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A COST AND PERFORMANCE SYSTEM (CAPS) IN A FEDERAL AGENCY

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The John C. Stennis Space Center (SSC) in southern Mississippi serves as NASA's primary facility for propulsion testing. This includes testing stages and propulsion systems, for the Saturn V moon rocket during the Apollo lunar landing program, and currently, for the Space Shuttle. In addition, SSC is building new test facilities to advance turbomachinery technology for propulsion systems of future generations of vehicles.

SSC also has capabilities in remote sensing, Earth sciences and applications development. SSC is NASA's lead Center for the commercial development of space remote sensing technology and has substantial work under way in the transfer of technology to the public sector. SSC also provides technical and institutional support services to 18 other Federal and state agencies in residence.

Although our principal mission for NASA is to support the development and acceptance testing of large propulsion systems for the Space Shuttle, National Launch System (NLS) and the Advanced Solid Rocket Motor (ASRM), the remaining missions of the Center foster cooperative research and development activities that serve to broaden our understanding and management of our natural resources. These missions are described in Figure 1.

SSC is organized in a classical government functional project structure. The functions of Legal, Public Affairs, Personnel, Resources, Procurement and Safety are shown in Figure 2. There are two project offices (ASRM and NLS) that carry out their responsibilities in a matrix organization with the line directorates. The three line directorates (Propulsion

