersonic flight, the launching of Sputnik 1 into orbit opened the door to the Space Age. A year later (1958) the National Aeronautics and Space Act was signed and the NACA High Speed Flight Research Station became the NASA Flight Research Center.

That same year the first of three X-15's was delivered to the Center by North American Aviation, and, in 1959 flight-testing of these hypersonic aircraft began. The goal of this program was to explore the realm of hypersonic flight, and the program was accelerated to accommodate the growing space program's increasing need for advanced aerospace information. By the time the nation decided to put a man into orbit, much of the technology that would be necessary and the confidence to use that technology had already been achieved by many government and industrial teams associated with the X-15 program.
The three X-15's made a total of 199 flights in the joint NASA-USAF program. A maximum speed of Mach 6.7 (4500 mph) and a peak altitude of 354,000 feet was attained by these aircraft.

In 1963, two other programs, that would soon have a major impact on the space program, were initiated at the Center. The first was called the Lunar Landing Research Vehicle, or LLRV. It was a free-flying simulator designed to develop control system requirements and piloting techniques that could be used during the final phase of the manned lunar landing.

The second was the M-1, the first of a series of aerodynamic reentry vehicles called "lifting bodies". This series of rocket-powered wingless vehicles derived all of their lift from their body shape. They were dropped from a B-51 mother-ship to make either a powered or unpowered flight before making a glide landing approach, usually touching down on the lakebed. The purpose of the lifting body program was to prove the concept "conventional" aerodynamic landing of manned reentry vehicles. Stability and control, handling qualities, and energy management through the critical transonic regime and on to touchdown for very low L/D vehicles were the major objectives of this program. Four vehicles (M-2, HL-10, X-24A, and X-24B) made 144 flights in cooperation with the Air Force. All objectives of the program were accomplished including the first unpowered low L/D landing on a standard runway, thus completing 69
validation of the technique to be used by the Space Shuttle.

Of course many other projects too numerous to describe have been carried out at the Dryden Flight Research Center during its thirty years of operation. The Center is proud of its accomplishments and is looking forward to its continued participating in the Space Shuttle program.

In January, 1976 the Flight Research Center was renamed the Hugh L. Dryden Flight Research Center in honor of the aeronautical research pioneer.

3.2.2 Research Goals and Objectives*

The major goal of the NASA Dryden Flight Research Center is to maintain a position of pre-eminence in the conduct of flight research in support of the nation's military and civil needs through:

- Flight research of new design concepts and new flight regimes, both high and low speeds.
- Flight research directed toward improving flight safety and/or public acceptance.
- Flight research in applied control technology.
- Development of improved cost-effective methods of flight testing.
- Flight research to contribute to space shuttle development.

* Portions of the materials presented in Section 3.2.2 were extracted and edited from the NASA Catalog of Center Roles, Dec. 1976, and the NASA/DFRC Capabilities Five Year Plan, DFRC, Aug. 19, 1977.
The Center's primary purpose is to plan, conduct, analyze, and report on flight research. DFRC represents particular areas of special capability which contribute to the agency-wide capabilities that form the core of our national capabilities in aeronautics and space. These special capabilities consist of areas of technical excellence and facilities of superior merit. These capabilities are shown following:

**Special Capabilities**

**Areas of Technical Excellence**
- Flight Research Instrumentation
- Flight Dynamics and Controls
- Flight Research Operations
- Technical Project Management
- Aeronautical Disciplinary Integration Effects
- Safety and Quality Assurance of Research Aircraft

**Facilities of Superior merit**
- Remote Piloted Research Facility
- Airborne Launch Aircraft
- Complete Flight Research Complex
- Airborne Flight Research Facilities
- Shuttle Recovery Site

Center roles must relate to the NASA goals in aeronautics and space. These goals identify the broad program areas in which work is assigned to the Centers. Subsequently, NASA has identified two kinds of roles for each Center. **Principal roles** are those roles of fundamental importance in meeting the agency's overall goals. Principal roles reflect the intrinsic character of the Centers and are assigned to the Center's on the basis of demonstrated Center excellence and expertise that are clearly discernible within NASA and recognized as a national
capability.

Supporting roles are of relative limited scope in the utilization of Center capabilities. These roles are nevertheless important toward meeting agency goals.

There are a number of program areas which are assigned to each Center relative to the identified principal roles and supporting roles. Table 3.2-1 shows the program areas, principal roles and supporting roles associated with DFRC.

3.2.3 Organization

An organizational chart for DFRC is shown on Figure 3.2-2. The Center is staffed by 493 civil servants and approximately 250 support contractors. The contractors are utilized for technical and administrative support.

DFRC is organized into four directorates: Aeronautics, Data Systems, Flight Operations, and Administration and Management Support. Figure 3.2-2 shows the division structure within the directorates.

The management concept of the Center relies on close-knit teams of people working multiple assignments. The Center has numerous skills in which often only one person is proficient. A matrix of efficient, innovative, experienced work teams are formed by the project management drawing from the line organization to conduct the flight research. Because of the expertise of the team members, assisted by their supervisors, the job can be done with a minimum of paperwork.
TABLE 3.2-1 DRYDEN FLIGHT RESEARCH CENTER PROGRAMS

<table>
<thead>
<tr>
<th>PROGRAM AREAS:</th>
<th>Aeronautics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Space Transportaion</td>
</tr>
<tr>
<td></td>
<td>Applications</td>
</tr>
<tr>
<td></td>
<td>Space Research and Technology</td>
</tr>
<tr>
<td></td>
<td>Tracking and Data Acquisition</td>
</tr>
</tbody>
</table>

**Principal and Supporting Roles**

**Principal:**

Aeronautical Flight Research - conducting aeronautical flight research in the areas of aerodynamics, structures, control systems, propulsion systems, disciplinary integration effects, safety, operations, and human-vehicle interactions, which involves the planning and preparation of flight test programs, the development of flight test instrumentation, flight testing, and data analysis. DFRC also provides a host Center function for NASA flight activities which are managed by other Centers but which require testing at the Edwards AFB complex. This function includes all institutional support and coordination as well as supervision of the flight operation.

Remotely Piloted Vehicle Research - development of remotely piloted research aircraft and management/operation of flight experiments.

**Supporting:**

Shuttle Orbiter Development - supporting Johnson Space Center (JSC) in the conduct of approach and landing tests. Provide landing and recovery capability during orbital flight tests (OFT) and contingency recovery capability after OFT.

Advanced Space Vehicle Configurations Technology - analysis and study of the effect of operational considerations on the design and test program of manned research vehicles.
Figure 3.2-2 ORGANIZATIONAL CHART FOR DFRC
3.2.4 Funding*

The sources of technical activities funds for the DFRC budget for 1977 are shown below:

<table>
<thead>
<tr>
<th>Office</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office of Aeronautics** and Space Technology (OAST)</td>
<td>78%</td>
</tr>
<tr>
<td>Office of Tracking and Data Acquisition (OTDA)</td>
<td>15%</td>
</tr>
<tr>
<td>Office of Space Flight (OSF)</td>
<td>5%</td>
</tr>
<tr>
<td>Office of Space Science (OSS) and Others</td>
<td>2%</td>
</tr>
</tbody>
</table>

**See Figure 3.2-1 for Offices on NASA organization chart

Agreements or "contracts" between a Headquarters Program Office and a Field Installation (Center) are negotiated for funds to perform work concerning a specific science and technology activity. These agreements are called RTOPs:

Research and Technology Objective and Plan. An RTOP represents an agreement between Headquarters and a Field Installation to perform the described research and technology within a specified time and resources. Headquarters agrees to supply

*Materials in Section 3.2.4 have been extracted and edited from NASA Management Instruction number 7100.12 dated July 25, 1975 and NASA/DFRC Capabilities Five Year Plan August 19, 1977.
funds in a specific amount, and the Field Installation agrees
to devote the manpower and facilities necessary to accomplish
the described research and technology (R&T). The agreement
is mutual and must assume performance by both parties. Neither
is free to unilaterally withdraw from the agreement. Once a
Field Installation commits its manpower and facilities to an
RTOP, Headquarters is obligated to authorize the agreed funding.
Conversely, once Headquarters has authorized the specified
funds, a Field Installation is obligated to deliver the work
product as agreed and to support the effort with the required
manpower and facilities. Deviations from these agreements
must be renegotiated between Headquarters and the Field
except where specifically authorized by NASA Management
Instructions (NMI). Some flexibility by a Field Installation
in executing its wide spectrum of R&T activities is recognized
and therefore incorporated into the specific instructions
contained in the NMI.

As mentioned earlier, the institutional management support
(IMS) funds are separated from the technology fundings (RTOP).
IMS pays for the overhead, that is; the wages, salaries,
utilities, services, etc. NASA Headquarters and the field
Centers also negotiate, but less formally, for these funds
which are fairly standardized.
3.2.5 **Current Technical Activities***

Current expertise based on highlights of the major programmatical accomplishment of fiscal year (FY) 1977 will be briefly reported in this section. Table 3.2-2 shows a summary of the flight activities for FY 1977.

**SPACE SHUTTLE SUPPORT**

**Approach and Landing Tests (ALT):** The first free flight of the Orbiter occurred at Dryden on August 12, 1977, under the direction of Johnson Space Center. That was a major milestone of the 40 month program to develop the Shuttle Carrier Airplane (SCA) and flight test the Orbiter in the final approach and landing phase.

During the period from February 15, 1977, to the present (October 26, 1977), a taxi test, eight (8) captive and five (5) Orbiter free flights have been performed in the Shuttle ALT program. The test operations have successfully demonstrated the "piggyback" concept of transporting the Orbiter on the Boeing 747 SCA and the capability of air launching the Orbiter from the SCA. A mated configuration flight envelope has been defined. Orbiter computer, control, and onboard operational systems have been tested. The Orbiter approach and landing performance and handling characteristics have been demonstrated both in the manual and semi-automatic mode of operation.

*M*Materials in Section 3.2.5 were extracted and edited from the NASA/DFRC Annual Report of Research and Technology Accomplishments and Applications FY 1977.
Table 3.2-2  FLIGHT ACTIVITIES SUMMARY

FY 1977

<table>
<thead>
<tr>
<th>PROGRAM</th>
<th>AIRCRAFT</th>
<th>FLIGHTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Fly-By-Wire</td>
<td>F-8C</td>
<td>20</td>
</tr>
<tr>
<td>Transonic Aircraft Technology</td>
<td>F-111A</td>
<td>18</td>
</tr>
<tr>
<td>Laminar Flow Control</td>
<td>Jetstar</td>
<td>67</td>
</tr>
<tr>
<td>Wake Vortex Upset Alleviation</td>
<td>L-1011, T-37</td>
<td>10</td>
</tr>
<tr>
<td>Advanced Supersonic Technology</td>
<td>YF-12</td>
<td>32</td>
</tr>
<tr>
<td>Propulsion/Airframe Integration</td>
<td>F-15</td>
<td>9</td>
</tr>
<tr>
<td>Oblique Wing Technology</td>
<td>Ames RPRV</td>
<td>1</td>
</tr>
<tr>
<td>RPRV Capability Development</td>
<td>Firebee II</td>
<td>1</td>
</tr>
<tr>
<td>Stratospheric Surveyor</td>
<td>Mini Sniffer</td>
<td>10</td>
</tr>
<tr>
<td>Television Landing Technology</td>
<td>PA-30</td>
<td>16</td>
</tr>
<tr>
<td>Research Program Support</td>
<td>B-52</td>
<td>8</td>
</tr>
<tr>
<td>Shuttle Program</td>
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<td></td>
</tr>
<tr>
<td>ALT</td>
<td>B-747 SCA</td>
<td>19</td>
</tr>
<tr>
<td>ALT</td>
<td>Mated SCA/Orbiter</td>
<td>11</td>
</tr>
<tr>
<td>ALT</td>
<td>Orbiter 101</td>
<td>3</td>
</tr>
<tr>
<td>MSBLS</td>
<td>Jetstar</td>
<td>58</td>
</tr>
<tr>
<td>SRB</td>
<td>B-52</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>287</td>
</tr>
</tbody>
</table>

NOTE:
The Dryden Flight Research Center has also been an active participant with the Air Force on the AMST and B-1 programs.
The final phase of testing in the ALT program will be devoted to an evaluation of the Mated Configuration performance related to the ferry mission. This testing was completed in calendar year 1977.

**Microwave Scanning Beam Landing System (MSBLS) Calibration:** The Dryden Lockheed Jetstar airplane was used during 1977 to calibrate the MSBLS installed at Edwards and to verify that it could be used for landing the Orbiter. Two MSBLS installations, one on the dry lake bed and the other on the main concrete runway, were commissioned by performing 28 Jetstar flights. The system met all the specific engineering and test objectives and is now operational. Two Orbiter landings have now been made successfully using the MSBLS.

**Solid Rocket Booster (SRB) Drop Tests:** During the FY 1977, DFRC provided support to MSFC for the Space Shuttle Program Solid Rocket Booster Decelerator Subsystem. This effort resulted in two planned captive flights and two successful air drops of the SRB Drop Test Vehicle from the DFRC B-52. These tests were accomplished at the National Parachute Test Range near El Centro, California, September 1977.

**AERONAUTICS RESEARCH AND TECHNOLOGY**

**Digital Fly-By-Wire (DFBW):** The DFBW program evaluates the use of a sophisticated triplex digital computer system and a three-channel analog system for emergency aircraft control applications.
**Transonic aircraft Technology (TACT):** The primary objective of this program was to validate in flight the potential improvements to aerodynamic characteristics promised by supercritical airfoils in wind tunnel investigations.

**Laminar Flow Control-Insect Contamination:** An experiment to investigate means of keeping insect impacts on a wing leading edge from tripping the natural laminar flow.

**Wake Vortex Upset Alleviation:** The program is directed at finding aerodynamic means to increase the dispersion or dissipation of vortex wakes of large aircraft so that landing separation distances can be safely decreased.

**Supersonic Cruise Propulsion System Research:** This YF-12 program is to contribute to the technology base for the design of efficient propulsion systems for supersonic cruise aircraft.

**High Altitude Autopilot/Autothrottle:** The development of an autopilot/autothrottle system that will permit supersonic cruise aircraft to maintain Mach number and altitude with much greater precision than was possible in the past.

**Compressible Turbulent Boundary-Layer Measurements:** Flight measured skin friction, heat transfer, boundary-layer transition and boundary-layer impact pressure profiles have been measured simultaneously on a 10 foot long 1.5 foot diameter hollow cylinder mounted on the lower centerline of a YF-12 airplane.
Integrated Propulsion Control Systems (IPCS): Objectives of the program were to develop, demonstrate, and evaluate digital integrated control of the left engine and inlet of an F-111 airplane.

Propulsion/Airframe Integration: A NASA F-15 program to determine installed inlet spillage and interference drag as well as nozzle drag and nozzle-afterbody interference flows.

Oblique Wing Technology: A program for the acquisition of flight data on the stability and control characteristics of a skewed wing vehicle.
4. APPROACH AND METHODOLOGY

The starting point for this investigation was with members of the faculty at the MIT Sloan School of Management. A bibliography was consulted to aid the conceptual process for CSFs (References 2.1 to 2.17 and 4.1 to 4.5).

Two Sloan School of Management Masters Thesis were also suggested for reference. These were: Key Variables - Comparative Study in the Oil Industry (Reference 4.5) by Tor J. Arnt-Nensen and The Key Variables in Planning and Control in Medical Group Practices by Gladys G. Mooradian (Reference 2.17).

The results of these initial discussions pointed out the paucity of data on the CSF concept. There are on-going CSF studies in various private sector industries and the Veterans Administration. Other CSF investigations are also being planned. No past, on-going nor planned efforts were identified in the area of interest for this thesis, CSFs for Government R&D Centers.

A thesis was proposed therefore, which would research the CSFs of two Government R&D Centers. As mentioned in the introduction, this thesis is primarily interested in the hierarchical CSF profiles within these organizations with the secondary objective of evolving an "industry set" of CSFs for Government R&D Centers. It was planned to acquire the necessary data through interviews. Upon acceptance of the thesis proposal this interview process began. The following
discussions will describe the preliminary consultations with the R&D Centers prior to the interviews, the interview process, and the interview data analysis.

4.1 Preliminary Consultations

The Center Directors of both R&D Centers, to be studied, were contacted during the formulation of the thesis proposal. The purpose of these contacts was; to discuss the intent, purpose and approach of thesis, and to obtain the approval of the DOT/TSC and NASA/DFRC Center Directors to conduct the planned interviews in their respective facilities. The two Directors expressed interest and support in the CSF concept. The interview approvals were granted.

In starting the process for obtaining information for the CSF profiles, interviews were arranged with Headquarters (HQ) Washington, D.C. personnel from both NASA and DOT. At DOT the Director of the Research and Special Programs Directorate and the Acting Chief of the Office of Plans, Policy and Administration were interviewed. At NASA officials from the Office of the Administrator were interviewed. Interest in the CSF concept was expressed by the HQ personnel from DOT and NASA.

In approaching the respective Headquarters, a "flyer" was prepared to explain the intent and purpose of the requested interviews. A copy of this flyer is included in Appendix B.
Subsequently, the managers to be interviewed at both R&D Centers were contacted. With the concurrence of the respective Center Directors, interview schedules were arranged with the various managers. We were limited, by time, to approximately 7 to 8 working days at each Center with three interviews scheduled a day with roughly two hours for each interview and follow-up as needed. The mentioned "flyer" was also sent to each manager to be interviewed.

In preparing for the upcoming interviews, lists of questions were developed. These questions were designed to help focus the interviews and to "draw out" the CSF information desired. Table 4.1-1 presents typical questions from these lists. As shown, these questions were mainly grouped into five categories. It was not intended to ask all these questions at each interview. Many questions were intentionally overlapped to explore different dimensions of a response. These questions provided a framework which we believed would add some consistency to the interviews. Using these questions as a guide, we were ready to start the interviewing.

4.2 Interview Process

A total of thirty nine on-site interviews were conducted, mainly from January 4 to February 6, 1978, to gather data for this study. A breakdown of these thirty nine interviews is presented in Table 4.2-1. As shown in the table, twenty one interviews were conducted with the DOT. The Director,
Table 4.1-1

TYPICAL QUESTIONS FOR CSF INTERVIEWS

I. Plans and Strategy
   - Does the Center have a strategic or Long Range Plan?
   - Is the capability to implement the strategy available in the organization?
   - Has the strategy been made clear to the entire organization?
   - Is the conceptual route to attain the goals and objectives well designed and clear to everyone?
   - What are the priorities, criteria and considerations in accepting work? In terminating work? How are projects established? Are new projects often not identified in the Center's plans, i.e., a surprise?
   - How well are the Center's plans implemented?
   - What approaches do the different levels of management take in identifying strategy? How do they define the critical missions?
   - What direction does top management provide in "steering the ship?"
   - What role do you play in the Center's plans and strategy?
   - How well is the budget integrated with the plans?

II. Objectives and Goals
   - Is top management clear on what it wants the organiza-
Table 4.1-1 continued

- tion to do? Are the middle levels clear on organization goals?
- Are the objectives and goals differentiated for each level, team or suborganization?
- What are the goals and objectives of your organizational element and their priorities?
- For your goals and objectives, what are primary variables to monitor and measure? What are the most important parameters of concern in these variables?
- How are objectives and goals established for your Directorate or Office? How well do they agree with the Center's objectives and goals?
- What are the Center's future objectives and goals? How do the present objectives and goals relate to those of the future?