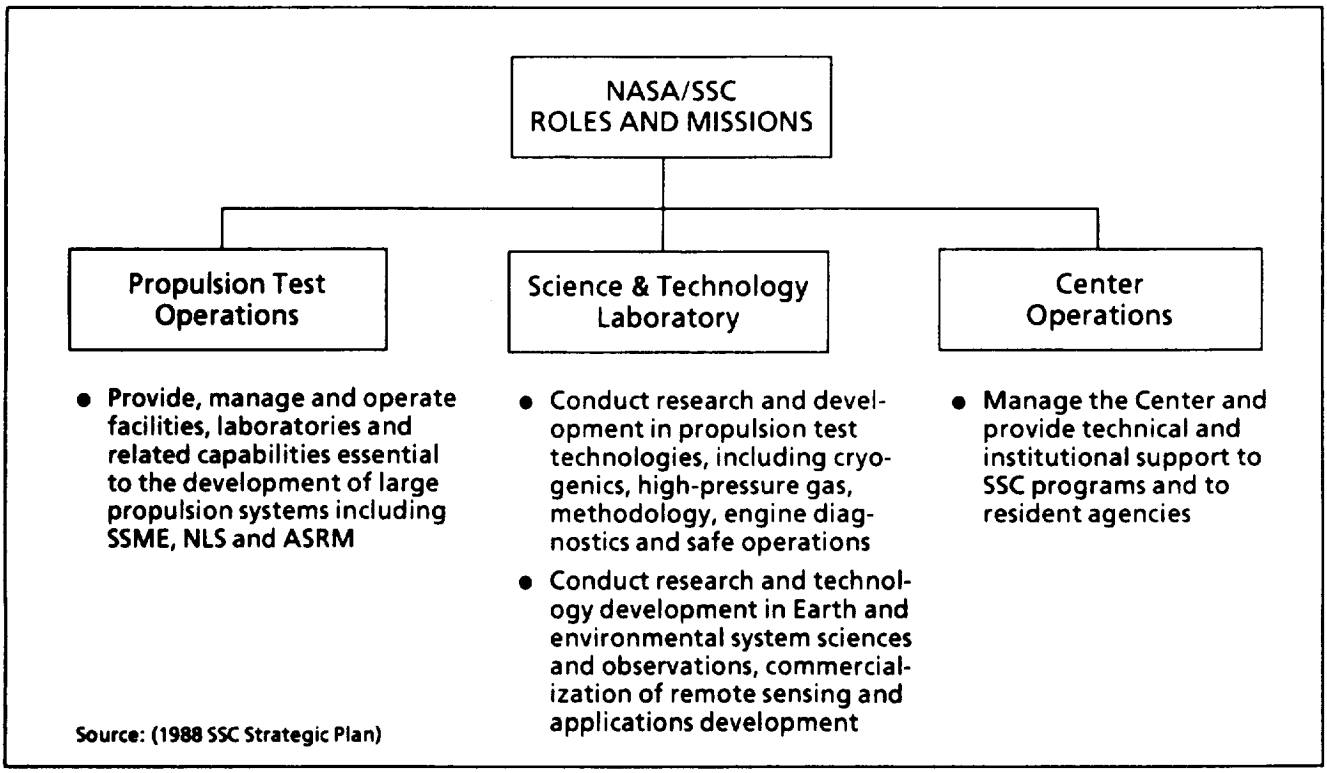

Figure 1. SSC Roles and Mission

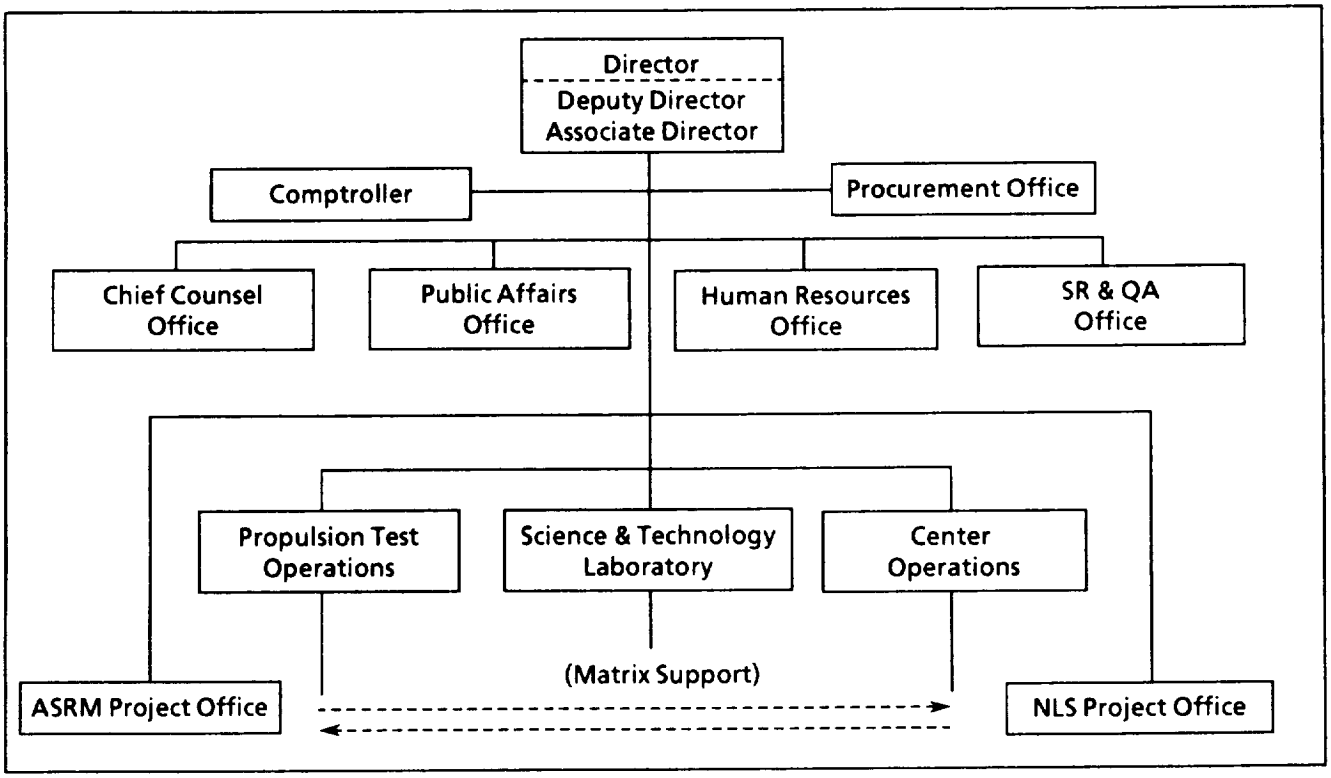

Figure 2. SSC Organization

Test, Science and Technology Laboratory and Center Operations) are functionally compatible with the SSC mission.

This organization structure, a hybrid of functional and matrix, mixed with the fact that the missions of the center are primarily accomplished by support contractors, makes the tracking of cost, schedule and performance a complex and difficult (yet necessary) management function.

Purpose

In the late 1970s, the NASA Administrator established a study to examine NASA project management and to make recommendations on how to improve the Agency's performance. A major conclusion of the study was "poor tracking of contractor accomplishments against approved plans in a timely fashion leads to late identification of problems" (Hearth, 1991).

This paper describes a systematic approach to aligning funding sources with cost planning and performance scheduling. This system establishes a monthly reporting status structure, correlates resources with schedule and performance, and assesses "what-ifs" and their alternatives for management review (Sneed, 1991). The Cost and Performance System (CAPS) provides the foundation for successful project management, functional organization management and oversight of the total organization's performance.

This system will be described in generic terms with results and implications from its specific use directly relating to the Science and Technology Laboratory (STL) at SSC.

Planning Phase

The model depicted in Figure 3 begins with a fund source and its identification within the federal financial system as a Unique Project Number (UPN). The UPNs are assigned according to the NASA Headquarters organization and program structure and tracked at various levels in the organization. For example, NASA may assign a three-digit UPN

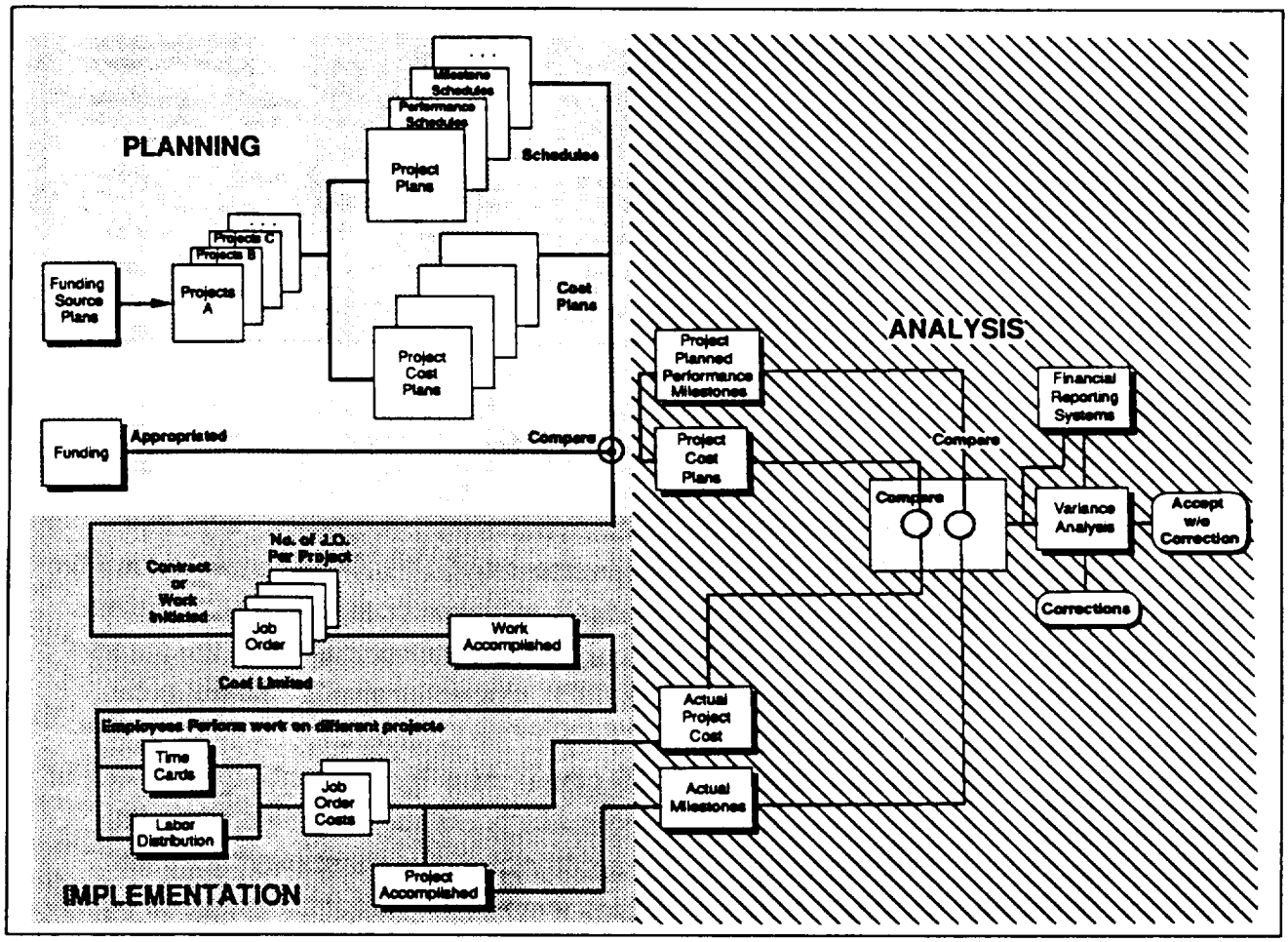

Figure 3. Generic Cost and Performance Model

XXX for an overall project fund source. The project may then be divided into subsets, each of which will be assigned a five digit UPN XXX-YY. These subsets may be further divided and funded with a seven-digit UPN XXX-YY-ZZ. Figure 3 represents the generic flow in the planning, implementation and analysis of cost and performance within STL at SSC.