III. Organization

- Is the organization structure properly designed relative to the program's sponsors and goals?
- How would you evaluate communications in the Center?
- How healthy is the organization? How about morale, turnover and the "bitch" level?
- Is there a unified effort at the Center?
- How is control and accountability established in this organization?
Table 4.1-1 concluded

IV. Important Variables

- What are those things which when done well (or poorly) will attract Headquarter's, the sponsor's and/or the Center's attention and evoke some response?
- What are primary areas of concern?
- What problems take most time at present?
- What must the Center do to succeed? What must your organization do to succeed?
- How does one measure the identified key variables?
  How does one exercise control over the key variables?
- How does the organization define critical mission?
- What are measures of performance that top management uses?
- How do the lower levels view the organization's problems regarding critical missions for success?

V. Reporting and Information Systems

- Is the right kind of information being provided to each level of management?
- How is the presently available information being used?
- What are the unsatisfied information needs?
- What is wrong with the present information system?
- What are special problems involved in monitoring non-quantifiable variables? Which are they?
- What are the most pressing information problems?
Research and Special Programs Directorate and the Acting Chief, Office of Plans, Policy, and Administration were interviewed from DOT Headquarters. The breakdown of the nineteen interviewed at TSC is shown by the Table.

At NASA eighteen interviews were conducted in total. The NASA Administrator, Deputy Administrator and the Associate Administrator for Aeronautics & Space Technology were interviewed at Headquarters. The breakdown of the fifteen interviewed at DFRC is shown.

On the average, two and one half hours were spent with each individual interviewed. Over 100 hours of interview and telecon follow-up time on measures with several key individuals were involved in this study. At TSC there were approximately thirty hours spent on interviewing the Director and his immediate staff.

The pre-interview materials had been distributed to all those interviewed well in advance of the interviews. A large number of managers had prepared lists of their objectives and goals, prior to the interviews. Two or three individuals, also prepared lists of CSFs before the interviews.

In attempting to "draw out" the CSF's, the managers were asked to tell us what was "on their mind" about their jobs, that is, to establish a priority list of their job-related goals, things that had to go right, and in some cases frustrations, etc. Questions were posed from the lists previously mentioned. This priority list was then discussed during the
interview to identify those variables which the manager was most concerned about and spent a large portion of his time upon. Thus, those variables which the manager was focusing his attention upon were surfaced. In addition, the many and varied dimensions which different managers were dealing with were also surfaced. Measurements for these variables were not established, as such, but rather the variables associated with these measurements were discussed.

Analysis of the interview results indicated that we were actually dealing with an objectives, goals, and dimensions process. This process goes from the organization's goals and objectives to the individual's critical success factors. Figure 4.2-1 graphically represents the process we encountered. As shown on the figure, the CSF determination is a very personal thing. The individual identifies his important objectives, goals and dimensions and subsequently formulates critical factors from this set of objectives, goals and dimensions. To properly arrive at CSFs, two conditions appear necessary. First a relationship of trust between the interviewer and the individual needs to be established. Second, the interviewer needs to carefully sort out what the individual's important objectives, goals, and dimensions are from his critical success factors. Finally, once the CSFs are established, one should attempt to formulate measures such that the individual can have a means of "control" relative to his CSFs.
FIGURE 4.2-1
THE OBJECTIVES, GOALS AND DIMENSIONS PROCESS ASSOCIATED WITH DETERMINING CRITICAL SUCCESS FACTORS.

ORGANIZATIONAL OBJECTIVES AND GOALS

INDIVIDUAL OBJECTIVES, GOALS AND DIMENSIONS

CRITICAL SUCCESS FACTORS

EXTERNAL INPUTS

INTERNAL INPUTS
4.3 Data Analysis

Having developed an understanding of the CSF process encountered, attention was turned to the large general data base at hand. Figure 4-3-1 shows the process followed to analyze the data. When the NASA/DFRC and the DOT/TSC data were compared it was found that the managers at both Centers were consistent in their concerns over their individual objectives, goals and dimensions as well as the critical management key variables. The hierarchical relationships of these objectives, goals, dimensions and key variables were observed to be consistent with Anthony's model (see Reference 2.9). The roles of top, middle and first level management appeared to fit Anthony's control categories: strategic planning, management control, and operational control. Also, the objectives, goals, dimensions and key variables became more specific and focused at successively lower levels of management. In general, the measures related to Anthony's model with the more subjective non-quantifiable measures being associated with top management, more objective and somewhat quantifiable associated with middle management, and specific quantifiable measures associated with first level management.

With this framework on CSFs, the next task was to organize the general data base, in some meaningful and consistent manner. From the general data, an aggregated set of CSFs developed which we call the "industry set". The "industry set"
FIGURE 4.3-1

PROCESS FOR GENERAL ANALYSIS OF DATA.

ORGANIZATIONAL OBJECTIVES AND GOALS

INTERVIEWS

GENERAL DATA BASE

INDIVIDUAL OBJECTIVES, GOALS, DIMENSIONS AND KEY VARIABLES

INDIVIDUAL CSFs AND MEASURES

TSC
CD CENTER DIRECTOR
DD OFFICE DIRECTOR "A"
DC DIVISION CHIEF "A"

DFRC
CD CENTER DIRECTOR
OH DIRECTORATE HEAD "B"
DC DIVISION CHIEF "B"

VERTICLE PROFILE
ALIGN INDIVIDUAL CSFs AND MEASURES

TSC
CD DD DC

DFRC
CD OH DC

GENERAL CSFs
INDUSTRY SET

ITERATIONS THEN AGGREGATE
had six key Critical Success Areas and grouped several generic CSFs under each of the six key CSF areas. This information was analyzed in terms of what constituted an effective R&D organization, as each person perceived it. A summary of these results are presented in Section 6.

Examination of the "industry set" of CSFs indicated that a more detailed understanding of the individual CSFs would be required to develop the CSFs profiles. Detailed CSFs were required because it was felt that a very careful alignment of CSFs was necessary between managers to generate an "accurate" profile.

Six managers, three from TSC and three from DFRC were interviewed in detail.

| Approximate Interview and Follow-up Times for Selected Managers |
|-------------------------------|-------------------|
| TSC                          | DFRC              |
| Director                      | 7                 | 6                 |
| Office Director "A"           | 6                 | -                 |
| Directorate Head "B"          | -                 | 6                 |
| Division Chief                | 4                 | 5                 |
|                               | 17 hr.            | 17 hr.            |

These six managers provided a vertical profile of managers in a single chain of command, for three levels of management in each organization. In addition we know these individuals, had an established relationship with them, understood their organizational functions and had relative easy access to
them for interview follow-up discussions. The latter is a necessity for developing detailed CSFs and their associated measures.

The CSFs for each of the above individuals were associated with each individual's set of objectives, goals and dimensions. Because of this, the individual CSFs were very "customized". This "customizing" is what gives the CSF approach, from an information system perspective, the benefits of focusing the individual manager's attention on areas critical to his operation.

In aligning CSFs, to obtain the vertical profiles, the authors found that it was important to:

1. Have detailed knowledge about the individuals themselves; their beliefs, aspirations, needs, motivations, etc.,
2. Have detailed knowledge of the organizational setting within which the individual is located,
3. Understand and have identified the individual's set of objectives, goals and dimensions associated with his CSFs,
4. Have a good perspective of the organization's mission and its future plans.

Only when information on the above four items was available, did the authors feel confident that they could align the CSFs and obtain a consistent CSF profile showing the hierarchical relationships.
Referring to Figure 4.3-1, one can obtain a perspective of how the data were analyzed. The "industry set" represent general CSFs which have been aggregated. There were six individual CSFs and measures worked up in detail. These detailed CSFs have been aligned such that the Center Director's (CD), the Office Director's (OD) and the Division Chief's (DC) individual CSFs match up were appropriate. The CD's, DH's and DC's individual CSF's for DFRC have been similarly aligned. The CSF profiles that result from these alignments are discussed in Section 6.

In retrospect, the interview approach used to obtain the "industry set" of CSFs was somewhat of a "shotgun" approach. The "rifle" approach was used to obtain the detailed individual CSF's for the profiles.
Table 4.2-1 SUMMARY OF INTERVIEWS

Department of Transportation (DOT) .................................. 21

<table>
<thead>
<tr>
<th>Position</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headquarters</td>
<td>2</td>
</tr>
<tr>
<td>Transportation Systems Center</td>
<td>19</td>
</tr>
<tr>
<td>Center Director</td>
<td>1</td>
</tr>
<tr>
<td>Deputy Center Director</td>
<td>1</td>
</tr>
<tr>
<td>Office of Plans &amp; Programs</td>
<td>4</td>
</tr>
<tr>
<td>Office Director</td>
<td>1</td>
</tr>
<tr>
<td>Office Director Deputy</td>
<td>1</td>
</tr>
<tr>
<td>Division Chiefs</td>
<td>9</td>
</tr>
<tr>
<td>Branch Chief</td>
<td>2</td>
</tr>
</tbody>
</table>

National Aeronautics and Space Administration (NASA) ............... 18

<table>
<thead>
<tr>
<th>Position</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headquarters</td>
<td>3</td>
</tr>
<tr>
<td>Dryden Flight Research Center (DFRC)</td>
<td>15</td>
</tr>
<tr>
<td>Center Director</td>
<td>1</td>
</tr>
<tr>
<td>Chief Engineer</td>
<td>1</td>
</tr>
<tr>
<td>Safety and Quality Assurance</td>
<td>1</td>
</tr>
<tr>
<td>Directorate Heads</td>
<td>4</td>
</tr>
<tr>
<td>Deputy Directorate Head</td>
<td>1</td>
</tr>
<tr>
<td>Division Chiefs</td>
<td>5</td>
</tr>
<tr>
<td>Pilots Office</td>
<td>1</td>
</tr>
<tr>
<td>MIS Office (Under Admin.)</td>
<td>1</td>
</tr>
</tbody>
</table>

Total = 39
5. CRITICAL SUCCESS FACTORS AND MEASURES

The interview process discussed in Section 4 surfaced many views of Government R&D management areas of concern, management techniques, and individual goals. Many critical success factors (CSF) and measures were identified among the top and middle level managers of the two Government R&D Centers. In this section we discuss a vertical profile of CSFs for each R&D Center. We present a detailed analyses of CSFs and measures for three representative managers in a single chain of command for each organization as shown in Figure 5.1; and, we make a hierarchical comparison of the CSFs and respective measures for such a vertical profile. In Section 6 we discuss an "industry set" of CSFs and note general profiles and observations of the interview and analysis findings. Comparisons are also made in Section 6 between the two R&D Centers and corresponding levels of management using, as a common base, the "industry set" of CSFs.

The material in this section is grouped and presented in the context of each organization. The format of presentation and discussion serves to emphasize the hierarchical character of the CSFs and different measures observed for the three levels of management in each organization. In the interviews with the managers, when shown summaries of their CSFs, good arguments were presented for not prioritizing the CSFs. As one manager put it, "They are all important to me, and I
really can't say which is more or less important. It is like asking me to choose favorites among my children". Another manager observed that, "It is like comparing apples and oranges. Besides, at one period of time one CSF may be more important than the other, but this changes depending upon the environment and pressures from above". A frequent point was made in the interviews by managers commenting on the temporal nature of CSFs. As noted in the quotation above, environmental changes can result in different concerns with the manager shifting his focus on a different dimension of organization performance. At other times, latent CSFs, not even discussed at the particular time of the interview, may emerge. We have chosen, therefore, not to prioritize the CSFs in this thesis.

Various measures for the CSFs are, however, more important than others for each manager. We will indicate important measures for each manager's CSF in the discussions below. The CSFs and measures are presented for DOT/TSC and NASA/DFRC in Sections 5.1 and 5.2, respectively.

5.1 Critical Success Factors for DOT/TSC

The vertical profile for DOT/TSC, as shown in Figure 5.1, is comprised of the Center Director, Office Director "A", and Division Chief "A". The latter two are from the same directorate, thus constituting a chain of command from the top echelon to the middle level of management within the Center. Because of time limitations for acquiring data,
Figure 5.1   TYPICAL VERTICAL PROFILE CHAIN OF COMMAND FOR THE TWO R&D CENTERS
an adequate data base was not obtained for the first level of supervisors, the branch chiefs under the division chief. The CSFs for the three level of management in DOT/TSC are presented in Table 5.1-0.* In accordance with the discussion above, and as noted, the tabulations do not represent priority listings. The organization of Table 5.1-0 is intended to show hierarchical relationships among similar CSFs. The discussions of CSFs, and measures which follow, focus on this hierarchical aspect.

The nature of the information comprising the measures of the CSFs for the Center Director are generally non-quantifiable. The measures for the corresponding CSFs at lower levels of management focus on specific data. As an illustration of this hierarchical relationship, the CSFs for the different management levels are shown in Table 5.1-0. The CSFs for the Office Director and the Division Chief are compared with the Director's CSF, Blend of High Priority Major Issue Programs. The Director expects his planning and senior management staff (Office Directors) to interpret the major needs of the Department's Modal Administrations and to jointly plan, coordinate and cultivate a portfolio of high priority, major issue programs with their respective modal sponsor organizations in Washington, D.C.

*The identification of CSFs at DOT/TSC was aided by an internal report entitled, "TSC Goals Document, dated December, 1977."
<table>
<thead>
<tr>
<th>CENTER DIRECTOR</th>
<th>OFFICE DIRECTOR &quot;A&quot;</th>
<th>DIVISION CHIEF &quot;A&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>• RECOGNITION AS THE NATIONAL CENTER FOR TRANSPORTATION R&amp;D</td>
<td>(included in other CSFs)</td>
<td>(included in other CSFs)</td>
</tr>
<tr>
<td>• ORGANIZATION'S SENSE OF COMMON PURPOSE</td>
<td>• ACCOUNTABILITY AND COMMUNICATIONS</td>
<td>• TEAM ATTITUDE</td>
</tr>
<tr>
<td>• PLANNING AND DEVELOPMENT OF MULTI MODAL PROGRAMS</td>
<td>• MULTI MODAL PROGRAM DIVERSIFICATION</td>
<td>• GOALS AND PROGRAM FOCUS</td>
</tr>
<tr>
<td>• CREDIBILITY WITHIN USER AND TECHNICAL TRANSPORTATION COMMUNITY</td>
<td>• REPUTATION IN MODAL TRANSPORTATION COMMUNITY</td>
<td>• PRODUCT UTILITY AND REPUTATION</td>
</tr>
<tr>
<td>• BLEND OF HIGH PRIORITY MAJOR ISSUE PROGRAMS</td>
<td>• SPONSOR RELATIONS AND LIAISON</td>
<td>• PROGRAM DEVELOPMENT</td>
</tr>
<tr>
<td>• CRITICAL AREA EXPERTISE AND SKILL BUILD-UP</td>
<td>• TEAM ATTITUDE AND SKILL IMPROVEMENT</td>
<td>• TECHNICAL SKILLS AND CAREER PLANNING</td>
</tr>
<tr>
<td>• RESPONSIVENESS AND PRODUCTIVITY</td>
<td>• PRODUCTIVITY AND QUALITY</td>
<td>• TECHNICAL QUALITY AND OUTPUT</td>
</tr>
<tr>
<td>• PROGRAM MANAGEMENT EFFECTIVENESS</td>
<td>• PLANNING AND RESOURCE CONTROL</td>
<td>• PROGRAM MONITORING AND CONTROL</td>
</tr>
</tbody>
</table>

*Note: The CSFs are not listed in any priority ordering in this table. They are organized to portray hierarchical relationships among the three levels of management.
The Office Director's corresponding CSF is **Sponsor Relations and Liaison**. The Office Director accomplishes this primarily through liaison and relations with the sponsor to assure that the Center is on top of important transportation problems and opportunities. This liaison increases the Center's awareness of emerging important programs and major issues which may confront the Department. A measure of success is reflected in the excess demand for the resources of his directorate for high priority work. The Office Director is also responsible for portfolio management by interpreting the Center's objectives, setting priorities, negotiating programs, and managing labor resources. This role is crucial because the Center's labor resources are in such demand that careful decisions must be made in the program portfolio management process.

The Division Chief represents the in-depth technical dimension of the program selection process. His corresponding CSF is **Program Development**. It is through direction of his staff and their efforts that new program proposals are prepared, with the cognizance of the Office Director, to address identified sponsor needs. The Division Chief develops and negotiates the technical content, defines deliverables, and scopes the resource needs for each project with the sponsor. His corresponding CSF, in developing new programs, may be measured in terms of the sponsor satisfaction with TSC's approach and its pertinence to the Department's high
priority needs.

The hierarchical relationships among CSFs and associated measures are consistent with R.N. Anthony's Planning and Control Systems: A Framework for Analysis (See Reference 2.9). Anthony views planning and control as a broad continuum, with planning on one end and control on the other. This framework is comprised of three major control categories: strategic planning, management control, and operational control. Anthony identifies the role of top management to be strategic planning and management control. Middle management also contributes to strategic plans but devotes much attention to management control with a small involvement in operational control. The first-level of management is primarily involved with operational control, but, depending upon circumstances, may be involved in some planning. The hierarchical CSF array fits this framework especially in terms of measures, the nature of important data, and, the relative involvements of each level of management in the management control role of the organization.

Discussions of each TSC manager's CSF and measures are presented below with reference to Tables 5.1-1 through Table 5.1-8. Each subsection is identified by the Center Director's CSF and includes his measures. The Tables and text discussions are set up to compare the CSF measures of the Center Director, derived from Table 5.1-0, with the appropriate CSFs and measures of Office Director "A" and Division Chief.
"A", respectively. Thus, for each of the Center Director's CSFs, we will present a unified discussion to show the hierarchical focusing effect at successively lower levels of the organization.

5.1.1 Recognition as THE National Center for Transportation RA&D

DOT/TSC is a unique multi-modal Research, Analysis and Development (RA&D) Center having the responsibility for solving high priority technological and analysis problems for the Department of Transportation. As mentioned in Section 3.1, TSC is THE DOT RA&D facility which has the in-house (in-house refers to Government employed staff) technical competence and versatility to work on high priority programs for the Office of the Secretary (OST) and for all of the Modal Administrations. While there are other in-house R&D facilities in the Department under the direct management of the Modal Administrators, TSC is the only R&D Center in DOT with the charter, competence, and capability which spans the full spectrum of major, multi-modal transportation issues and problems confronting the Department. One objective of the Center Director of TSC is to maintain the Center at the leading edge of the transportation sciences, so that it may continually respond as needed with its broad technical capability to emerging, critical transportation issues or problems, and have a salutary impact on improving the Nation's transportation systems. The CD paraphrased the TV commercial, 104
for the investment firm E. F. Hutton, by saying, "When TSC speaks, the transportation community listens". In this slogan the CD is emphasizing the credibility of the Center for producing results having significant impact on the solution of the Department's transportation problems.

Recognition as THE National Center for Transportation RA&D results from the Center's ability to participate in and contribute expertise to solving high priority major issues facing the Department. A few recent examples where TSC had made significant contributions and impacted key transportation decisions are as follows:

- Super-sonic transport noise measurements of the Concorde SST supported recent decisions by the Secretary of Transportation;
- Motor Vehicle Fuel Economy Goals were set by the Secretary of Transportation based on TSC research and analysis;
- Airport detection systems were evaluated so that flight security was enhanced;
- Research was performed to support the decision for the national 55 mph speed limit and daylight savings time as a result of the 1974 Energy Crisis;
- Analyses of waterway user charge options supported recent policy decisions of the Secretary of Transportation on charges for using the Nation's waterways;
Nondestructive testing techniques, developed for motor vehicle tires, were used to test structural flaws in tires of two DC-10 aircraft that have had accidents.

The measure of success for the "recognition" CSF, as shown in Table 5.1-1, is the impact of the Center's contribution on key decisions. The results of such work can have high leverage on the national transportation community. Closely related to the "impact of work" measure is the demand for the Center's expertise. Demand may be observed by the nature of the problems that the Center is asked to address and the amount of staff in labor years, supporting such work measured over a period of time.

Esteem and acknowledgement of the Center's contribution, and the confidence in the results of the Center's work, expressed by high level officials, such as the Secretary of Transportation, and Congress provide direct feedback to the CD of the Center's success, e.g., in the above mentioned high priority issues. Such praise will lead, hopefully to favorable funding decisions and increased personnel ceiling allocations, thus improving the Center's ability to respond to other urgent research needs of the Department.

The "recognition" CSF for the Center Director (CD) is unique to the chief executive level for DOT/TSC, as shown in Table 5.1-0, in which corresponding CSFs are not listed for the Office Director (OD) or Division Chief (DC). This CSF
<table>
<thead>
<tr>
<th>CENTER DIRECTOR</th>
<th>OFFICE DIRECTOR &quot;A&quot;</th>
<th>DIVISION CHIEF &quot;A&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RECOGNITION AS THE NATIONAL CENTER FOR TRANSPORTATION RA&amp;D</strong></td>
<td>Critical Success Factors and measurements are not specifically identified but are included in other CSFs.</td>
<td>Critical Success Factors and measurements are not specifically identified but are included in other CSFs.</td>
</tr>
<tr>
<td><strong>MEASURES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Impact of Center's contributions on key decisions and programs affecting the national transportation community.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Federal, state and local issues</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Roles, regulations, standards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Construction contracts and grants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Transportation crises</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Demand for Center's capability to participate in and contribute expertise to high priority major transportation issues facing DOT. (Number of labor years devoted to key decision work.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Acknowledgement of Center's role and contribution in Transportation RA&amp;D by the Secretary of Transportation and Congress.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Favorable funding and personnel allocations resulting from recognition of Center's contribution and effective liaison with key decision makers.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
pertains mainly to mission, role and strategic decisions in the Department. The CD is concerned about the effectiveness of the Center in fulfilling its RA&D role in the Department. The fact that there is not a corresponding CSF listed (for DOT/TSC) for the OD or DC levels does not mean that the managers at these levels fail to consider strategy, work impact, or credibility important. Senior or middle-level managers generally feel that if they perform their function successfully and contribute to the organization's effectiveness, Center credibility will be enhanced. The CD is concerned more with strategic decisions of the Department, which are impacted by the contributions of the Center since these lead to the recognition of the Center. The CD desires to maintain effective liaison with high level Government Officials and key decision makers. Open communication establishes a good rapport with these officials and increases their awareness of Center capabilities.

5.1.2 Organization's Sense of Common Purpose

Team-building and teamwork are stressed by the Center Director in this CSF. The CD seeks to strengthen and integrate the participation of the senior management staff's planning inputs so that the Center has a unified and timely response to the needs of the Department. Initiative and proactive responses from his senior management staff are desired. Senior management's enthusiasm and creative par-
icipation in long range planning and strategic decision making are indications to the CD of the senior staff's commitment to the future well-being and success of the Center. In planning for the Department's technological needs, the development of a sense of common purpose will emerge in the form of a stronger appreciation for the Center's role with regard to the Department's priorities. A measure that the CD uses is the initiative and innovation demonstrated by senior management in recognizing and taking the initiative to respond to the Department's major issues and high priority programs in a timely, urgent manner (see Table 5.1-2).

The molding of a cohesive organization leads to a channeling of efforts with improved productivity of urgent, high priority program activities. The CD is seeking closer working, intra-directorate relationships so that the Center can fulfill its multi-modal mission through optimum utilization of its limited labor resources. The ability to adapt experience and knowledge gained in one mode to the solution of another mode's problems is thus part of this CSF.

The CD also is seeking organizational structure and management staff improvements. His objective is to adapt the form and functional alignment of the organization to the long term evolutionary developments and growing opportunities emerging in transportation. The objective is to be more effective in responding to the needs of the Department. The measure for this dimension is increased productivity through
Table 5.1-2 COMPARISON OF CSFs AND MEASURES FOR DOT/TSC CENTER DIRECTOR:
ORGANIZATION'S SENSE OF COMMON PURPOSE

<table>
<thead>
<tr>
<th>CENTER DIRECTOR</th>
<th>OFFICE DIRECTOR &quot;A&quot;</th>
<th>DIVISION CHIEF &quot;A&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ORGANIZATION'S SENSE OF COMMON PURPOSE</strong></td>
<td><strong>ACCOUNTABILITY AND COMMUNICATIONS</strong></td>
<td><strong>TEAM ATTITUDE</strong></td>
</tr>
<tr>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
</tr>
<tr>
<td>- Effective team-building, leadership and demonstration of initiative and innovation by senior management in responding to the Department's high priority major issue programs and problems.</td>
<td>- Technical staff productivity, enthusiasm, esprit de corps, and bottoms-up feedback in reaction to supervisors' initiative, leadership and discharge of expected responsibilities.</td>
<td>- Timely, unfiltered top-down communications on policies, directives and other significant information.</td>
</tr>
<tr>
<td>- Achievement of a strong sense of common purpose through enthusiastic participation by senior management in long range planning, coordinated program development, and critical problem solving for DOT.</td>
<td>- Senior-level sponsor official's attendance at program reviews. Effectiveness of presentation of program review by management staff. Willingness of sponsor to resolve issues and seek productive ways to improve performance.</td>
<td>- Commitment and sustained interest of top management on sponsor major issues and programs.</td>
</tr>
<tr>
<td>- Willingness of senior management to &quot;pull together&quot; in interpreting and implementing the objectives of the Center, assuring top-down and bottoms-up communication, and discharging managerial duties with proper delegation of responsibilities.</td>
<td>- Sponsor feedback and attitudes regarding performance on assigned projects. Satisfaction versus &quot;grief&quot; level with staff and sponsors on projects. Amount of intervention time required by Director in &quot;fixing&quot; unnecessary problems.</td>
<td>- Higher productivity resulting from initiative, motivation and team spirit of staff. Willingness of staff to align their goals and pull together for the overall benefit of the Center.</td>
</tr>
<tr>
<td>- High morale and healthy attitudes of staff toward work responsibilities with the interest of improving the well-being of the Center through high individual effort and enthusiasm.</td>
<td>- Improved management control through effective lines of responsibility on program assignments within the organization. Top down perspective of the accountability structure and well identified authority relations for sponsor confidence.</td>
<td>- Minimum impact on technical/managerial staff, and improved real productivity, as a benefit of streamlined and coordinated management information systems and administrative data gathering.</td>
</tr>
</tbody>
</table>
improved intra-directorate effectiveness and communications. The improvements in productivity will be further discussed in Section 5.1.7 under the CSF Responsiveness and Productivity. The CD observes intra-directorate program participation, planning efforts and sharing of technology and information. The CD is establishing procedures for seminars and information sharing so that specific discipline areas can exchange critical ideas and information in solving multi-modal problems of the DOT.

Organizational health is another measure that the CD uses as a means of assessing common purpose. The state of morale is quickly communicated to the CD through effective bottom-up communication channels. The CD of TSC meets regularly with groups of non-supervisory staff to air issues and problems and to "test the water". Many personnel decisions, potentially affecting staff morale, are made with participative involvement from his staff. The CD accomplishes this through establishment of committees, or task forces, made up of interested staff members from across the organization, to address a problem of concern by the staff. Examples of the use of special task force groups have been technical and managerial promotion opportunities, dual career opportunities, flexi-time, merit promotion panels, training plan objectives, technical report procedures; etc. Each of these has resulted in improved or streamlined Center operations, or employee morale.
The corresponding CSF for Office Director "A" is Accountability and Communications. Enthusiasm and esprit de corps leads to improved productivity of the technical staff. The OD also gets bottoms-up feedback to observe whether his supervisor staff are discharging their responsibilities properly.

Sponsor feedback is an indication of a "satisfied customer" and serves as a check for accountability. Often, problems with accountability are latent and the OD first hears of them at sponsor program reviews. The frequency of "surprises" like this are measures for the OD. As with the CD, "grief" level or frequency with which it occurs, is a measure of accountability. The amount of intervention time required to fix problems, which the OD (or CD) should not normally be involved with, is also a measure of accountability.

Office Director "A" emphasized another aspect of accountability, although it is difficult to measure. This pertains to improved management control which he, or the CD, enjoys by having established lines of responsibility identified for the programs. This is especially true from the perspective of the sponsor. Clear lines of authority are essential in order to win the confidence of the sponsor.

The corresponding CSF for Division Chief "A" is Team Attitude. The DC emphasized that this must first start from the top down (above him) to provide timely communications on
policies, directives and significant announcements. The Center Director is sensitive to this and consequently has frequent meetings with all management staff, e.g., weekly senior staff meetings, bi-weekly meetings with all management staff, bi-weekly "listening" sessions by the CD with employees, laboratory visits by CD, division/branch/program reviews by the CD's office, weekly "TSC Bulletin" for all employees.

The DC also emphasized strong commitment and sustained interest of top management on important programs. This is conducive, not only to assuring a satisfied sponsor, but also for improving staff morale and productivity. People work harder when they feel that their superiors show an interest in their work and really care. This contributes to the staff aligning their goals to those of the Center with spin-off benefits of teamwork and vigorous effort.

The last measure cited by DC "A" was the frequency of his staff's responding to data requests and administrative actions. These actions come "hot and heavy" at times and affect productivity because they detract from the on-going technical work. They are a distracting and disturbing influence upon technical/managerial people and the DC hoped that such administrative data requests could be minimized by a more effective MIS. In his view, the effectiveness of the MIS (or lack of it) is measured by the frequency in responding to data gathering actions which may be made available from the existing data banks.

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The three corresponding CSFs relate to team-building and organizational cohesiveness. The measures associated with each manager's CSF is primarily an attitude assessment of the staff reporting to him. The hierarchical focusing effect is not immediately obvious for this CSF insofar as measures are concerned. It is interesting to note, however, that the CD has a top down concern while the DC has a bottom-up concern. The focal point for team-building from this observation is the Office Director.

5.1.3 Planning and Development of Multi-Modal Programs

This CSF pertains to the long range planning and program development activities of the Center. The measures for this CSF appear in Table 5.1-3 which also shows the related CSFs, Multi-Modal Program Diversification and Goals and Program Focus, for the OD and DC, respectively, along with their corresponding measures.

The DC has established a revitalized Office of Plans and Programs. A primary role of this Office is to formulate new program initiatives through collaboration with the TSC line organizations, and to encourage, support, and coordinate the preparation of proposals and presentations relating to these initiatives. The Office Chief serves as the Director's representative in the acquisition of new programs for TSC.

TSC is continually developing new programs to meet sponsor needs. At all levels of management and staff, individuals
<table>
<thead>
<tr>
<th>Table 5.1-3 COMPARISON OF CSFs AND MEASURES FOR DOT/TSC CENTER DIRECTOR: PLANNING AND DEVELOPMENT OF MULTI-MODAL PROGRAMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CENTER DIRECTOR</td>
</tr>
<tr>
<td>PLANNING AND DEVELOPMENT OF MULTI-MODAL PROGRAM</td>
</tr>
<tr>
<td><strong>MEASURES</strong></td>
</tr>
<tr>
<td>• Ability of Center to anticipate long range technology needs of Department and plan accordingly. Identification of specific major issues to be addressed and pursued of new opportunities in the DOT.</td>
</tr>
<tr>
<td>• Improved DOT comprehension of TSC as an organization with a clear view of its future.</td>
</tr>
<tr>
<td>• Potential impact of new program work on major issues facing the Department. Number of proposals funded by Department and level of staff labor years assigned by Center for work on high priority, major issue, multi-modal programs. Number of new starts relative to previous projections.</td>
</tr>
<tr>
<td>• Percent of Center’s total funding and labor level on new high priority projects inspired by long range plans and program development proposals.</td>
</tr>
<tr>
<td>OFFICE DIRECTOR &quot;A&quot;</td>
</tr>
<tr>
<td>MULTI-MODAL PROGRAM DIVERSIFICATION</td>
</tr>
<tr>
<td><strong>MEASURES</strong></td>
</tr>
<tr>
<td>• Credibility of staff, technical competence, operational awareness, and versatility for addressing multi-modal transportation problems.</td>
</tr>
<tr>
<td>• Capability of Center to draw upon an “institutional memory” of knowledge and apply it to high priority multi-modal programs.</td>
</tr>
<tr>
<td>• Improvement in performance on DOT high priority, multi-modal programs assigned to Center as a result of technical interchange, data sharing and mutual working relationships with other government R&amp;D centers.</td>
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<tr>
<td>• Adaptation of Center’s long range technical plans by sponsors into their own long range plan.</td>
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<tr>
<td>DIVISION CHIEF &quot;A&quot;</td>
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<tr>
<td>GOALS AND PROGRAM FOCUS</td>
</tr>
<tr>
<td><strong>MEASURES</strong></td>
</tr>
<tr>
<td>• Clarity of top-down communications of Center’s goals and guidance on priorities for sponsor programs.</td>
</tr>
<tr>
<td>• Establishment, by top management, of a sense of purpose and direction for the Center within the Department and with sponsors. Provision of a sense of focus for programs.</td>
</tr>
<tr>
<td>• Percent of sponsor’s R&amp;D budget submissions inspired by Center’s on-going programs, front-end system analyses, program proposals, and long range plans.</td>
</tr>
<tr>
<td>• Funds received from sponsors to expand Center’s long range plans and pursue front-end program development activities.</td>
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</table>
and groups of professionals continually seek and find opportunities for new projects.

The CD through the unifying efforts of the Office of Plans and Programs provides the needed focus and top management direction to future program growth. The CD thus assures more careful coordination of overall TSC goals, objectives, and long range plans in the process of planning and negotiating new work for TSC that is relevant to DOT needs. Through such activities, the CD achieves a coordinated and comprehensive program development liaison capability which draws upon and complements the entrepreneurial interests of the line organizations. In this manner the CD provides the focus and sense of unified direction to TSC's program growth. A measure for this CSF is an improved TSC comprehension of the emerging needs of the DOT.

Another measure of the CD for this CSF is senior management participation in long range planning and program implementation efforts. He monitors how the ODs interpret the Department's high priority technology needs and what guidance they give to the professional staff for program development in the major issue, high priority areas. Innovation and entrepreneurial activities are high on the CD's list of measures in judging the senior management's performance. The specific measure is the coordination of the Center's long range technical plans for high priority DOT work in accordance with the planned utilization of limited labor resources.
The nature of the work brought in and the potential impact to the major issues of the Department are quality judgements exercised by the CD of his senior management staff's performance. Though of lesser importance to the above quality judgement, the CD may also judge the "activity level" of his senior management by the number of proposals initiated and coordinated and the number funded relative to opportunities known to be available or projected at some previous time benchmark. This might become part of a management-by-objectives performance evaluation process for the senior staff.

The corresponding CSF measures for Office Director "A" relate to the diversification capabilities of the directorate staff. This OD was showing much success in expanding into another modal sponsor area different from the sponsor historically supported. The OD's measure for this CSF is related to his staff's technical competence and versatility in combination with operational system awareness. This OD feels that technical "smarts" and operational "smarts" are key to marketing programs with sponsors. Another measure of multi-modal effectiveness of the OD's directorate relates to the ability to support several of DOT's Modal Administrations. Versatility of the staff is a measure of the ability to utilize knowledge and expertise gained in work for one mode to the high priority problems of another mode. In this regard, the Center provides an "institutional memory" for knowledge.
and experience which can be applied across modes or be benef-

ficial to Modal Administrations comprised of transitory staff.  

Finally, efforts and coordination with other Government R&D 

Centers involved with transportation may also lead to a 

synergistic effect in contributing to the Department's high 

priority needs.

In regard to long range planning, measures for the OD 

would be the level of funds received from sponsors to expand 

upon the Center's long range plans related to that sponsor. 

Programs may be stimulated by the long range plan to pursue 

specific front-end system design and development of critical 

technologies. Other measures related to long range planning 

success are shown in Table 5.1-3.

Division Chief "A" felt that clarity of top down direc-

tion, as related to Goals and Program Focus, was an important 

measure to achieve success. Top-down direction and goal 

setting provides better defined targets of performance and 

helps to create positive tension in his group. The result is 

improved staff perspective of the benefits of their contribu-

tions. These contributions are related to the success of the 

Center and to the "big picture" of transportation.

The planning/multi-modal CSFs corresponding to the three 

managers appear to have a hierarchical focusing effect rela-

tive to measures. The CD is concerned with the impact of the 

Centers plans and program development activities on the 

Department's high priority needs. The OD focuses his efforts
on several Modal Administration sponsors. The DC's measures relate to specified factual data relative to fund levels and budget submissions.

5.1.4 Credibility Within User and Technical Transportation Community

This CSF is closely related to the "recognition" CSF of Section 5.1.1; however, there are distinctions associated with the measures of the "credibility" CSF to identify this as a separate CSF for the CD.

The Center Director believes that having a good reputation is conducive to improved performance of the Center in fulfilling its mission for the Department. The effectiveness of the Center is enhanced by virtue of a knowledgeable and objective position in the transportation community in that open lines of communication can be established between the Center's professional staff and experts in transportation. Communications with experts who wish to associate and identify with the Center avails the Center staff of an important source of data, knowledge, and capability resident in the technical transportation community. The advantage of such interchange with industry experts adds to the awareness, perspectives and insight of the resident staff, thus enabling the Center to be more effective and efficient in the work it performs for the Department. The other advantage of credibility is that the Center's work is more likely to have a
significant favorable impact and acceptance by the transportation community.

The reputation of the Center enables it to attract experts to the Center who seek information or employment. More will be discussed on the employment aspect under the CSF Critical Area Expertise and Skill Build-Up in Section 5.1.6. The CD is interested in broadening both, the sphere of contacts for the Center professional staff, and the base of information support from the industry. In addition, the CD is interested in disseminating information to the technical transportation community.

TSC frequently receives requests from high level officials in the Department to sponsor and conduct special conferences; workshops and seminars at the Center to assemble and discuss views with industry experts. These conferences pertain to important national transportation issues facing the Department and the transportation community which TSC is actively working on. A list of some recent or planned conferences sponsored by TSC are:

- Freight systems
- Advanced Technology
- Rapid Transit Construction
- Air Transportation Safety
- Urban Rail Vehicle Crashworthiness
- International Air Transportation Conference
- Urban Rail System Noise
A measure of the Center's success, by the CD, in sponsoring these conferences is who attended, their affiliation, area of expertise, reputation within the transportation community and nature of dialogue established with Center experts. Feedback from the conferences, either word of mouth, letters, or responses by the Center and industry participants. The feedback provides a measure, to the CD, of the effectiveness of the conference, the dissemination of information, and establishment of new contacts for the Center staff. In the long run, performance improvements on important programs for DOT are viewed as a measure. Sharing information with the transportation community at such conferences would also aid the overall decision process of the Department on key national issues by obtaining assurance and early endorsements from known industry experts (see Table 5.1-4).