These funding sources (UPNs) represent the dollar amounts assigned to the project from the various headquarters organizations. It further represents the overall results of the budgetary cycle within the organization or agency for the fiscal year. Thus, given the dollar amounts assigned to the UPNs, the project planning cycle can begin. Cost plans for individual projects are developed for specific elements of cost and spread across the fiscal year. A typical cost plan is shown in Figure 4.

The elements of cost are the classical labor, materials, equipment and other direct costs (ODC). Also included are the subsets of labor (straight time, overtime, etc.), subcontractor cost and the subsets of ODC (travel, training, bases, etc.). The plan "cost elements" and the report of actual costs by the contractor should be completely compatible. The cost plan should reflect the manpower required each month, the anticipated cost of equipment or materials and projected travel and training and other costs as listed. The cost plan is, at best, just a plan. It should have adequate schedule slack and budget contingency to solve inevitable problems along the way (Longanecker, 1990). It and the elements of cost can be and should be adapted to

the types of cost one may incur in any specific project. There may also be unique costs. Within STL, for example, aircraft missions flown to collect remote sensing data for scientific research and development projects are one important cost that is planned, tracked and reported by either the contractor or government personnel as "aircraft missions."

At the top left of the STL Project Plan is the UPN number (551-20-00) for this project. The UPN may support more than one project; therefore, this project is assigned a benefitor code (BF) of VVB. Each project has assigned a benefitor code which is directly related to a UPN. The next item on the top left side is the project name (SIDS/IDS). SIDS/IDS stands for the Shuttle Ice Detection System, a subset of the Infrared Detection Systems being developed at SSC. The final description is the crew/depart. The Technology Development Division within STL is responsible for the project and has a department number of HA20 designated by 20 on the form.

On the top right side is the financial status at the beginning of the fiscal year when the plan is initially developed; the uncosted carry-over, new obligation authority, total available to cost and planned carry-over.

The actual work tasks represented in the elements of cost are scheduled in the performance milestone plan. Figure 5 is a typical milestone chart for a particular project. The project tasks are listed, and expected completion dates are spread across the fiscal year by month.

The cost plans and milestone schedules are necessarily prepared at the beginning of the fiscal year. They are the basis for planning resources across the organization. This includes, but is not limited to, personnel staffing, skill mix, procurement plans, training budgets, travel budgets and office space requirements. Actual monthly costs are compared with the plans and any significant variance ($\pm$ 10%) is explained. Knowledge of this variance and the explanation for it allow the project manager to make the necessary adjustments to keep the project on schedule and within budget. Therefore, the first step in CAPS is planning.

UPN: 551-20-00
BF Code: VVB
Project: SIDS/IDS
Contractor: LESC
Crew/Dept: 20 (TDD)

Mid-Year Update

Uncosted Carry Over (Prev. Year): $450,782
New Obligation Authority (Current Year): $0
Total available to Cost: $450,782
Planned Carryover (1st Quarter '92): $0

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL
Commitments:													$0
Obligations:													$0
Labor:													
- Straight Time						$24,586	$4,836	$4,836	$4,836	$4,835	$4,835	$4,835	$53,599
- Overtime						$1,823							$1,823
- Shift Differential													$0
- O/T Premium													$0
Actual Labor Cost:	$0	$0	$0	$0	$0	$26,409	$4,836	$4,836	$4,836	$4,835	$4,835	$4,835	$55,422
TOTAL LOADED LABOR:	$0	$0	$0	$0	$0	$40,888	$7,487	$7,487	$7,487	$7,486	$7,486	$7,486	$85,807
Subcontractor Cost:													$0
LOADED Sub/C. Cost:	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Equipment:												$310,000	$310,000
LOADED Equipment:	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$352,916	$352,916
Materials:											$251	$177	$428
LOADED Materials:	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$286	$202	$487
ODC:													
- Travel/Training						$1,264	$4,900		$2,000		$2,000		$10,164
- A/C Missions													$0
- Services/Seased													$0
Total ODC	$0	$0	$0	$0	$0	$1,439	$5,578	$0	$2,277	$0	$2,277	$0	$11,571
Totals for Month:	$0	$0	$0	$0	$0	$42,327	$13,065	$7,487	$9,764	$7,486	$10,049	$360,604	$450,782
Cum. Month Totals:	$0	$0	$0	$0	$0	$42,327	$55,392	$62,879	$72,643	$80,129	$90,178	$450,782	$450,782