An important mission for DOT/TSC pertains to dissemination of Department information on technology development. To the laymen, much of the technology development work of the Department would go unnoticed if it were not for the dissemination activities of the Center staff. DOT/TSC maintains a dedicated staff who serve as focal points for disseminating information and assure "technology sharing" in the transportation user and industry communities. A large number of requests are handled by a special Technology Sharing Office to help the public become aware of DOT activities. These may range from regulations, applying for grants, transporta-
Table 5.1-4  COMPARISON OF CSFs AND MEASURES FOR DOT/TSC CENTER DIRECTOR: CREDIBILITY WITHIN USER AND TECHNICAL TRANSPORTATION COMMUNITY

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<th>OFFICE DIRECTOR &quot;A&quot;</th>
<th>DIVISION CHIEF &quot;A&quot;</th>
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<tr>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
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<tr>
<td>Requests from outside transportation authorities for Center staff experts to participate on national/international committees, transportation advisory boards, technology study panels and at key transportation symposia.</td>
<td>Requests from outside transportation authorities for Center staff experts to participate on national and international transportation commissions, advisory boards and technology study panels.</td>
<td>Identified impacts and benefits of work products in sponsor critical areas.</td>
</tr>
<tr>
<td>Success of transportation conferences sponsored by TSC. Transportation community attendance at Center sponsored workshops, seminars and symposia: who attended/affiliation/level and feedback.</td>
<td>Publications by staff in refereed professional journals. Feature articles about Center's work in trade journals.</td>
<td>Industry and operational user community interest and adaptations of work.</td>
</tr>
<tr>
<td>Feedback on interest and applications of developed technology by user community: impact, usefulness, and cost advantages resulting from applications of transportation R&amp;D work.</td>
<td>Professional recognition received by technical staff from sponsors and transportation community for recognition of exemplary work and contributions.</td>
<td>Feature articles about Division's work in trade journals.</td>
</tr>
<tr>
<td>Professional reputation enjoyed by technical staff in Department, transportation community, and professional societies for recognition of advancements in the transportation sciences.</td>
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tion concepts studied by DOT, or new technology developments. Feedback on these activities, from letters or simple questionnaires, which are sent out (with each document released), provides feedback to the CD especially if a user identifies the impact, cost savings or other benefits from applications of the Center's work.

Frequently the Center is requested by transportation authorities to send experts to participate on national/international committees, transportation advisory and review boards, technology study panels and transportation symposia. On a few occasions, Center experts have been requested to testify at investigations, hearings, and in litigation proceedings on matters dealing with transportation safety and system performance. Such requests also constitute measures for the CD of the Center's reputation. Recognition of the professional staff by the Department, transportation community and professional societies is yet another measure of the reputation of the Center. Such recognition shows that TSC is working on the "right" issues and has the resident expertise to be of long term value to DOT.

The OD has similar measures for his CSF Reputation in Modal Transportation Community. A measure of the staff's reputation, in addition to those already discussed for the CD, are quality publications in professional journals, especially those journals which technically scrutinize and referee the contributions. In addition, feature articles in
trade journals about the Center's work in the area of responsibility of the directorate provide measures of reputation in the modal transportation community. Publication in the trade journals leads to peer recognition by industry experts.

Division Chief "A" cited the impact of his staff's work in critical areas of interest to the sponsor as a measure of his "reputation" related CSF, Product Utility and Reputation. As with the OD, feature articles in trade journals are also used as a measure for the DC. Of importance to the DC is industry and user community interest and adaptations of the work of his staff. If technology developments for which he is responsible become operationally applied, this also constitutes a measure. When working on lead technology programs, operational applications in the transportation community can often take five to ten years so that recognition for operational applications of work does not provide an immediate measure.

This credibility CSF has specific measures for all three levels of management with a hierarchy of observed measures. The CD's measures relate to feedback received from the general transportation community and experts. The OD's measures are related to the CD's but are focused on the specific benefits of the work his directorate performs. The DC's measures pertain, specifically, to the identification of the Division's work impact on the sponsor, industry, and the user community.
5.1.5 **Blend of High Priority, Major Issue Programs**

The typical Center project life-cycle spans several years, resulting in long-term commitments of key staff to various sponsors. In an environment of personnel ceilings, long-term program commitments and new project demand exceeding the supply of labor, "pick and choose" decisions associated with new work involve delicate trade-offs in the program selection process. The Center Director maintains cognizance over the commitment of staff, carefully avoiding overcommitment, but being mindful of the effective and efficient utilization of his staff resources for on-going work. The Center is limited in the amount of work that it can take on, and therefore it is necessary to prioritize the many demands. An example of the demand/supply dilemma is the fact that the Center must turn away over 40% of the work, relative to the amount currently booked, in terms of total level of funding.

The CD also reviews the appropriateness of the Center's long term programs for possible program attrition since this makes available a supply of staff resources that may be applied to satisfy new, more important project demands. Other trade-offs have to be managed in selecting the work by matching work with the capabilities of available staff. In a multi-discipline Center the skill matching process is crucial and plays an important role in the "pick and choose" process. The advantage of long-range plans for human resource
development should anticipate the skill needs and skill availability relative to emerging technologies and program attrition.

In Section 5.1.2, under the CSF Organization's Sense of Common Purpose, we identified the process by which the Center Director develops new programs, through his staff office, Office of Plans and Program. As indicated, the CD uses this office to coordinate the activities of the line organizations in their development of new programs which meets sponsor needs. It is through the efforts of the Office of Plans and Programs that the CD blends-in emerging high priority, major issue, multi-modal programs with the existing program portfolio. This activity gives the CD the control necessary to manage the in-take of the work that the Center performs.

The hierarchical aspects of this CSF for the CD were discussed above in Section 5.1-2. The "blend" CSF addresses the management problems related to program portfolio management, Department obligations, and staff performance. The key activity monitored by this CSF, as indicated in Table 5.1-5, pertains to portfolio management by the Center's senior staff. With demand exceeding the supply of critical skill resources, careful management of the work intake is necessary to assure that the Center can deliver on those projects most important to the Department. The CD expects his technically-oriented OD and staff to identify major issues facing each sponsor which the Center should be addressing, and to develop
Table 5.1-5  COMPARISON OF CSFs AND MEASURES FOR DOT/TSC CENTER DIRECTOR:
BLEND OF HIGH PRIORITY MAJOR ISSUE PROGRAMS

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<tr>
<td><strong>BLEND OF HIGH PRIORITY, MAJOR-ISSUE PROGRAMS</strong></td>
<td><strong>SPONSOR RELATIONS AND LIAISON</strong></td>
<td><strong>PROGRAM DEVELOPMENT</strong></td>
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<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
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<tr>
<td>- Attitudes and ability of senior management staff in identifying high priority, major issues confronting each mode. Potential impact of projects on key national issues in the future.</td>
<td>- Commitment, sustained interest and visibility of Center senior management in undertaking and performing a new sponsor's program, thus achieving:</td>
<td>- New projects and funding as a result of established reputation with sponsor and perception of sponsor's major issues and needs.</td>
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<td>- Expansion of on-going programs into priority areas in which the sponsor has delegated more responsibility to the Center.</td>
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<td>- Capture share ratio of sponsor's high priority programs in the areas of expertise of the Division.</td>
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<td></td>
<td>- Turnover of projects and attrition of low priority projects.</td>
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<td></td>
<td>- Increased program responsibility assignments from sponsor stemming from liaison and perceptions of sponsor's high priority major issues.</td>
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<td>- Cross-mode utilization of expertise among projects of different modal sponsors. Assignment to Center, by all modes, of work on their high priority, major issue programs.</td>
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<td></td>
<td>- On-going project life-span maturity estimates. Annual estimates of project attrition and labor availability.</td>
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<td></td>
<td>- Percent of total Center labor supporting high priority, major issue program of the Department.</td>
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Program Development

- New projects and funding as a result of established reputation with sponsor and perception of sponsor's major issues and needs.
- Expansion of on-going programs into priority areas in which the sponsor has delegated more responsibility to the Center.
- Capture share ratio of sponsor's high priority programs in the areas of expertise of the Division.
- Turnover of projects and attrition of low priority projects.
priorities and criteria for program selection. A key measure for the CD is based on the senior management's interpretations of high priority, multi-modal major issues facing the Department. A measure for the CD's CSF is thus the effectiveness of his senior staff's recommendations of work that potentially may have the greatest impact on key transportation decisions.

The Center has the unique capability in DOT to adapt technology developed for one mode to the problems facing another mode. The CD can judge his staff by the amount of support the Center delivers to all the modes on their high priority work.

A measure related to program maturity is the percentage of the current work performed for each mode which is determined still to be high priority by the Department. This will require periodic rating and must take into account long-term commitments. However, project maturity provides the signal to the CD to start giving consideration to how he will utilize the staff soon to be available.

The corresponding CSF for Office Director "A" is Sponsor Relations and Liaison. In his role in managing the program portfolio, a measure for the OD is the state of relations with the sponsor. The sponsor feels confident in awarding his high priority programs when he perceives the Center's top management commitment to the programs. Moreover, high level management commitment is conducive to high morale and
increased productivity by the performing staff as they perceive strong interest from their superiors.

A measure of success with the sponsor that OD "A" may use is identified as the capture share ratio (analogous to "market share" in the business world). The capture share ratio identifies the fraction of the sponsor's high priority work that is assigned the OD's directorate relative to the amount that the sponsor chooses to assign to other (non-transportation) Government R&D Centers, industry, non-profit R&D companies (under task order contract to the sponsors) or to R&D laboratories at universities. This pertains to work that DOT should be performing in-house and not "farmed out to outsiders". In effect these are sources of "competition" for this directorate at TSC, especially the non-profit companies. As in the business world, capture share indicates the relative success of the "product" and "marketing". Such a ratio is important especially if TSC had the skill resources available and the interest to perform the work and was not assigned the work by the sponsor. The capture share ratio also relates to missed opportunities by the Center when it was not able to accept the sponsor's program because of a critical skill deficiency.

The corresponding CSF for Division Chief "A" is Program Development. The measure of performance for the DC is his staff's ability to develop new projects by perceiving sponsor needs consistent with organizational objectives. The acti-
vity is basically technical liaison which is coordinated with the CD's staff. A measure of performance is expansion of important on-going work and increased responsibility for high priority programs. Capture-share ratio is a useful measure here also. The ability to attract new programs may also be related to the maturity and attrition of projects which have gone through their life-cycle span and probably should be transitioned to a contract by the sponsor, or to other sponsor laboratories or test facilities. It is presumed that the work no longer is in the category of work that TSC should be doing, thus justifying termination. This must be done with care by the DC and OD, because the Center's policy is not to abandon a sponsor and leave previous commitments unsatisfied.

The high priority blend CSF measures have a definite hierarchical focusing effect. The CD is concerned with implementing strategy associated with long range plans in performing high priority work for the modes. In this process he is concerned with new program starts, program maturity and the overall management problems of "picking and choosing" in an environment where the demand exceeds the supply of limited Center labor resources. Office Director "A" is concerned with development of specific high priority programs with the sponsors. The DC's measures related to follow-on work and development of new projects with each sponsor plus the share of high priority work he performed for a particular sponsor.
5.1.6 **Critical Area Expertise and Skill Build-Up**

Skilled people are a scarce resource for Government R&D Centers. Planning for the Center's human resources is a crucial process for the Center Director of TSC because he must have the proper skills on board in critical "areas of expertise" when program opportunities develop. This is particularly true in Government R&D Centers where civil service regulations and personnel ceilings place severe constraints on the degrees of freedom for management. One of the purposes of the long range plan is to project staff skill requirements. In Table 5.1-6 a measure of the in-house competence is the ability of the Center to attract highly trained people with the proper technical credentials. This is a form of skill competence "bootstrapping" in that "good people attract good people". An influx of competent people provides two measures: the closure of the gap between skill requirements versus on-board capability and the competence of the on-board staff. This is a difficult measure, unfortunately, because of the on-again, off-again hiring spurts of the Government.

Attrition rate, or turnover of staff, in critical skill categories constitutes a measure of in-house problems for maintaining staff. Lack of attrition in non critical areas also is a concern to the CD.

The corresponding CSF for Office Director "A" is **Team Attitude and Skill Improvement**. The primary measure of team
### Table 5.1-6 COMPARISON OF CSFs AND MEASURES FOR DOT/TSC CENTER DIRECTOR: CRITICAL AREA EXPERTISE AND SKILL BUILD-UP

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<th>CENTER DIRECTOR</th>
<th>OFFICE DIRECTOR &quot;A&quot;</th>
<th>DIVISION CHIEF &quot;A&quot;</th>
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<tbody>
<tr>
<td>CRITICAL AREA EXPERTISE AND SKILL BUILD-UP</td>
<td>TEAM ATTITUDE AND SKILL IMPROVEMENT</td>
<td>TECHNICAL SKILLS AND CAREER PLANNING</td>
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<tr>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
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<tr>
<td>- Capability build-up in &quot;areas of expertise&quot; with requisite skills to concentrate on major issues of importance to the Department and manage critical multi-modal programs in key areas.</td>
<td>- Improved productivity of staff through pride, participative goal setting, commitment to the team with a &quot;turned-on&quot; enthusiastic attitude, and desire to accomplish something extra for the job.</td>
<td>- Closure of gap between skill requirements versus availability.</td>
</tr>
<tr>
<td>- Influx of competent people with good technical credentials, attracted to Center by reputation and work of in-house peers, or, by reputation of Center in transportation community.</td>
<td>- Risk in accepting and performing high priority work. Frequency of missed opportunities in not being awarded work because of poor team attitude, deficiencies or lack of availability of in-house critical skills.</td>
<td>- Attrition and turnover of competent technical staff in critical skill categories. Attrition (or lack of) in non-critical skill categories.</td>
</tr>
<tr>
<td>- Attrition and turnover of competent technical staff in critical skill categories. Attrition (or lack of) in non-critical skill categories.</td>
<td>- Closure of the gap between requisite skills versus skills available to staff high priority R&amp;D programs.</td>
<td>- Corrective action in rectifying areas of technical obsolescence relative to Center's critical skills categories.</td>
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<td>- Willingness of staff to prioritize personal and professional interests and improve, broaden and deepen skill capabilities for the best interest of the Center.</td>
<td>- New hires or new transfers into the Division.</td>
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<td>- Skills and labor made available from project attrition.</td>
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<td>- Feedback on intern and coop programs and staff retraining programs. Effectiveness of work study programs with universities. Number of quality schools participating and feedback on students-employees.</td>
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<tr>
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<td></td>
<td>- Division training accomplishments in relation to individual development plans, Center's training plans and critical skill/expertise deficiencies.</td>
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</tbody>
</table>
attitude for this OD is enthusiasm and staff being "turned-on" by the work. The OD noted that he looked for staff who were always willing to give that "something extra". In addition, the OD observed the willingness of his staff to retrain and adapt to new skills.

This OD uses risk assessment of accepting work as an indicator of his confidence of having the proper skills matched to the needs of the program. A measure for OD "A" may be the frequency of missed opportunities in not being able to accept work because of skill deficiencies. Monitoring skill needs in terms of projected skill requirements versus on-board capability is an indication of skill deficiencies.

The corresponding CSF for Division Chief "A" is Technical Skills and Career Planning. This CSF focuses on the supervisor-individual interface. Attrition and turnover were noted as measures for skill build-up. Specific corrective action to rectify technical obsolescence is also monitored such as retraining. Project attrition is also a measure since staff is made available for high priority needs.

The success of university work-study relationship is a measure of staff skill improvement. The quality of students attracted, with feedback from participating universities on the learning experience of the students, is also an indication of the quality of on-board in-house staff and the quality of work performed by the Center. As noted earlier, good people attract good people. Effective programs for cooperative
education students, interns, fellowships or work-study students provide a useful indicator of skill and staff competence improvement adding to the overall competence and improving the Center's capability to respond to the technological problems of the Department.

Monitoring of first-level supervisor-employee relations provides a measure of staff performance for the DC. Career planning, with specific emphasis on training, is a step to assure the proper skill resources in the areas critical to the Center's success. In order for Division Chief "A" to prepare training plans for his staff, he felt he needed top-down guidance to help him identify important training objectives in line with Center needs. Thus, human resource planning by the Center Director relates Center strategy and goals to skill deficiencies and training objectives. These then become action plans for the middle- and first-level supervisors.

The expertise CSF shows a definite hierarchical focusing of measures for each management level. The CD was concerned with expertise build-up through new hires, and an influx of experts in critical areas identified in the long range plan. The OD was concerned with the consequences of not having the proper staff skills to realize opportunities when they surface. He was also interested in a team attitude dimension, feeling that this would contribute to having a more productive staff. The DC's measures related primarily to personnel activities with his on-board staff.
5.1.7 Responsiveness and Productivity

The Center Director of DOT/TSC emphasises responsiveness of the staff for addressing the high priority needs of the Department. The objective of the CD, as reflected in the CSF measures of Table 5.1-7, is to achieve a productive Center responsive to the high priority needs of the Department.

Most definitions of productivity identify it as the efficiency and effectiveness in utilizing resources to produce a valuable output. In arriving at a measure of productivity for this CSF, we will extend this definition to the situation at TSC. "Value" may be defined as the quality, utility and favorable impact of the results of work on a high priority need of the Department. Of concern to the CD is the ability of the Center to be responsive on as many high priority projects as possible keeping in mind that projects mature and that there are scarce labor resources that may be needed on other important projects. Thus a measure of productivity for the CD could be the increase each year in the number of high priority projects that the Center can take on for the same level of in-house labor, with performance and quality (as defined above) for all projects meeting or exceeding expectations. This measure, unfortunately, is impossible to quantify due to the many parameters that affect the evaluation process. There are many judgment factors in this definition of projects but the important dimension is the increase in high priority projects for the same level of staff.
Table 5.1-7  COMPARISON OF CSFs AND MEASURES FOR DOT/TSC CENTER DIRECTOR:
RESPONSIVENESS AND PRODUCTIVITY

<table>
<thead>
<tr>
<th>CENTER DIRECTOR</th>
<th>OFFICE DIRECTOR &quot;A&quot;</th>
<th>DIVISION CHIEF &quot;A&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RESPONSIVENESS AND PRODUCTIVITY</strong></td>
<td><strong>PRODUCTIVITY AND QUALITY</strong></td>
<td><strong>TECHNICAL QUALITY AND OUTPUT</strong></td>
</tr>
<tr>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
</tr>
<tr>
<td>* Consistent delivery of negotiated work products and meeting quality expectations on all programs.</td>
<td>* Increase in number of high priority programs for the same level of in-house labor with performance and quality meeting or exceeding expectations.</td>
<td>* Branch output: new programs assigned in high priority areas; program documentation generated; staff availability for &quot;quick response&quot; actions.</td>
</tr>
<tr>
<td>* Increase in number of high priority programs for the same level of in-house labor with performance and quality meeting or exceeding expectations on all programs.</td>
<td>* In-house labor on projects versus contractor leverage. More short term &quot;bang for the buck&quot; traded-off with long term obsolescence of in-house technical skills.</td>
<td>* Identified advancements in technology and the state-of-art. Spin-off technology benefits. Patents.</td>
</tr>
<tr>
<td>* Increase in ratio of technically effective direct labor to indirect.</td>
<td>* Improved turnover of low priority projects in directorate. Increases in the number of high priority, major issue projects.</td>
<td>* Publication of papers in refereed professional journals, peer recognition, and feedback.</td>
</tr>
<tr>
<td><strong>PRODUCTIVITY AND QUALITY</strong></td>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
</tr>
<tr>
<td>* Improved productivity benefits from cohesiveness, intra-directorate communications, and sharing of knowledge and expertise on high priority programs.</td>
<td>* Observed delivery of negotiated work products to sponsor on all projects. Frequency of milestones met versus milestones missed. Quality and impact of work product.</td>
<td></td>
</tr>
</tbody>
</table>


Consistent delivery of negotiated work products within the allocated resources and schedule, which meet the expectations of the sponsor is also a measure of productivity. If the assumption is made that the negotiation process with the sponsor properly programmed funds and labor allocations for the program's deliverables, then consistent meeting of the negotiated work products within the programmed resources is an indication of productivity. This assumes an effective negotiation process with the sponsor and that work estimation and fund allocation procedures were accurate.

The Center's performance is measured by the CD, first, on technical output. But, another overall productivity measure for the CD, is the ratio of technically effective direct labor to indirect labor employed by the Center for a given personnel ceiling level. As in the business world, overhead costs can raise the "cost of goods" and make the product difficult to sell. The same applies to a Government R&D Center with regard to the adjusted cost per labor year. If the total indirect labor force is too large, the services offered are no longer "competitive" due to the total costs involved; or conversely, the Center's productivity is diminished because it may have applied more technical people to the Department's problems.

The corresponding productivity CSF for Office Director "A" is Productivity and Quality. The increase of high priority projects in the directorate, as with the CD, is a
useful measure of productivity. The OD indicated that the level of labor assigned to projects is a measure of productivity, looked at from the point of view of funding levels, or the number of staff per project dollar. The contract-to-in-house labor ratio is a useful measure of staff leverage to enhance productivity. Increasing the amount of work contracted out can free up staff for priority in-house work. However, careful decisions with regard to what gets contracted out must be made. Industry should not be doing the work more properly done by in-house staff, and conversely. The Center has criteria for what work should be done in-house and what work contracted. Examples of the type of work that in-house Government staff should be doing are:

a. front-end planning,
b. cost-benefit studies,
c. evaluations (of concepts or specific safety related components),
d. preparation of specifications,
e. defining data bases for transportation, etc.

Examples of the type of work that industry should be doing under contract to the Government are:

a. detailed hardware design/development,
b. system implementation/hardware manufacturing,
c. collecting of information, etc.

Contracting work out may pose other problems for the long run, because of the danger of staff becoming technically
obsolete. High quality technical people generally do not like to monitor large contracts because of the administrative demands on their time. An R&D center offering in-house capability will, in time, weaken this capability if it attempts to increase funding levels out of proportion with personnel staff increases. The aggregate measure serves only as a rough measure of productivity in terms of funds obligated per man year.

What the proper leverage ratio should be cannot be specified, the comparison of leverage ratio across organizational elements is a more useful measure of productivity and indicator of proper staffing. The relative leverage ratio among directorates, sponsors and individual FPA's provides the CD and OD with more useful information than an aggregate ratio for the entire Center. The relative leverage ratio allows the CD to make judgments of proper staffing on projects for which it is not possible (or proper) to contract the work. On the other hand, work for some sponsors may permit much more contracting and require a smaller staff.

The corresponding "productivity" CSF for Division Chief "A" is **Technical Quality and Output**. The DC is concerned with output for the resources he has assigned to his staff. Technical quality in terms of benefit to the Department is his primary dimension for productivity along with the meeting of milestones and staff availability for quick response actions. The DC identified, as measures of technical quality,
advancements in technology and the state-of-the-art. Any spin-off benefits for the technology, especially those leading to new programs, were identified as relevant measures. Patents and publications were offered as related measures. The DC emphasized feedback from his in-house staff, and his peer groups and sponsors as useful measures of quality and productivity.

The productivity CSF for TSC had measures which did not demonstrate hierarchical focusing. This is attributed to the problems of quantifying productivity in the Government. All three managers relied upon measures relating to delivery of a quality product within the resources and schedule negotiated with the sponsor. Both the CD and the OD used, as a measure of productivity, the increase in high priority projects for the same level of in-house labor. The DC was concerned more with technical quality and the potential benefits and recognition of his group's work.
5.1.8 Program Management Effectiveness

The discussion of Section 3.1.3 described the general method of funding which supports the work TSC performs. A project plan agreement (PPA) is prepared within the umbrella of the general working agreement (GWA) between the Center Director and high level Modal Administrator Officials (the sponsoring organizations). The PPA is basically an outline of objectives and work between TSC and the sponsor Modal Administration. The PPA outlines the technical approach, scope, outside contracts, and specifies all deliverables and schedules. Overall funding, labor, contract and miscellaneous uses of funds are specified and agreed to in the negotiation process. When the negotiation process is completed, usually before the fiscal year commences, the end result is considered by both TSC and the sponsor as a binding agreement, TSC for its deliverables and the sponsor for his funding support. The process is an annual one with a new PPA renegotiated at the start of the fiscal year, however, longer term agreements are frequently understood to be in effect for both parties. Unlike R&D management and control systems elsewhere in the Government, the TSC-sponsor PPA assures a high degree of accountability since program staff are held to their obligations. The sponsor has assurance of proper management of the funds, work, deliverables and schedules.

The measures for the Center Director's CSF Program Management Effectiveness are shown in Table 5.1-8 along with
Table 5.1-8 COMPARISON OF CSFs AND MEASURES FOR DOT/TSC CENTER DIRECTOR: PROGRAM MANAGEMENT EFFECTIVENESS

<table>
<thead>
<tr>
<th>CENTER DIRECTOR</th>
<th>OFFICE DIRECTOR &quot;A&quot;</th>
<th>DIVISION CHIEF &quot;A&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROGRAM MANAGEMENT EFFECTIVENESS</td>
<td>PLANNING AND RESOURCE CONTROL</td>
<td>PROGRAM MONITORING AND CONTROL</td>
</tr>
<tr>
<td>MEASURES</td>
<td>MEASURES</td>
<td>MEASURES</td>
</tr>
<tr>
<td>- Effective and efficient utilization of Department resources, in meeting delivery of satisfactory products within negotiated funds, labor and schedule.</td>
<td>- Percentage of Directorate's total funding and labor levels, and the number of new projects awarded by sponsor which were inspired by Directorate's long range plans and program development proposals.</td>
<td>- Effectiveness of program negotiations with sponsor and commitment of top management.</td>
</tr>
<tr>
<td>- Senior level Department Official attendance at program reviews. Effectiveness of presentation by Center management staff.</td>
<td>- Attention of managers to commitment versus risk in negotiating project agreements with sponsor. Efficient planning and utilization of negotiated sponsor funds and Center's in-house direct labor.</td>
<td>- Available skills and competence of staff assigned.</td>
</tr>
<tr>
<td>- Sponsor feedback and attitudes regarding performance obligations on assigned projects. Satisfaction versus &quot;grief&quot; level and frequency on projects. Amount of intervention time required by senior management staff in fixing problems.</td>
<td>- Effectiveness of resource tracking and surfacing of latent problems by program administrative staff and the management information system:</td>
<td>- Deliverable and schedule negotiations.</td>
</tr>
<tr>
<td></td>
<td>- Critical milestone accomplishment/slippage</td>
<td>- Funding and labor levels.</td>
</tr>
<tr>
<td></td>
<td>- Procurement status</td>
<td>- Assessment of technical uncertainties.</td>
</tr>
<tr>
<td></td>
<td>- Program cost variances: actual versus planned</td>
<td>- Priority and visibility of program.</td>
</tr>
<tr>
<td></td>
<td>- Labor allocations and charges</td>
<td>- Program resource obligation variances</td>
</tr>
<tr>
<td></td>
<td>- Cost to complete projections</td>
<td>- Funds</td>
</tr>
<tr>
<td></td>
<td>- Travel/training, etc.</td>
<td>- Labor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Procurements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Favorable allocation of Center's labor resources assigned to directorate by CD to fulfill growing demand of sponsor high priority projects.</td>
</tr>
</tbody>
</table>
the corresponding CSFs and measures for Office Director "A" and Division Chief "A". In accordance with the PPA and sponsor negotiations, the CD's measures reflect sponsor relations. The PPA negotiation process is carried out under the purview of the OD. The CD monitors whether or not the products being delivered are satisfactory in terms of quality, schedule, resources utilized, and deliverable responsiveness. If so, the CD can conclude that sponsor resources are being effectively and efficiently utilized.

Obviously, an important measure is sponsor satisfaction and feedback on quality, performance and efficiency. The priority and importance of the work to the sponsor can be judged by the CD by feedback from the sponsor regarding the input and use made of results on important problems with each sponsor. One other measure that the CD knows is the "grief" level and frequency with which it occurs on projects. The amount of time he must spend intervening into program problems, which normally should not involve his time, is an obvious measure of performance of his staff.

The corresponding CSF for Office Director "A" is Planning and Resource Control. The measures are shown in Table 5.1-8 and focus on sponsor relations. The OD has more visibility and detailed insight into sponsor program operations than does the CD. The OD also monitors the linkage between plans and resources. As indicated above, PPA's are normally re-negotiated each year; thus, the OD must be acutely aware of
next year's program. Plans and funds corresponding to the overall PPA portfolio with a given sponsor reflect, directly, the relations with the sponsor.

The long range plan, forms the basis for a more proactive relationship with each sponsor. Here the measure is the amount of funding and projects which the OD can claim were inspired by his long range planning and proposal development activities which he nurtured with each sponsor.

Many problems can be avoided simply by properly negotiating a PPA. Office Director "A" is mindful of unnecessary risk on the part of the TSC staff in committing to the sponsor. This pertains primarily to having the people available with the skills to do the job promised. As OD "A" put it, "There is plenty of work and the management does not require the staff to take on more work than that which be satisfactorily delivered". In an environment of personnel ceilings and full employment, overcommitment risk is a real problem especially in view of the spirit of the negotiation-delivery posture of the Center.

In order to facilitate problem tracking, TSC has instituted an efficient program control management information system (MIS) which can (and usually does) surface many latent problems. Typical of the cross-check provided by the MIS is the procurement initiation tracking process. Procurements are visible in a Government R&D Center since procurement initiation milestones are used by high-level
officials from Washington, D.C., as a productivity overview measure. If initiation milestones are running behind, large amounts of procurement funds may not be obligated and will have to be carried over to the next fiscal year burdening next year's program staff. This usually requires explanation at high-levels since it is indicative of the Center's output as well as the thoroughness of the initial planning and estimating process.

The DC has similar measurements for his CSF Program Monitoring and Control which usually get into the details of his program monitoring responsibilities. Variances in resource utilization are tracked. At the level of the DC, accomplishments versus schedules are more frequently visible. Schedule slippage is a first indicator of program problems requiring corrective action. The DC with his branch chief and staff get more directly involved in "fixing" such problems.

The Division Chiefs and Branch Chiefs obtain resource control data from the MIS project cost summary print-outs. All labor charges on projects are identified. Detailed cost data relating to salaries, travel, ADP, documentation, equipment and procurements, etc., are made available and scrutinized each month at this level of management.

The program management CSF resulted in a distinct hierarchical focusing effect and conformed closely to Anthony's planning/control continuum. The CD is concerned with the
overall efficient and effective use of resources. Emphasis is on the meeting of sponsor's program objectives, especially as it impacts future program development and implementation of long range plans. His measures relate therefore to sponsor feedback. The CD does not get involved in the details associated with program management. The OD also is concerned with sponsor satisfaction and the impact of any problems on short term efforts. The OD carefully reviews the programs under his responsibility to keep abreast of developments, being alert for problems. The DC is involved with operational control related to program monitoring and fund utilization.
5.2 **Critical Success Factors for NASA/DFRC**

As mentioned in Section 5.1, the emphasis is upon obtaining the vertical CSF profile for three levels of management at DFRC. This profile considers managers in comparable positions to those of TSC. The NASA/DFRC profile is comprised of the Center Director, (CD), Directorate Head "B" and Division Chief "B". The latter two are from the same directorate to establish a chain of command from the top echelon to the middle level at DFRC.

The CSFs for the individuals, representing three levels of management in NASA/DFRC, are shown on Table 5.2-0. As shown on the table there are seven factors for the CD, seven factors for Directorate Head "B" (DH) and only six factors for Division Chief (DC). The CSFs are not prioritized in this table. The CSFs have been aligned to show those factors which relate to each other as one moves down the "chain of command". The intent is to show hierarchical relationships among similar factors. This hierarchical aspect will be the focus of the discussion on CSFs and their associated measures.

For an example of the hierarchical relationship among the CSFs at the different management levels refer to Section 5.1.

Each individual manager's CSF and measures are presented in the following sections. The discussions will key on the CD's CSF and measures. The appropriate CSFs and measures of DH and DC will be compared with the CD's. Thus, a unified
Table 5.2-0  CRITICAL SUCCESS FACTORS: VERTICAL PROFILE FOR NASA/DFRC

<table>
<thead>
<tr>
<th>CENTER DIRECTOR</th>
<th>DIRECTORATE HEAD &quot;B&quot;</th>
<th>DIVISION CHIEF &quot;B&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>• CENTER PRODUCTIVITY</td>
<td>• PROJECT PRODUCTIVITY</td>
<td>• PERFORMANCE AND TECHNICAL QUALITY</td>
</tr>
<tr>
<td>• LIAISON WITH KEY DECISION MAKERS</td>
<td>• LIAISON WITH THE AERONAUTICS INDUSTRY</td>
<td>• LIAISON WITH THE TECHNICAL AERONAUTICS COMMUNITY</td>
</tr>
<tr>
<td>• MANAGEMENT RESPONSIBILITY EXECUTION</td>
<td>• MANAGEMENT AND TECHNICAL COMPETENCE</td>
<td>• COMPETENT AND RECOGNIZED STAFF</td>
</tr>
<tr>
<td>• STAFF COMMITMENT TO THE ORGANIZATION'S GOALS</td>
<td>• ORGANIZATIONAL UNITY</td>
<td>• COMMITMENT AND SUPPORT OF STAFF TO DIRECTORATE GOALS</td>
</tr>
<tr>
<td>• SUPPORT OF AGENCY'S OBJECTIVES AND GOALS</td>
<td>• PLANS, OBJECTIVES AND STRATEGIES</td>
<td>• LONG RANGE PLANS AND STRATEGIES</td>
</tr>
<tr>
<td>• RECOGNITION AS A NATIONAL CENTER FOR FLIGHT EXPERIMENTATION</td>
<td>• ASSURANCE OF SAFETY IN FLIGHT EXPERIMENTATION</td>
<td>• PRODUCT RESPONSIVENESS ON CRITICAL PROJECTS</td>
</tr>
<tr>
<td>• ACCOUNTABILITY AND RESOURCE CONTROL</td>
<td>• PROJECT RESOURCE CONTROL</td>
<td>(included in other CSFs)</td>
</tr>
</tbody>
</table>

*Note: The CSFs are not listed in any priority ordering in this table. They are organized to portray hierarchical relationships among the three levels of management.
discussion will be presented which shows the hierarchical focusing effect at the lower level of the organization.

5.2.1 Center Productivity

This factor is self explanatory. Current tight budget constraints and labor ceilings or cutbacks, coupled with increasing complex projects which must meet schedules, create pressures to improve productivity. Of all CSFs, this appears to be the most difficult to measure. Suggested measures for this CSF appear in Table 5.2-1, which also indicates that this factor is common to the DH and DC. The hierarchical aspect can best be addressed by the questions each of the managers ask about productivity.

The CD asked the following questions:

1. How do you measure the productivity of the Aeronautical, Data Systems, Flight Operations, and Administration and Program Support directorates?
2. When are people being used effectively? How do you measure their effectiveness?
3. Is that the most efficient organizational structure? How can I measure it?

Clearly the CD's concerns cover a wide range of productivity concerns. But, how does one measure productivity for an R&D center? Productivity cannot be measured absolutely in an R&D center. Many ideas for measures are offered but are very subjective. Thus, incremental measures appeared as being more
Table 5.2-1 COMPARISON OF CSFs AND MEASURES FOR NASA/DFRC CENTER DIRECTOR:
CENTER PRODUCTIVITY

<table>
<thead>
<tr>
<th>CENTER DIRECTOR CENTER PRODUCTIVITY</th>
<th>DIRECTORATE HEAD &quot;B&quot; PROJECT PRODUCTIVITY</th>
<th>DIVISION CHIEF &quot;B&quot; PERFORMANCE AND TECHNICAL QUALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
</tr>
<tr>
<td>• Savings in time, cost and/or manpower for on-going projects with work product quality meeting or exceeding quality expectations.</td>
<td>• Decrease in negative variance from target schedule, manyears effort and costs for each project and disciplinary group.</td>
<td>• Decrease in negative variance from target schedules, manyears effort and costs for each project and disciplinary group.</td>
</tr>
<tr>
<td>• Increased number of projects for same level of in-house manpower, meeting schedules and costs with work product quality meeting or exceeding expectations.</td>
<td>• Savings in time, cost and/or manpower for on-going projects with small changes in work product quality.</td>
<td>• Identification of productivity &quot;bottlenecks&quot; within Division to focus on problems and concentrate corrective actions.</td>
</tr>
<tr>
<td>• Improvement in ratio of effective direct labor and indirect labor.</td>
<td>• Increased number of projects with same level of in-house manpower, meeting schedules and costs, with work product quality meeting or exceeding expectations.</td>
<td>• Savings in time, cost and/or manpower for on-going projects striving for consistent high quality.</td>
</tr>
<tr>
<td></td>
<td>• Improvement in ratio of effective direct labor and indirect labor.</td>
<td>• Increased number of projects with same level of in-house manpower, meeting schedules and costs, meeting or exceeding work product quality expectations.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Improvement in ratio of effective direct labor and indirect labor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Feedback on client and sponsor satisfaction on performance per negotiated work products deliverable for given resources.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Clear objectives and performance goals.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Realistic estimates.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Good organization and control.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Frequent feedback with sponsor and clients.</td>
</tr>
</tbody>
</table>
meaningful measurements, as shown by the first two measures under CD's factor. By increasing the number of projects for the same level of in-house manpower while meeting schedules and costs without compromising work product quality, the CD can raise a number of productivity related questions of his managers, such as, if we are at peak productivity in terms of cost, manpower, schedule and quality:

1. Who is idle? Why?
2. Do the idle people indicate a skill mix problem?
3. Do we need different projects to utilize our skill mix properly?
4. Is this idleness caused by an identifiable "bottle-neck"?

Considering the DH, his questions about Project Productivity indicate more specific concerns:

1. How do you measure project and disciplinary group productivity?
2. What deliverables are necessary to improve the Directorate's output? Report?
3. For those who don't have the opportunity to write reports, how do we measure their output?

Again, the questions are difficult to answer. A more quantifiable measure was the variance from target schedule, labor effort and costs for each project and disciplinary group.

The DC views his productivity in terms of the division's Performance and Technical Quality of its work products. The
DC was very specific about his productivity concerns. He desired measures which would identify productivity "bottle-necks" within the division so that he could concentrate his corrective actions. Product quality is judged by client and sponsor satisfaction. Thus, the information which will improve or meet this satisfaction is needed by the DC.

Notice, in this simple case, the hierarchical focusing that takes place. The CD's factor is dealing with the general, DH's factor is more specific and the DC's factor is very specific.

5.2.2 Liaison with Key Decision Makers

To obtain the vital information for management decision making, liaison was considered important by the DC in Table 5.2-2 because it provides the opportunity to interact with the key decision makers. This interaction permits the CD to focus on the Agency high priority needs so that the Center can be more responsive.