Figure 4. Project Cost Plan

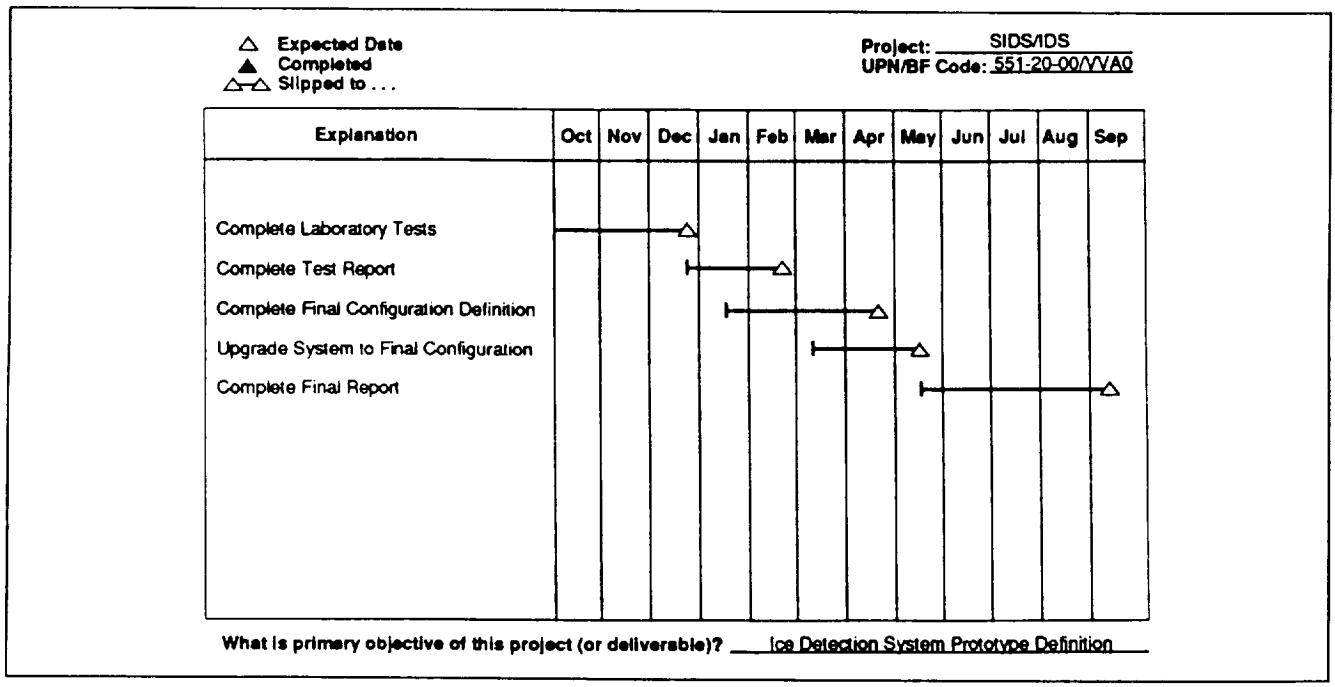

Figure 5. Milestone Schedule

The Science and Technology Laboratory has in any one fiscal year 60-65 fund sources (UPNs) at the seven-digit level. These are broken out into 164 benefitor codes (separate projects) which are planned and scheduled in detail by 40 project scientists and engineers.

The planning process starts approximately three weeks prior to the end of the fiscal year (September) and is completed one week prior to the first fiscal month (October). The cost plans and milestone schedules are formulated and put in place to track cost and performance. At STL, they remain unaltered (not changed) until midyear. At midyear the plans are updated to project the remaining work over the April/September timeframe. These plans are projected based on what occurred in the first six months, what is remaining to be done and what resources are available for the second half of the fiscal year. Other agencies may require adjustments more frequently, depending on the projects and stability of the fund sources.

The planning process is completed when the project tasks and the necessary dollars to accomplish those tasks are realistically scheduled across the fiscal year. The planning portion of the generic cost and performance model of Figure 3 is contained in Figure 6. After the planning phase, the organization proceeds with the implementation phase.

Implementation Phase

To implement CAPS, it is necessary to establish a structured mechanism for assigning work tasks that can be directly associated with the "lowest" designated funding source. A "work order" provides the authority to apply resources, (human, physical and financial) to accomplish the tasks required to support the project. Each work order must be accounted for in the Project Cost Plan (Figure 4). The work order includes more than just the tasks to be accomplished. It also includes the schedule for completion, deliverables expected, the dollar limit and the suborganizations or shops involved in the work.