Liaison improves Center to Agency priority programs. For instance, if the proper liaison is conducted then, the proposed center plans, projects and budget should be "on target" with the decision makers, resulting in improved support to the Agency.

Corresponding factors for the DH and DC are, Liaison With The Aeronautics Industry and Liaison With The Technical Aeronautical Community, Table 5.2-2. The titles of these
Table 5.2-2 COMPARISON OF CSFs AND MEASURES FOR NASA/DFRC CENTER DIRECTOR:
LIAISON WITH KEY DECISION MAKERS

<table>
<thead>
<tr>
<th>CENTER DIRECTOR</th>
<th>DIRECTORATE HEAD &quot;B&quot;</th>
<th>DIVISION CHIEF &quot;B&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIAISON WITH KEY DECISION MAKERS</td>
<td>LIAISON WITH THE AERONAUTICS INDUSTRY</td>
<td>LIAISON WITH THE TECHNICAL AERONAUTICAL COMMUNITY</td>
</tr>
<tr>
<td>MEASURES</td>
<td>MEASURES</td>
<td>MEASURES</td>
</tr>
<tr>
<td>- Increased approval of proposed plans, projects and budgets through liaison with key decision makers.</td>
<td>- Increase knowledge and perception of all important aeronautical efforts, needs and plans to guide Directorate actions.</td>
<td>- Increase knowledge and perception of all important technical activities, state-of-art, techniques and analysis, and processes which are ongoing in the technical community to guide Division activities. Emphasis is on knowledge related to functions and disciplines of Division.</td>
</tr>
<tr>
<td>- Increased sensitivity to and perception of important aeronautical issues being considered and the objectives of the key decision makers.</td>
<td>- Identify environmental opportunities.</td>
<td>- Identify environmental opportunities.</td>
</tr>
<tr>
<td>- Develop a current overview of entire local national and international environment with emphasis of flight experimentation to guide Center's actions.</td>
<td>- Identify critical people to deal with.</td>
<td>- Identify potential break-throughs in terms of who, what, why and when.</td>
</tr>
<tr>
<td></td>
<td>- Identify way to compliment aeronautics industry's efforts without duplication.</td>
<td>- Identify areas of ongoing work and avoid duplication.</td>
</tr>
<tr>
<td></td>
<td>- Increased approval of proposed plans, projects and budgets through liaison with key influential members of the aeronautics industry.</td>
<td>- Effectiveness of transmission of pertinent technical information into the decision support systems of key decision makers.</td>
</tr>
<tr>
<td></td>
<td>- Guidance of Directorate efforts through the development of a current overview of aeronautical industry which is national and international in scope.</td>
<td>- To perceive objectives of key technical decision makers to direct development of Division plans and strategies.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Develop a current overview of the technical aeronautical community which is national and international in scope to guide the Divisions activities.</td>
</tr>
</tbody>
</table>
factors indicate different levels of concentration. There is a "nesting" of the CSFs. The CD's are high level and not restricted to an industry. For the DH, his CSF is primarily keyed to an industry. Finally the DC is concerned mainly with a subset of that industry, the technical community.

As one moves down the management hierarchy the measures become more specific. The DC has an interesting measure, the transmission of pertinent technical information into the decision support systems of key decision makers of the Agency. This demonstrates the "two way street" character is liaison.

5.2.3 Management Responsibility Execution

The new (acting) CD believes that to have an effective organization, the Center must decentralize authority, responsibility and decision making. To effect this decentralization, requires that all managers perform their managerial functions including decision making. The CD also desires to develop a highly competent management staff. This decentralization effort is a part of that management development effort. The CSF encompasses all Center directorates. For this CSF the measures of Table 5.2-3 are very specific.

The DH's factor, Management and Technical Competence, is shown in Table 5.2-3. The management concept of the center relies on having people working multiple assignments in close-knit teams. The technical expertise of many managers, in the Directorate, is often critical in these teams. In this
### Table 5.2-3 COMPARISON OF CSFs AND MEASURES FOR NASA/DFRC CENTER DIRECTOR:

**MANAGEMENT RESPONSIBILITY EXECUTION**

<table>
<thead>
<tr>
<th>CENTER DIRECTOR MANAGEMENT RESPONSIBILITY EXECUTION</th>
<th>DIRECTORATE HEAD &quot;B&quot; MANAGEMENT AND TECHNICAL COMPETENCE</th>
<th>DIVISION CHIEF &quot;B&quot; COMPETENT AND RECOGNIZED STAFF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
</tr>
<tr>
<td>● Decrease in number of minor matters coming to</td>
<td>● Closure of the gap between requisite future skills</td>
<td>● Closure of the gap between requisite future</td>
</tr>
<tr>
<td>Director for resolution.</td>
<td>and current resident skills.</td>
<td>future skills and current resident skills.</td>
</tr>
<tr>
<td>● Increase of decision making on more important</td>
<td>● Ability of staff to exploit unanticipated</td>
<td>- Corrective action on technical obsolescence.</td>
</tr>
<tr>
<td>matters throughout management hierarchy.</td>
<td>opportunities.</td>
<td>- Criteria for new hires.</td>
</tr>
<tr>
<td>● Acceptance of responsibility for discharging</td>
<td>● Improvement of capabilities in unique &quot;areas of</td>
<td>- Career planning and development.</td>
</tr>
<tr>
<td>management functions by all managers, to improve</td>
<td>expertise&quot; with requisite skills to address major</td>
<td></td>
</tr>
<tr>
<td>total operation.</td>
<td>issues of importance to the Agency.</td>
<td></td>
</tr>
<tr>
<td>● Revised performance appraisals to indicate</td>
<td></td>
<td>● Increased Agency and technical community</td>
</tr>
<tr>
<td>accountability for performance relative to</td>
<td></td>
<td>recognition of staff's contributions. Accolades,</td>
</tr>
<tr>
<td>discharge management functions.</td>
<td></td>
<td>awards, and letters of thanks and praise</td>
</tr>
<tr>
<td>● Number of top management interventions required</td>
<td></td>
<td>received from sponsors, clients and the</td>
</tr>
<tr>
<td>because of sponsor and/or client disatisfactions</td>
<td></td>
<td>technical community for recognition of</td>
</tr>
<tr>
<td>resulting from a lack of the discharge of</td>
<td></td>
<td>exemplary work and contributions.</td>
</tr>
<tr>
<td>management responsibilities within the Center.</td>
<td></td>
<td>● Frequency of requests for technical assistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>by the technical aeronautical community.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Impact of Division's contributions on the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agency's plans and programs and upon the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aeronautical Industry.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Increased resources to expand role and improve</td>
</tr>
<tr>
<td></td>
<td></td>
<td>capabilities.</td>
</tr>
</tbody>
</table>

- Corrective action on technical obsolescence.
- Criteria for new hires.
- Career planning and development.
directorate the traditional route into management has been by virtue of technical competence or expertise. New management talent is selected from the technically competent.

Measures for the DH's CSF focus on a different dimension than those of the CD for this CSF. The first measure indicates a concern for the future. The dynamic state of technology, forces the DH to look ahead or suffer consequences in having obsolete technical skills resident in his staff.

Considering the traditional career path into management, the DC's CSF, Competent and Recognized Staff, appears geared to providing new potential managers. This CSF is consistent with the DH's CSF. The measures suggest that the DC welcomes the opportunity to have his division exercise its managerial responsibilities. The corner stone for the performance of this technical division is its competent and recognized staff, without it, the DC is ineffective. Here the measures dovetail the need.

The factors tend to focus or converge upon more specific things as one moves down the management hierarchy. The CD is looking at a general Center staff competence CSF while the DH is looking at the Directorate and the DC is concentrating upon Division staff competence. The measures appear specific and quantifiable for all three management levels.

5.2.4 Staff Commitment to the Organization's Goals

This CSF, shown on Table 5.2-4, deals with the Center's
# Table 5.2-4 COMPARISON OF CSFs AND MEASURES FOR NASA/DFRC CENTER DIRECTOR: STAFF COMMITMENT TO ORGANIZATION'S GOALS

<table>
<thead>
<tr>
<th>CENTER DIRECTOR</th>
<th>DIRECTORATE HEAD &quot;B&quot;</th>
<th>DIVISION CHIEF &quot;B&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STAFF COMMITMENT TO THE ORGANIZATION'S GOALS</strong></td>
<td><strong>ORGANIZATIONAL UNITY</strong></td>
<td><strong>COMMITMENT AND SUPPORT OF STAFF TO DIRECTORATE GOALS</strong></td>
</tr>
<tr>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
</tr>
<tr>
<td><em>Willingness of staff to &quot;pull together&quot; by prioritizing their personal goals consistent with the best interest of the Center's needs.</em></td>
<td><em>Improved intra-Directorate productivity through synergism resulting from cohesive relationships and communications.</em></td>
<td><em>Increased enthusiasm demonstrated by initiative and motivation of staff members, particularly leaders, towards accomplishment of Directorate goals.</em></td>
</tr>
<tr>
<td><em>Commitment and sustained interest of management to motivate their staffs toward the accomplishment of Center's goals.</em></td>
<td><em>Improved project performance resulting from control and accountability.</em></td>
<td><em>Improved cohesiveness of staff and team members to achieve team synergism.</em></td>
</tr>
<tr>
<td><em>Improved productivity of staff through an enthusiastic and cohesive &quot;can do&quot; attitude, commitment to the &quot;team&quot;, and desire to extend self for the job.</em></td>
<td><em>Improved inter-Directorate productivity resulting from cooperation, support and commitment amongst Directorates.</em></td>
<td><em>Increased willingness to set aside self-goals and work for the good of the group.</em></td>
</tr>
<tr>
<td><em>Initiative, responsiveness and effectiveness of the manager's actions and approaches to achieve Center's goals.</em></td>
<td></td>
<td><em>Improved ability to resolve conflicts, compromise and find the win-win position.</em></td>
</tr>
<tr>
<td></td>
<td><em>Less grief through harmony and cohesiveness between Directorates.</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Increased participative joint goal setting amongst Directorates leading to intra-Directorate agreements.</em></td>
<td></td>
</tr>
</tbody>
</table>
staff having a common sense of purpose. The common purpose must be the accomplishment of the Center's goals. The type of work that DFRC does, requires that it perform this work through a number of "closely-knit" teams. Since manpower is a scarce resource to accomplish the work, the Center's management concept emphasizes its reliance on this "close-knit" team concept with people working multiple assignments. Because the "team" is the fundamental unit of operation, it is natural for the CD to consider a CSF related to "team-building".

Measures deal with roughly four dimensions of team building; enthusiasm and cohesiveness, management commitment, communication, and adaptability. These four dimensions appear as a common thread for all the measures shown.

Organizational Unity, the DH's CSF, is directly related to the Director's factor. Team-building is being stressed, by the DH, with intra-Directorate productivity being the synergistic result sought. Control and accountability are seen as measures needed to indicate the attainment of the synergism desired.

The Division Chief's factor, Commitment and Support of Staff to Directorate Goals, is viewed as being congruent with the other two CSFs considered above.

Hierarchical focusing appears related to the "team" size being addressed by the three levels of management. The CSFs focus on the Center team, the Directorate team and the
Division team as one goes down the hierarchy.

5.2.5 **Support of Agency's Objectives and Goals**

Today's tight budget environment and the state of the national economy have resulted in increased scrutiny by the public, Congress and the Executive Branch. NASA must carefully plan its programs to be responsive to the Nation's technological needs. NASA management seeks a highly effective and efficient, highly motivated, cost conscious, credible technical organization. This will require improved responsiveness by the technical staff. Thus, **Support of the Agency's Objectives and Goals** is a CSF for the CD as shown in Table 5.2-5. With this background, this CSF is straightforward. Measures associated with this CSF are rather subjective except for the increased share of Agency's total flight experimentation funds. This last measure is the measure of how well the Center is accomplishing this CSF.

The DH addresses these Agency responsiveness requirements in the **Plans, Objectives and Strategies** CSF. To integrate these considerations into the Center's plans and strategies is very important. The measures indicate this concern for meeting these requirements. These measures also address the purpose of the Center.

**Long Range Plans and Strategies**, for the Division Chief, are required as he is one of many responsible for the intra-Center implementation and execution of the planned approaches.
### Table 5.2-5 COMPARISON OF CSFs AND MEASURES FOR NASA/DFRC CENTER DIRECTOR:
SUPPORT OF AGENCY'S OBJECTIVES AND GOALS

<table>
<thead>
<tr>
<th>CENTER DIRECTOR SUPPORT OF AGENCY'S OBJECTIVES AND GOALS</th>
<th>DIRECTORATE HEAD &quot;B&quot; PLANS, OBJECTIVES AND STRATEGIES</th>
<th>DIVISION CHIEF &quot;B&quot; LONG RANGE PLANS AND STRATEGIES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
</tr>
<tr>
<td>• Changes in the way Center addresses and supports Agency's current and future flight experimentation objectives.</td>
<td>• Clarification of objectives and goals for improved management orientation and focusing on right set of key decisions.</td>
<td>• Clarification of objectives and goals for improved management orientation and focusing on right set of key decisions.</td>
</tr>
<tr>
<td>• Increased staff's objective acceptance of Agency's requests with genuine concern for commendable performance in satisfying these requests.</td>
<td>• Endorsement and support by Agency of Center's long range plan objectives.</td>
<td>• Endorsement and support by Agency of Center's long range plan objectives.</td>
</tr>
<tr>
<td>• Frequency of staff initiatives to accomplish Agency's flight experimentation objectives resulting in increased flight testing at Center.</td>
<td>• Develop and improve procedures and criteria for individual project evaluation and selection consonance with Agency needs.</td>
<td>• Develop and improve procedures and criteria for individual project evaluation and selection consonance with Agency needs.</td>
</tr>
<tr>
<td>• Increased Center's share (%) of Agency's total flight experimentation funds.</td>
<td>• Increased planning and strategy coordination between Centers and Headquarters for developing integrated Agency plans to attain synergism through effective and efficient joint inter-Center programs.</td>
<td>• Increased planning and strategy coordination between Centers and Headquarters for developing integrated Agency plans to attain synergism through effective and efficient joint inter-Center programs.</td>
</tr>
</tbody>
</table>
Careful attention is required to integrate the Division's capabilities, obligations and long lead time requirements with new changes in direction or emphasis of work for the Agency.

The CD's concern is to achieve responsiveness to NASA high priority needs and support other centers on flight programs. Development of plans and strategies for achieving this goal is the concern of the DH. Implementation and results achievement as a part of intra-Center effort falls on the DC shoulders. This requires very careful planning on the part of the Division Chief to adapt to the evolving needs of the Agency.

5.2.6 Recognition as a National Center for Flight Experimentation

Current external environment considerations have caused the new CD to carefully appraise the purpose of the organization to align it with the high priority needs of the Agency. He feels that the Center should concentrate its efforts in those areas where the strong internal capabilities match the needs of the Agency. The Center should find and secure its unique "niche" within the Agency. This CSF, shown on Table 5.2-6, is intended by the CD to be a statement of the purpose of the Center and its "niche" within the Agency. Measures which indicate that DFRC is establishing itself in the desired "niche" are suggested.
<table>
<thead>
<tr>
<th>CENTER DIRECTOR</th>
<th>DIRECTORATE HEAD &quot;B&quot;</th>
<th>DIVISION CHIEF &quot;E&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECOGNITION AS A NATIONAL CENTER FOR FLIGHT EXPERIMENTATION</td>
<td>ASSURANCE OF SAFETY IN FLIGHT EXPERIMENTATION</td>
<td>PRODUCT RESPONSIVENESS ON CRITICAL PROJECTS</td>
</tr>
<tr>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
</tr>
<tr>
<td>● Frequency of requests seeking expertise on flight experimentation techniques, problems and/or support.</td>
<td>● Reduced accidents and incidents through improved risk assessments and precautions recommendations.</td>
<td>● Increased responsibility on those projects which the Agency addresses major national issues and/or needs. Be &quot;on target&quot;.</td>
</tr>
<tr>
<td>● Number of special requests to provide technical expertise to Headquarters and other Centers.</td>
<td>● Continued safety of operation.</td>
<td>● Challenge to and stimulation of staff.</td>
</tr>
<tr>
<td>● Impact of contributions on aeronautical industry.</td>
<td>● Safety, accident, and incident reports.</td>
<td>● Capability development for the future.</td>
</tr>
<tr>
<td>● Increased funding to improve capabilities and services.</td>
<td>● Severity rate statistics, injury records, accident classification reports, and injury reports.</td>
<td>● Visibility and &quot;can do&quot; image building.</td>
</tr>
<tr>
<td>● Public and media perceptions of Center's mission, image, contributions and competence. Frequency, tone and accuracy of media references (newspapers, magazines, TV, radio, films and NASA materials).</td>
<td>● Safety investigations finding's reports.</td>
<td>● Known applications and needs for work products.</td>
</tr>
<tr>
<td></td>
<td>● Detailed test planning and test plan reviews for safety, safety awareness, concern for hazards and safety conscious attitude.</td>
<td>● Improved visibility of contributions to project success.</td>
</tr>
<tr>
<td></td>
<td>● Pilot simulation rehearsals.</td>
<td>● Consistency of resource allocations in proportion to task importance and/or priority.</td>
</tr>
<tr>
<td></td>
<td>● Quality control, maintenance, reliability and environmental test reports.</td>
<td></td>
</tr>
</tbody>
</table>
Natural facilities due to geographical location plus other facilities such as dedicated restricted airspace and a specially designated 200 mile supersonic corridor are factors in establishing DFRC's niche. However, a key ingredient toward establishing DFRC as a National Center for Flight Experimentation is safety. Safety of operation plus the natural facilities plus having a competent staff are the major ingredients in the formula for success.

Of the DH's CSFs, Assurance of Safety in Flight Experimentation was indicated as being his highest priority CSF. Safety is recognized by the DH as being vital to the recognition desired. His attention to safety is reflected in the suggested measure list.

Product Responsiveness on Critical Projects, the DC's factor, addresses his part in the competent staff element in the above mentioned success formula. Participation in critical projects, with DFRC successfully performing its responsibilities, increases NASA's confidence in DFRC abilities to function as a National Center and improves the credibility of DFRC. This participation can favorably impact the Division's staff. Improved motivation, visibility, image and competence can be favorably affected as shown by the measures.

With this CSF the CD is attempting to enhance DFRC's credibility in the Agency. The DH is directly working a key element in the formula for successfully establishing the
Center's "niche" and reputation. The DC is working another key element by performing work on critical projects for the Agency.

5.2.7 Accountability and Resource Control

Accountability in a Government R&D Center is perhaps, the most elusive of all management control problems. Good accountability improves control and causes the organization to function in a more responsive manner. Accurate and timely knowledge about the status of the R&D Center's resources is a vital element in the decision making process. Essentially all decisions the CD makes are linked to resources in some manner, thus the CD's CSF is Accountability and Resource Control.

Measures of this CSF, as shown in Table 5.2-7, are generally associated with negative results. That is, if there is not accountability and resource control then Center performance and productivity will not be good.