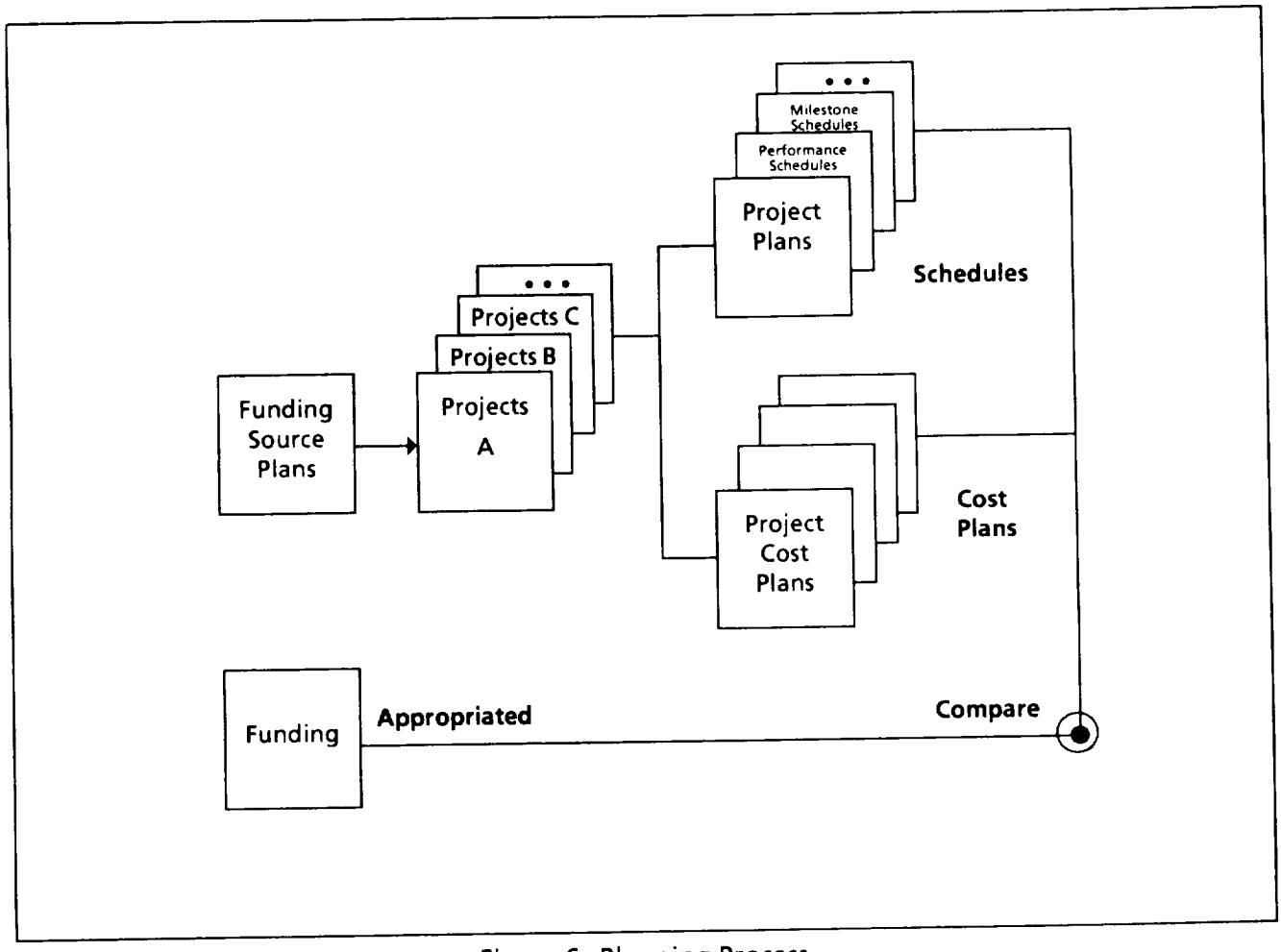

Figure 6. Planning Process

In a customer/contractor arrangement as occurs within Federal agencies, the contract document provides insight into the mechanisms used to initiate work. For example, in the SSC government contractor environment, work requests take the form of job orders (JOs) for the research contractor; facility service requests (FSRs) for the facility support contractor; and technical work requests (TWRs) for the technical services contractor. The format used by STL is the job order as shown in Figure 7.