At the Directorate level, the CSF is Project Resource Control. The accountability aspect is implied as shown by the stewardship concept in the first measure. Control over usage and allocation of resources is important because of the desire to achieve effectiveness and efficiency on the many ongoing projects. The Directorate management seeks this control and accountability to be able to respond intelligently to the many demands made for resources by the different sponsors and clients.
### Table 5.2-7 COMPARISON OF CSFs AND MEASURES FOR NASA/DFRC CENTER DIRECTOR: ACCOUNTABILITY AND RESOURCE CONTROL

<table>
<thead>
<tr>
<th>CENTER DIRECTOR</th>
<th>DIRECTORATE HEAD &quot;B&quot;</th>
<th>DIVISION CHIEF &quot;B&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACCOUNTABILITY AND RESOURCE CONTROL</strong></td>
<td><strong>PROJECT RESOURCE CONTROL</strong></td>
<td><strong>MEASURES</strong></td>
</tr>
<tr>
<td><strong>MEASURES</strong></td>
<td><strong>MEASURES</strong></td>
<td>Critical Success Factors and measurements are not specifically identified but are included in other CSFs.</td>
</tr>
<tr>
<td>• Improved and timely resources tracking to surface latent problems by management information system.</td>
<td>• Increased effective utilization of resources each manager has stewardship over, for the attainment of objectives and goals.</td>
<td></td>
</tr>
<tr>
<td>• Frequency of milestones missed and accompanying management action to improve future performance. Improved control and accountability solution to minimize milestone slippages.</td>
<td>• Improved and timely resource tracking by managers to surface latent problems.</td>
<td></td>
</tr>
<tr>
<td>• Effective and efficient utilization of Agency resources, in delivery of satisfactory work products within negotiated resources and schedule.</td>
<td>• Frequency of missed milestones because of lack of information to exercise proper management controls.</td>
<td></td>
</tr>
<tr>
<td>• Sponsor and client feedback and attitudes regarding performance obligations on projects. Amount of senior management time required to correct problems regarding project performance.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A specific CSF for resource control was not expressly identified by the Division Chief. This does not mean that the DC forgets about resource control. It is important to note that resource control is an intrinsic dimension of the DC's CSFs **Performance and Technical Quality**, **Commitment and Support to Directorate Goals**, and **Product Responsiveness on Critical Projects**.

**Accountability and Resource Control**, as viewed by the CD, provides an accurate status of Center resources which is an important ingredient in Center decision making and accountability to the Agency. The DH is obligated to advise and recommend to the CD on the control and status of project and Directorate resources. Finally, the DC uses these resources in performing work. Productivity and technical performance are the areas where the DC mainly exercises resource control.
6. COMPARISONS AND DISCUSSIONS

The findings of the interviews with the management staffs of the two Government R&D centers, DOT/TSC and NASA/DFRC, were presented in Section 5. Critical success factors and measures were presented to illustrate the hierarchical relationships which were observed at different levels in the organization. We showed such a relationship for a single vertical profile in each organization by comparing the CSFs and measures of the Center Director, Office Director (or Directorate Head), and Division Chief. In Section 6 we make a comparison of the CSFs between the Center Directors of the two Government R&D Centers.

6.1 Comparison of CSFs for the Two Center Directors

Although the missions for DOT/TSC and NASA/DFRC are widely differing, both Centers perform advanced R&D responsive to sponsor needs and support (funding); therefore, a comparison of the Center Director's CSFs for the two Government R&D Centers is valid and is shown in Table 6.1. For reasons explained in Section 5, the CSFs of Table 6.1 are not listed in any priority.

Table 6.1 was constructed by matching the CSFs for the two CDs on the basis of the measures for each CSF. It may be noted that there are semantic differences between corresponding CSFs, but these differences stem from specific statements of objectives, and the perception of each CD of his own
Table 6.1 COMPARISON OF CENTER DIRECTORS' CSFs FOR TWO GOVERNMENT R&D CENTERS

<table>
<thead>
<tr>
<th>DOT/TSC</th>
<th>NASA/DFRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>• RECOGNITION AS THE NATIONAL CENTER FOR</td>
<td>• RECOGNITION AS A NATIONAL CENTER FOR</td>
</tr>
<tr>
<td>TRANSPORTATION R&amp;D</td>
<td>FLIGHT EXPERIMENTATION</td>
</tr>
<tr>
<td>• CREDIBILITY WITHIN USER AND TECHNICAL</td>
<td>• LIAISON WITH KEY DECISION MAKERS</td>
</tr>
<tr>
<td>TRANSPORTATION COMMUNITY</td>
<td>• SUPPORT OF AGENCIES OBJECTIVES AND GOALS</td>
</tr>
<tr>
<td>• PLANNING AND DEVELOPMENT OF MULTI-MODAL</td>
<td>• CENTER PRODUCTIVITY</td>
</tr>
<tr>
<td>PROGRAMS</td>
<td>• ACCOUNTABILITY AND RESOURCE CONTROL</td>
</tr>
<tr>
<td>• BLEND OF HIGH PRIORITY, MAJOR ISSUE</td>
<td>• STAFF COMMITMENT TO THE ORGANIZATION'S GOALS</td>
</tr>
<tr>
<td>PROGRAMS</td>
<td>• MANAGEMENT RESPONSIBILITY EXECUTION</td>
</tr>
<tr>
<td>• RESPONSIVENESS AND PRODUCTIVITY</td>
<td></td>
</tr>
<tr>
<td>• PROGRAM MANAGEMENT EFFECTIVENESS</td>
<td></td>
</tr>
<tr>
<td>• ORGANIZATION'S SENSE OF COMMON PURPOSE</td>
<td></td>
</tr>
<tr>
<td>• CRITICAL AREAS OF EXPERTISE AND SKILL</td>
<td></td>
</tr>
<tr>
<td>BUILD-UP</td>
<td></td>
</tr>
</tbody>
</table>

Note: Table is not a priority listing of CSFs
CSFs which were brought out during the interviews.

The CDs of both Centers expressed strong allegiance to the objectives of their respective Headquarters. Both CDs made the assertion that recognition directly benefits from their professional staff's expertise, contribution of knowledge, and ability to significantly impact the high priority technical programs of the Agency or the Department. The professional staff of each Center values the importance, as perceived by project supporters and peers, of the recognition of their Center's mission and role. The CDs appreciate, however, that the recognition and credibility that really counts is with Agency or Department Officials who control Center assignments, programs and resources. Both CDs are striving to improve their Centers' recognition by directing staff efforts to address problems and achieve accomplishments that best satisfy needs of their Agency or Department.

Long range planning, program development and effective liaison with key decision makers to assure responsiveness to Headquarters, was a common CSF. The CD of DOT/TSC has multi-modal objectives in performing work for the Department. The CD of DFRC seeks to have the Center assume more of the flight experimentation responsibilities for other NASA Centers (Langley, Ames and Lewis). To accomplish this is going to require active program development on the part of the CD of NASA/DFRC, but, he appeared to have support from Headquarters to establish DFRC as THE NASA Flight Experimentation Center.
Both CDs feel that long range plans, responsive to Headquarters, well coordinated with their support bases, and, proactive with regard to each Center's charter and mission are important to future success. Entrepreneurial program development by the sensor management staff, coordinated with the Center's long range plan, is being emphasized so that both Centers are more responsive to the projected high priority needs of their respective Headquarters.

The two CDs emphasized the need for improving the accomplishments of the Centers' on-going work. The CD of DOT/TSC was interested in performing more high priority, major issue, multi-modal work responsive to the Department. The CD of NASA/DFRC wanted his staff to be more involved in flight test programs of importance to NASA Headquarters and to seek work that was directed to specific flight experimentation goals rather than being open-ended research. In this regard, flight testing in support of other NASA Centers and the accomplishment of the Center's on-going flight experimentation programs are crucial to DFRC's long range success.

Productivity was a CSF both CDs were interested in improving. Each measured productivity by the increase in high priority programs that the Centers were performing satisfactorily. Personnel ceilings were a constraint in both Centers and, therefore, taking on more high priority work, (without compromising quality) could be accomplished by loading up the staff, eliminating low priority work, and
possibly contracting out work which industry could perform more effectively, and, which did not require in-house expertise to perform.

Program management effectiveness, accountability, and resource control are CSFs common to the two CDs. At DOT/TSC an effective project cost summary MIS was in operation while a similar system at NASA/DFRC was being set up to replace the manual system in use. "Surprises" on project problems were identified by each CD as reminders of the improvements needed for communications and accountability.

Cohesive organizations, with everyone pulling together, was cited by both CDs as being important. In each organization, the CD was trying to create an esprit de corps in which teamwork would result from long range plans, participation of staff in coordinating their programs, and from management executing their responsibilities.

The only CSF that appears to stand alone is the skill build-up CSF for the CD of DOT/TSC. The CD of NASA/DFRC is concerned about management skills and technical skill broadening within the specific lines of on-going technical responsibility. The CD of DOT/TSC wants to develop new "areas of expertise". In a civil service organization, with Headquarter's imposed personnel ceilings, development of new critical skills must be carefully managed. Extensive re-training of in-house staff cannot be counted upon to develop all the desired skills and competence. The CD of DOT/TSC views
attraction of experts from the technical transportation community as one of the important CSF measures for upgrading the on-board staff. In addition, DOT/TSC is organizationally aligned and structured to support many sponsors. As a result this tends to spread staff expertise and competence somewhat thin amongst the sponsors. Managers at NASA/DFRC did not express as much concern as their counterparts in DOT/TSC for broadening their technical skill categories.

In concluding the comparison, we note the existence of similarities of CSFs and measures for the R&D Centers despite the semantic discrepancies in terminology. The basic charters of the two R&D Centers are widely different, but, we observe that the two Center Directors have closely paralleled CSFs. Differences in CSF measure quantities and information requirements relate to the differences in how each R&D Center functions within its overall Agency or Department. Organizational maturity relative to mission are also reasons for distinctions.

6.2 An "Industry Set" of CSFs

In this section we present a summary of the CSFs for the two Government R&D Centers in terms of an "industry set". The industry set is presented as a list of generic CSFs which were distilled in the analysis of the volume of interview data acquired from the managements of the two Centers. The list is shown in Table 6.2. We refer to the CSFs in this
TABLE 6.2 AN "INDUSTRY SET" OF CSFs FOR TWO GOVERNMENT R&D CENTERS

PURPOSE AND DIRECTION

- Mission and Role
- Liaison and Recognition
- Objectives Goals and Plans
- Program Selection and Diversification

RESOURCES AND PRODUCTIVITY

- Budget Justification
- Resource Appropriations
- Resource Utilization Efficiency
- Productivity

PRODUCT EFFECTIVENESS AND VALUE

- Product Responsiveness
- Product Utility and Applications
- Technical Quality and Excellence
- Product Dissemination and Reputation

CONTROL AND ACCOUNTABILITY

- Project Management and Control
- Management Responsibility
- Communications and Commitment
- Personnel Evaluations

ORGANIZATIONAL UNITY

- Authority Relations
- Team Cohesiveness
- Health and Morale
- Safety

HUMAN RESOURCE DEVELOPMENT

- Staff Competence
- Skill Needs Planning
- Recruitment and Recruitment
- Individual Career Planning
list as generic in the sense that we have used precise terminology for each CSF. The terminology focuses more on the meaning of the basic words for the CSF rather than on semantics, a problem which we encountered in analyzing and grouping the CSF data. An example of the use of generic CSFs is the factor Mission and Role which is our generic for the actual CD's CSF, "Recognition as the National Center --- etc.". Similarly, Program Selection is a generic CSF for the actual CSF "Blend of High Priority --- etc.". Since we interviewed only two Government R&D Centers we cannot say with confidence that the industry set CSF list is complete; however, the list does represent the results of the interviews. It is possible to identify each CSF, that was discussed in the interviews, with a generic CSF in Table 6.2. The list also has some intuitive appeal when thinking about management concerns in Government R&D Centers.

The CSFs in Table 6.2 are collected into six groups. Each group has a major heading, which we identify as the "critical areas" of concern for Government R&D Centers. The six critical areas are:

- PURPOSE AND DIRECTION
- RESOURCES AND PRODUCTIVITY
- PRODUCT EFFECTIVENESS AND VALUE
- CONTROL AND ACCOUNTABILITY
- ORGANIZATIONAL UNITY
- HUMAN RESOURCE DEVELOPMENT
Each critical area is comprised of an interrelated group of critical success factors. Figure 6.1 depicts the six critical areas with the lists of associated CSFs. We have arrayed the critical areas around a nucleus, or center focus, which we represent on Figure 6.1 as Organizational Effectiveness and Success. All critical success factors impact organization effectiveness and success to give the R&D Center a favorable image. Management can control some dimension associated with each critical area to improve organization effectiveness. However, management is not able to manipulate organization effectiveness, since this is not amenable to direct control, but, rather, is a dependent consequence of success in the critical dimensions of the organization embodied in the critical success factors. The critical areas can be controlled by management given the proper amount of information and insight of what must be changed to affect certain performance dimensions. The concept of management control by critical success factors is postulated on this precept.

In showing the critical success factors as we have in Figure 6.1, we also show some interrelationships among the critical areas. Although we have tried to identify each critical area as being mutually exclusive, in reality, they are not. There are certain measures common to two or more critical areas and CSFs. For example, communications in the organization affects the critical success factor Control and
Figure 6.1 - CRITICAL SUCCESS FACTORS FOR GOVERNMENT R&D CENTERS
Accountability, but it also impacts Human Resource Development.

Other interplay is implied by the interconnections between each critical area in Figure 6.1. We have attempted to juxtapose critical areas in accordance with dependent relationships among critical success factors. If we start with mission direction, the goal is to achieve endorsement and funding of plans. Approval of the plans affects resources for programs. Productivity of the Center culminates in effective and valuable products. Certain controls must be exerted and staff held accountable to produce effective products consistent with efficient utilization of the resources available. Organizational unity is essential for teamwork, high morale of the staff and cohesive productivity. The human resources actually perform the control function and produce the product. The organization staff receives its directions from the objectives and plans which are prepared in accordance with the mission statements sanctioned by the Agency or Department Headquarters and sponsor staff. We thus have gone full circle to illustrate the importance of interplay among the critical areas and CSFs.

6.3 Profile Matrix of CSFs

In Table 6.2 and Figure 6.1 we list 6 critical areas and 24 (generic) critical success factors which were identified in the course of the interviews. In Table 6.3 we present a
<table>
<thead>
<tr>
<th>CRITICAL AREAS</th>
<th>CRITICAL SUCCESS FACTORS</th>
<th>DOT/TSC</th>
<th>NASA/DFRC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PURPOSE AND DIRECTION</strong></td>
<td>- Mission &amp; Role</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Liaison &amp; Recognitions</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Objectives, Goals &amp; Plans</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Prog. Select. &amp; Diversification</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>RESOURCES AND PRODUCTIVITY</strong></td>
<td>- Budget Justification</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- Resource Appropriations</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Resource Utilization Efficiency</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Productivity</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>PRODUCT EFFECTIVENESS AND VALUE</strong></td>
<td>- Product Responsiveness</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Product Utility &amp; Application</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Technical Quality &amp; Excellence</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Prod. Dissemination &amp; Reputation</td>
<td>X</td>
<td>1</td>
</tr>
<tr>
<td><strong>CONTROL AND ACCOUNTABILITY</strong></td>
<td>- Project Management &amp; Control</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Management Responsibility</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- Communications &amp; Commitment</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Personnel Eval. &amp; Incentives</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>ORGANIZATIONAL UNITY</strong></td>
<td>- Authority Relations</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Team Cohesiveness</td>
<td>X</td>
<td>X</td>
</tr>
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<td></td>
<td>- Health and Morale</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Safety</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>HUMAN RESOURCE DEVELOPMENT</strong></td>
<td>- Staff Competence</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>- Skill Needs Planning</td>
<td>X</td>
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<td></td>
<td>- Recruitment/Recruitment</td>
<td>X</td>
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</tr>
<tr>
<td></td>
<td>- Individual Career Planning</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

*Note: CSFs were discussed in Section 5.*
profile matrix comparing the industry set of CSFs for the
management staffs at DOT/TSC and NASA/DFRC. In this matrix
we also show CSFs for the two R&D Centers which were iden-
tified for the Headquarters (HQ) level. These CSFs represent
an aggregate of HQ CSFs since we interviewed two HQ officials
of DOT and three HQ officials of NASA. Table 6.3 also shows
CSFs for the two CDs, three ODs, three DCs of TSC, and
three DHs and three DCs of DFRC. This is still only a par-
tial representation of the interviews conducted. It is pos-
sible, however, to deal only with seven from each organiza-
tion to enable the comparisons to be made below. Included in
the profile matrix are the management staff members OD "A",
DC "A", DH "B", and DC "B" for which detailed discussions
were presented in Section 5.

The profile matrix of Table 6.3 identifies by an "X" the
CSF of primary importance to each management level. In
checking off the CSFs, we limited our choice to seven CSFs for
each staff member. The two exceptions are where we list eight
for the DOT Headquarters Officials, and the CD of DOT/TSC, since
we had eight CSFs identified in the findings of Section 5.
The method of identifying the most important CSFs is our best
estimate from interpretations of the raw interview tape
recordings.

Two columns of Table 6.3 are marked as #X's. These
columns identify the number of times a CSF was checked off by
the management staffs for the respective organizations, e.g.,
Objectives, Goals and Plans was checked off 5 times for DOT/TSC and 7 times for NASA/DFRC.

The management staffs of the two R&D Centers identified many CSFs in the critical area PURPOSE AND DIRECTION. Both management staffs feel that purpose and direction must be defined at all levels to assure success.

The dominant critical area for DOT/TSC is PRODUCT EFFECTIVENESS AND VALUE. The management of TSC feels that it is crucial that the work it performs result in products having value to the Department, and, are effective in solving pressing transportation problems.

The critical area CONTROL AND ACCOUNTABILITY is important to the management of NASA/DFRC. This relates to the concern of the Center management for controlling resources and assuring that the technical staff delivers the agreed-to technical product. It also relates to the Center management's desire to support other NASA flight experimentation programs for other NASA Centers.

The critical success factors of Table 6.3 are customized to individuals in accordance with situation, environment, responsibility and immediate concerns. As discussed in earlier sections, CSFs are expected to be temporal for individuals. Therefore, a fairly large spread spans the list of Table 6.3. Nevertheless, some interesting groupings are prevalent. The most popular CSF for both Centers is Objectives, Goals and Plans with 5 management staff members and 7
from DOT/TSC and NASA/DFRC, respectively, identifying this CSF. A closely related CSF is **Program Selection and Diversification**. The management staff members identified either one or the other of these CSFs. The implication is that the management of R&D Centers feels that goal orientation is important. Top management levels feel that long range planning is key while the middle level managers need targets to motivate the technical work force.

A CSF common to several of the management staff members of DOT/TSC is **Product Utility and Applications**. This CSF relates to the requirement to achieve credibility with the user transportation community. In order to maintain credibility the Center's work product should have value, be acceptable and demonstrate cost/benefit advantages.

Closely related to product utility is **Product Responsiveness**. The management staff at NASA/DFRC and DOT/TSC consider that responsiveness to the program and sponsor's objectives is important. The concern of management is to assure that the technical staff keep in mind the requirements of "customer satisfaction".

**Staff Competence** and **Technical Quality and Excellence** were popular CSFs. Because DOT/TSC is growing and in a "proving itself" state, technical quality was identified. Technical quality at NASA/DFRC was assumed to be a "given" by the staff. Most of the NASA/DFRC managers felt a more pressing need for improving management skills and competence.
without sacrificing technical quality. Technical quality of work output is satisfactory and therefore was not a dominant CSF at the time of the interviews at NASA/DFRC. Both R&D Centers were concerned about maintaining staff competence. DOT/TSC management identified Skill Needs Planning because of its diversified mission and need to develop new areas of expertise.