Any number of work requests or job orders may be required to carry out any one project. These are identified by the JO numbering system, which is directly related to the projects and organization. Some intelligence has been built into this system in that the first three letters of the job order number are the benefitor code (funding source). The fourth and fifth numbers are simply the sequence number and the sixth and seventh numbers are the division number from which the job order originates.

For example, a job number at STL is VVD.01.20; where VVD is the benefitor code, 01 is the sequence number and 20 indicates that the job order originated in the HA20 division. This numbering system provides a mechanism for tracking personnel and equipment charges. Personnel time cards and labor distribution sheets reflect job order charges. These records are the fundamental database for the subsequent accumulation of

NASA
National Aeronautics and Space Administration
John C. Stennis Space Center

SUPPORT CONTRACTOR JOB ORDER

DATE: 10/15/90
CONT. CONTROL NO.:

CONTRACTOR	ORGINATOR	EXTENSION	DIVISION	NASA CONTRACT NO.
LESC	Penton	1932	HA00	NAS13-315

TASK & JOB ORDER NO.	CONTRACTOR PROJECT NO.	ACCOUNTING CODE NO.
CSB0-07-01	018-CSBO7	

TITLE: PRESENTATION GRAPHICS

DESCRIPTION

Background: Graphic arts services are required to produce materials required for briefings of general, non-project topics. Only such generic, all-STL topic materials should be produced on this job order. Where there is doubt as to the scope of the requested support, the Technical Monitor, or identified alternate(s) should be consulted. In many cases, materials must be produced and modified on short notice, thus establishing the need for the capability to respond to "quick-reaction" requests.

Tasks:
1. Maintain necessary graphic arts supplies and equipment to support this job order.
2. Maintain a file of reproducible masters of graphics, purging file as requested by technical monitor.
3. Produce graphic arts in response to requests fron STL technical monitor.
4. Coordinate and monitor any graphics work sent to other SSC contractors.
5. Provide oversight to cost-effective operation of graphic functions and recommend changes to technical monitor as appropriate. Maintain adequate records so that technical monitor will have immediate and full insight in deliverable schedules. Such schedules are to be established when individual graphic arts tasks are accepted.

Schedules: As established when individual tasks are accepted.

Deliverables:
1. Graphic arts products as specified when requested.
2. Full records of production in weekly activity report.
3. Other records of production when audits are required.

Cost of J.O. not to exceed $19,608.

RESOURCES REQUIRED		SCHEDULE	
EST. CONTRACTOR MANHOUR REQUIREMENTS: 846		EST. BEGINNING DATE: 10/1/90	EST. COMPLETION DATE: 7/31/91
EST. MATERIAL COST	TOTAL EST. COST: $19,608	DATE COMPLETED	SIGNATURE

CONTRACTOR COORDINATION	DATE	NASA CONCURRENCE/APPROVAL	DATE
SECTION SUPERVISOR		TECHNICAL MONITOR	
TECHNICAL SUPERVISOR		TECHNICAL MGR'S REP	
PROGRAM MANAGER		GROUP CHIEF	
DISTRIBUTION		PAGE OF PAGES	

Figure 7. Job Order Form

project costs. As the work is accomplished, charges (costs) are made to the job order. These charges are reflected in the cost plans as illustrated in Figure 4.

An individual monthly job order report is furnished by the contractor. A sample report from STL is shown below in Figure 8.

JOB ORDER REPORT FOR THE MONTH OF JUNE

RUN DATE 06/28

JOB ORDER VVBO.01.20 Ice Detection Prototype

JOB ORDER TOTAL $ 300,782

LABOR	YEAR TO DATE ACTUALS	CURRENT MONTH ACTUALS
Hours		
ST Hours	1836.9	158.6
OT Hours	131.2	0.0
Total Hours	1968.1	158.6
MYE		
ST Labor	1.3	1.1
OT Labor	0.0	0.0
Total MYE	1.4	1.1
Cost		
ST Labor	$41,819	$ 4,192
OT Labor	2,665	0
Shift Diff	0	0
OT Premium	15	0
Total Cost	$44,499	$ 4,192
Overhead	$16,100	$ 1,551
Subcontracts	$ 0	$ 0
Equipment	$ 40	$ 0
Material	$ 2,760	$ 0
OTHER DIRECT COST		
Travel	$ 4,469	$ 742
Services/Leases	2,916	3
Relocation	0	0
Use Tax	188	124
Total ODC	$ 7,573	$ 869
Total Cost Before G&A	$70,972	$ 6,612
G&A	$ 4,258	$ 397
Cost of Money	$ 50	$ 5
Total Cost Before Fee	$75,281	$ 7,013
Fee	$ 4,483	$ 425
Indirect Cost	$ 0	$ 0
TOTAL COST	$79,764	$ 7,438
OBLIGATIONS		
MATERIAL/EQUIPMENT	$ 9,927	
TRAVEL	$ 0	