Comparisons of the CSFs in Table 6.3 reveal another interesting fact. There is consistency among the management staff CSFs of each R&D Center. If top management identifies a CSF in a certain critical area, the middle level of management, in general, was found to identify a closely related CSF. This may be a direct benefit of goal congruence in the organization. Goal congruence is also confirmed by the findings presented in Section 5 in which it was shown that the CSFs and the corresponding measures for the various levels of management were hierarchically related. Thus the consistency of observations of Table 6.3 appear to support this hypothesis.
7. SUMMARY AND CONCLUSIONS

This thesis has examined two Government R&D Centers, DOT/TSC and NASA/DFRC, with the objective of identifying critical success factors (CSF) and measures for three levels of management at each Center. Thirty-nine interviews were conducted to obtain the critical success factor data for the two Centers. Conclusions about critical success factors in Government R&D Centers can be drawn. These conclusions are:

- CSFs are identifiable for managers in Government R&D Centers
  - 8 CSFs for Center Director of DOT/TSC
  - 7 CSFs for Center Director of NASA/DFRC
- CSFs in an organization are manager-specific
  - depends on individual goals
  - temporal and situationally dependent
  - function of R&D environment dynamics
- Hierarchical alignment or "nesting" was observed for CSFs and measures for a given chain of command
  - supports Anthony Planning - Control framework
  - confirms similar observations by Rockart
  - CSF congruence related to clarity of organization's goals.
- Correlation was observed between Center Director's (CD) CSFs and measures for DOT/TSC and NASA/DFRC.
More similarities than differences in CSFs were observed for corresponding management levels of the two R&D Centers. This validates the industry set of CSFs and reflects shared concerns of R&D Managers in the Government.

In expanding the above conclusions it should be noted that the CD of each Center identified information which was used to monitor on-going operations and performance. This information forms the basis of the measures associated with each CSF. In several instances in this thesis, latent measurable quantities, not currently in use by the CD, were identified for the CSFs. The CSFs enable a definition of information for the CD as well as other levels of management for each organization. The presentation of the CSF and measures provides an attention focus on data which might otherwise not be collected or observed, but which is significant for monitoring performance and assuring management control.

CSFs and measures were obtained at three levels of management in each Center. The CSFs were found to be unique to the individuals interviewed which confirms Rockart's observation that CSFs are manager-specific and closely related to specific goals. Most managers felt that the CSFs were also situationally dependent upon existing environmental influences. Thus, relative importance among a list of CSFs is temporal for most managers. This prioritization was
emphasized by several managers in the interviews. In fact some CSFs were not mentioned in some of the interviews (e.g. budget justifications, resource allocations or even technical quality of work) owing to the fact that things were going well enough for the managers to not have to worry about these areas. The fact that CSFs and measures change for a given manager suggests, as Rockart has pointed out, that the information systems in an organization should be adaptable and should accommodate changes in the organization's strategy, environment, or organizational structure.

Hierarchical relationships among CSFs and measures were identified and a "nesting" of CSFs was observed for a vertical profile in each of the R&D Centers. The three-management-level hierarchical relationship was manifested by the fact that the CSFs were closely aligned for the various tiers in a chain of command. The information measures become more focused at successively lower levels in the R&D Centers. The CD's measures for CSFs are based on non-quantifiable information or observations. Data for the middle level of management was more specific in nature and for many measures, was available from the existing management information systems.

The hierarchical alignment of CSFs appears to provide
a basis for judging the commitment of a management staff and for establishing accountability relative to the CD's objectives. It is believed that CSFs could provide a performance evaluation yardstick for the management staffs of Government R&D Centers. CSFs provide a tool for the CD to measure the performance of his middle-level management staff against specific goals established for the organization. The CSFs may be used to replace the traditional yardstick for performance evaluation in the Government. An application for CSFs may be in a management-by-objectives performance evaluation process.

An "industry set" of CSFs was identified in this thesis. The industry set of CSFs is common to the two R&D Centers and is clustered into six interrelated critical areas: (1) Purpose and Direction, (2) Resources and Productivity, (3) Product Effectiveness and Value, (4) Control and Accountability, (5) Organizational Unity, and (6) Human Resource Development. A total of twenty four CSFs were grouped into the critical areas. The CSFs, organized in this manner, enabled a comparison between the two R&D Centers on the basis of descriptive factors which avoided semantic differences.

Many CSF similarities were observed between the two R&D Centers. On the basis of the CSFs, both management
staffs were objective and goal oriented. Both organizations had CSFs related to long range plans and strategies for strengthening their responsibilities and improving recognition (by Washington Officials) of their roles as R&D Centers. NASA/DFRC was interested in improving its internal management effectiveness and therefore regarded control and accountability as a critical area. DOT/TSC was interested in establishing itself within the technical-transportation community and considered product effectiveness and value as a critical area.

Recapitulating the background discussion of Section 2, in context with the findings and summaries of Section 5 and 6, the benefits of CSFs in an organization accomplish the following:

- Focuses management's attention.
- Provides measures of performance.
- Insures that critical areas will receive conscious and timely management attention.
- Facilitates planning process and control process.
- Defines both important and unimportant information.
- Moves the organization away from unnecessary reporting and data collection. Potential for optimum paperwork level.
In conclusion, the concept of critical success factors does appear to be applicable to Government R&D Centers. Government managers, however, are not accustomed to thinking in terms of CSFs. A possible explanation for this is that accountability is more difficult to establish in the Government compared to industry. Industry has specific profit/loss dimensions to focus upon. Politics, longevity of top-level executive assignments, diffusion of decision-making responsibility, civil service protection of employees, and absence of reward and punishment leverage are a few reasons why it is difficult in the Government to define specific measures of performance and hold staff accountable to them. As summarized above, CSFs may provide the needed focus if measures can be well defined; however, it became apparent during the research on this thesis that some managers in the government do not think in terms of specific CSFs, and resist doing so for whatever reasons they may have. Some managers felt that the concept of CSFs may be useful to them while others remained indifferent.

A final observation is that goals are easy to formulate by managers. Whether or not they are meaningful and form the basis of accountability is another matter. The real challenge for the manager is to identify measures of goal accomplishment for his staff. Accountability for goal achievement can then be established by evaluating performance.
against the measures of goal accomplishment. The concept of critical success factors is predicated on this statement.
8. RECOMMENDATIONS FOR FURTHER STUDY

The research on critical success factors is being investigated by Dr. John Rockart of MIT. The concept is relatively new and has not yet been adapted on a widescale by managers; therefore, almost any work done in the area of CSFs amounts to original research, as in this thesis. There is not much information on the subject in the open literature, nor, have there been many research studies other than those reported on in Section 2. Recommendations for further work are made below:

- A broader data base could be obtained for Government R&D Centers. It is recommended that more Centers be interviewed and that other vertical profiles be studied. In addition, comparisons of inter-organization units could be made in studies of horizontal profiles. More work is needed to corroborate the industry set of CSFs for Government R&D Centers.

- It is postulated that the concept of critical success factors may be integrated with behavioral science studies to establish a performance evaluation concept. This may be related to management-by-objectives, or, to coin a new phrase "management-by-CSFs".

- More specific information and measures, in addition to the findings in this thesis, could be obtained for the two Government R&D Centers studied. The work in this
thesis should provide a starting point for research that should "bore-in" on hard measureables.

- Additional data should be obtained for other industries. It is recommended that interviews be directed along a specific organizational chain of command, defined beforehand, to better study the hierarchical focusing effects. The interviews should be carefully structured by a list of questions to be answered by all interviewees. Before the interview starts, the manager should write his goals down on paper so that the interview can focus on these goals. The manager should be asked to define how he will measure performance against such goals. Interview experience gained on this thesis indicated, in general, that better results were obtained when the managers did prepare themselves for the interview by defining their goals and measures beforehand.
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Section 2.
2.4 Dougherty, op. cit., p. 1.
2.5 O'Reilly, op. cit., p. 7.
2.6 "Corporate 'war rooms' plug into the computer", Business Week, August 23, 1976, p. 65.
2.7 David T. Carroll, "How the President Satisfies his Information Systems Requirements", Society for Management Information Systems Proceedings,
2.8 List taken for Exhibit 1 from Daniel T. Carroll, "How the President Satisfies his Information Requirements", op. cit., p. 14.
2.12 Daniel, op. cit., p. 111.
2.15 Anthony et al., op. cit., p. 148
Section 2.
2.16 Ibid, p.

Section 4.
APPENDIX A*

The CSF Approach in Use

An example of the use of the CSF approach is presented. The President interviewed is Larry Gould, Ph.D., President of Microwave Associates - a $60 million sales firm serving several aspects of the microwave communication industry. When he first looked carefully at the "information" he was receiving, Dr. Gould found that some 97 "reports" crossed his desk in a typical month. Almost all were originally designed by someone else - someone who felt that he "should be receiving this vital data."

However, almost all of the reports provided him with nothing he could use. A few gave him some "scorekeeping data", such as the monthly profit statement. One or two other reports provided him with bits and pieces of data he wanted, but, of these, all, exasperatingly, left major things unsaid. The data was either unrelated to other key facts or related in a way that was not meaningful to him.

The concept of "critical success factors" sounded to him like one way out of this dilemma. He therefore invested two

*The material in this appendix is the verbatim continuation of the draft report referenced in Section 2, entitled, "A New Approach to Defining the Chief Executive's Information Needs", April 5, 1978, by John F. Rockart of the Center for Information Systems Research, MIT.
two-and-a-half hour periods of working through his goals, critical success factors, and measures. First, he noted the objectives of the company and the current year's goals. These objectives were worked up without numerical targets. Then he went to work to assess what factors were critical in accomplishing these objectives.

There were seven CSFs developed. Two or three prime measures are also shown for each factor (although some additional measures were also developed). It should be noted that this particular set of factors emerged only after intensive analysis and discussion. At the end of the first meeting, nine factors were on the list. By the end of the second meeting, two had been combined into one, and one had been dropped as not being significant enough to command on-going close attention.

It was around the measures for each factor that most discussion took place. Where "hard" data was perceived to be available the discussion was short. Where "softer" measures were necessary, however, lengthy discussions of the type of data needed and the difficulty and/or cost of acquiring it often ensued. Yet convergence on the required "evidence" as to the state of each CSF occurred with reasonable speed and clarity in each case. Some discussion concerning each CSF and its measures is perhaps worthwhile.
Image in Financial Markets

The company is growing and making acquisitions as it seeks to dominate a growth segment of the electronics industry. Much of the company's growth is coming from acquisitions. Clearly, the better the image on Wall Street, the higher the PER. The measure of success here is clear - the company's multiple vis-a-vis others in its industry segment.

Technological Reputation with Customers

Although it has some standard projects, the majority of the work done by Microwave Associates is on a tailored job, one-shot basis. A significant number of these jobs are state-of-the-art- work which leads to follow-on production contracts. To a very large extent, buying decisions in the field are made on the customer's confidence that Microwave can deliver technologically. Its customers' perception of Microwave's technical ability is all-important.

Seven measures were developed for this CSF. The two values are at the opposite extremes of hard-soft-data. Total orders/total bids can be easily measured. This measure is indicative of customers' perception of Microwave's technical ability - but also has other factors - such as "sales aggressiveness" confounded in it.
The most direct measure possible is person-person interviews. Although this measure was seen to be "soft", it was felt to be the best way for the president to understand this most critical CSF. It was decided to initiate a measuring process through field interviews by the company's top executives. (Other measures of their critical success factors included field interviews by sales personnel, assessment of the rise or fall of the percent of each major customer's business being obtained, etc.).

Market Success

On the surface, this CSF is straightforward. But, when considering the measures, it includes attention to current market success, as well as the understanding of significant new market opportunities (e.g., the relative rate of growth of each market segment, opportunities provided by new technology, and relative - not just absolute - competitive performance.

Risk Recognition in Major Bids and Contacts

Since many of the jobs accepted are near-or at-the state of the art, controlling the company's risk profile is seen to be critical. As noted by Dr. Gould, a variety of factors contribute to risk. The measurement process designed involves a computer algorithm to consider these factors and to highlight particularly risky situations.
Profit Margin on Jobs

When profit center managers have low backlogs, they are often tempted to bid very low to obtain additional business. While this procedure is not necessarily bad, it is critical for the corporate level to understand the expected profit profile and, at times, to counter lower level tendencies to accept low profit business.

Morale

Because of its high-technology strategy, the company is clearly heavily dependent on the "esprit" of its key scientists and engineers. It must also be able to attract and keep a skilled work force. Thus morale is a critical success factor. Measures of morale range from hard data (turnover, absenteeism, tardiness) to informal feedback (management discussion sessions with employees).

Performance to Budget on Key Job

This final CSF reflects the need to control major budget expenditures such that jobs are completed on time and on target. Adverse results with regard to timeliness can severely affect CSF #2 (technological perception) and significant cost overruns can affect CSF #1 (financial market perception) similarly. In general, no single job is crucially important. Rather it is the profile of performance across major jobs that is significant.
Reports and Information Systems Design

Given these CSF's and measures, the next step was to design a set of report formats. This step required both examination of existing information systems and data sources.

For the "soft" informal subjective measures, this process was straightforward. Forms to record facts and impressions were designed so as to scale (where possible) perception and highlight significant "soft" factors.

For some of the "harder" computer-based measures, existing information systems and data bases supplied most of the necessary data. However, in every case - even where all data was available - existing report forms were found to be inadequate and new reports have had to be designed.

Most important, however, it was found that two completely new information sub-systems have to be built to support the President's CSFs. These are a "bidding sub-system" and a vastly different automated "project budgeting and control" system. Significantly each of these systems had been requested many times by lower level personnel - who needed them for more detailed planning and control of job bidding and monitoring at the product line manager and manufactory levels. These sub-systems have finally been placed at the top of the priority list for data processing.
Advantage of the CSF Approach

In summary, in this case the exercise of discovering information needs thorough examination of a chief executive's critical success factors had a number of advantages. As we see it now, the benefits are:

- The conscious listing of (or bringing to the surface) of the most significant areas on which the executive needs to focus for the next several months at least. In other words, CSFs tend to provide a focus for attention.
- The design of a useful set of reports which provide the information needed to monitor on-going operations at the general executive level. (There clearly are other data needed – for the development of strategy, dealing with special situations, etc.). The CSF route, however, focuses on the data needed for the ongoing "management control" process in Anthony's terms.
- The development of priorities for information system development. It is clear that information needed for control purposes by the chief executive should have some priority. (It often will, as in this case, highlight priorities for other management levels, also.)
- The provision of a means of hierarchical communication among executives as to what the critical factors are
for the success of the company. Too often, only
goals provide a major communication link to enhance
shared understanding of the company and its environ-
ment among management levels. CSFs provide another —
and we believe more pragmatic and action-oriented
means of communication. (At Microwave at the present
time there is a project aimed at developing and
sharing CSFs at the top four management levels.) We
believe this hierarchical approach will lead to
significantly enhanced communication and a clear,
comprehensive plan for information system development.

The "by-product approach" gets paperwork processed and
can establish a useful data base. The "null approach"
provides a warning that much management data cannot and
should not be formally designed and regularly generated (even
by exception reporting). The "key indicators approach" can
make available useful financial data ordinarily available
from the company's data base. And the "total-study" method
also has its time and place. Yet, for zeroing-in on a very
critical area for any organization — the provision of
information to its top executive — the "critical success
factor approach" has a unique place in terms of speed,
effectiveness, and completeness in performing this job.
APPENDIX B

M.I.T. THESIS RESEARCH STUDY

ALFRED P. SLOAN FELLOWSHIP EXECUTIVE PROGRAM

This thesis will research two Government Field R&D Centers, the DOT/Transportation Systems Center at Cambridge, Massachusetts and the NASA/Hugh L. Dryden Flight Research Center at Edwards, California. To gather the required information for this research, structured interviews with the Headquarters management and the field Center management of both agencies are required.

Messrs. Joseph M. Gutwein and Earl J. Montoya are presently participating in the Alfred P. Sloan Fellowship Executive Program. Mr. Gutwein is from the Department of Transportation/Transportation Systems Center and Mr. Montoya is from the National Aeronautics and Space Administration/Hugh L. Dryden Flight Research Center. Messrs. Gutwein and Montoya are working on a joint thesis and have chosen a topic within the area of strategic planning and management control. This thesis has been entitled "CRITICAL SUCCESS FACTORS FOR GOVERNMENT R&D CENTERS".

Dr. John F. Rockart, Director of Center for Information Systems Research at the MIT Sloan School of Management, is the thesis advisor. Dr. Rockart is currently studying
critical success factors for non-profit organizations as well as private industry. He has encouraged this thesis because there appears to be a lack of information on critical success factors for government R&D organizations. An MIT associate of Dr. Rockart, Ms. Christine Bullen, is performing research in this area and is working closely with the authors of this thesis.

Critical success factors (CSF) are those key state variables that must be monitored and controlled to achieve the organization's goals and to ensure the organization is operating both efficiently and effectively. Thus, the critical success factors focus management's attention on key operational aspects. Critical success factors can be non-quantifiable subjective assessments of performance as well as quantifiable measures of performance. Critical success factors are different then objectives and goals. An example of critical success factors which are non-quantifiable and tend to deal with effectiveness follows:

| Objective | • conduct the Space Shuttle Approach and Landing Tests at the Hugh L. Dryden Flight Research Center |
| Goal      | • perform the Approach and Landing Tests on schedule within the money and resource constraints budgeted |
| CSF       | • identification of facilities requirements and provision of same |
|           | • relations between organizations involved in the Approach and Landing Tests |
- headquarters satisfaction
- morale/employee relations and communications
- human resource development-job role planning.

An example of critical success factors in terms of quantifiable values as applied to administrative efficiency could be:

<table>
<thead>
<tr>
<th>Objective</th>
<th>Goals</th>
<th>CSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>to improve management efficiency at the DOT/Transportation Systems Center</td>
<td>lower current overhead rate to 80%</td>
<td>current overhead rates</td>
</tr>
<tr>
<td></td>
<td>reduce procurement carry over funds to less than 10% of total program projections</td>
<td>ratio of procurement obligations to procurement plans</td>
</tr>
<tr>
<td></td>
<td>achieve manpower utilization estimates accurate to 3%</td>
<td>variance between actual manpower utilization and estimate</td>
</tr>
<tr>
<td></td>
<td>tighten travel cost estimates to within 10% of actual costs</td>
<td>difference between actual travel costs and estimated costs.</td>
</tr>
</tbody>
</table>

An important element in this research is to obtain both the vertical (chain of command) and horizontal (across the organization) profiles of the critical success factors as perceived by managers at various levels in the organizations being studied. As a preliminary step to the interview, it is requested that each manager list their current and projected
objectives and goals. Each manager interviewed will then be requested to:

1. Identify his or her critical success factors;

2. Establish a priority listing of the identified critical success factors;

3. Determine valid measurement criteria for the critical success factors;

4. Describe critical success factor performance information needs.

Because it is important that each manager's own views and perspectives on the critical success factors be obtained, it is requested that those managers to be interviewed do not discuss these issues with their colleagues until after the interviews are concluded. The responses of the various managers will be kept anonymous. Summaries of these interviews will be made available for comment prior to final thesis preparation.

Copies of the final thesis will be made available to the various organizations involved.

These interviews will be conducted within the month of January and early February of 1978. We look forward to meeting with the various managers.