Figure 8. Job Order Report

Similar to the cost plans, the job order report is broken into cost elements and shows the monthly data as well as Year-to-Date (YTD) data. If a principal investigator or project manager has multiple job orders under one benefitor, in various suborganizations or shops, the activities and tasks can be accomplished as well as costs in the different areas.

The cumulative costs for the benefitor are shown in the contractor's 533M (Monthly) Report, shown below in Figure 9.

BENEFITOR CODE REPORT FOR THE MONTH OF June

RUN DATE 06/28/

BENEFITOR CODE VVB0 SIDS/IDS

HA20 SPIERING

COST PLAN DATE 04/17/91

COST PLAN TOTAL $ 450,782

LABOR	YEAR TO DATE BUDGET	YEAR TO DATE ACTUALS	O/U VARIANCE	CURRENT MONTH BUDGET	CURRENT MONTH ACTUALS	O/U VARIANCE
Hours						
ST Hours	1883.1	1836.9	-46.2	254.5	158.6	-95.0
OT Hours	91.2	131.2	40.0	0.0	0.0	0.0
Total Hours	1974.3	1968.1	-6.2	254.5	158.6	-95.9
MYE						
ST Labor	1.4	1.4	0.0	1.8	1.1	-0.7
OT Labor	0.1	0.1	0.0	0.0	0.0	0.0
Total MYE	1.5	1.5	0.0	1.8	1.1	-0.7
Cost						
ST Labor	$39,094	$41,819	$ 2,725	$ 4,836	$ 4,192	$ -644
OT Labor	1,841	2,665	824	0	0	0
Shift Diff	0	0	0	0	0	0
OT Premium	12	15	3	0	0	0
Total Cost	$40,947	$44,499	$ 3,552	$ 4,836	$ 4,192	$ -644
Overhead	$14,882	$16,100	$ 1,218	$ 1,789	$ 1,551	$ -238
Subcontracts	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Equipment	$ 40	$ 40	$ 0	$ 0	$ 0	$ 0
Material	$ 81	$ 2,760	$ 2,679	$ 0	$ 0	$ 0
OTHER DIRECT COSTS						
Travel	$ 8,164	$ 4,469	$ -3,695	$ 2,000	$ 742	$ -1,258
A/C Missions	0	0	0	0	0	0
Services/Leases	48	2,916	2,868	0	3	3
Relocation	0	0	0	0	0	0
Use Tax	10	188	178	0	124	124
Total ODC	$ 8,223	$ 7,573	$ -650	$ 2,000	$ 869	$ -1,131
Total Cost Before G&A	$64,173	$70,972	$ 6,800	$ 8,625	$ 6,612	$ -2,013
G&A	$ 3,850	$ 4,258	$ 408	$ 518	$ 397	$ -121
Cost of Money	$ 46	$ 50	$ 5	$ 6	$ 5	$ -1
Total Cost Before Fee	$68,069	$75,281	$ 7,212	$ 9,149	$ 7,013	$ -2,136
Fee	$ 4,130	$ 4,483	$ 353	$ 490	$ 425	$ -65
Indirect Cost	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
TOTAL COST	$72,199	$79,764	$ 7,565	$ 9,639	$7,438	$ -2,201

OBLIGATIONS

MATERIAL/EQUIPMENT	$ 9,927
TRAVEL	$ 0

Figure 9. Benefitor (533M) Code Report

The 533M report is a requirement levied on the contractor by the government. Contractors must provide a monthly summary of costs for the current month and YTD costs for each project (benefitor). This monthly cost summary (533) has basically the same elements of costs as the cost plans. The only difference is the contractor overhead, G&A and fee statements. The current month's budget, current month's actual cost and variance are listed in the right three columns. The YTD budget, YTD actual cost and variance are listed in the left three columns next to the elements of costs. Project managers must understand the variance column of this report in order to judge performance of the contractor.

At this point in the generic model, the implementation phase is complete. This process is shown in Figure 10. The subsequent phase is the analysis of the data on a monthly basis.

Analysis Phase

The analysis phase of the process provides the analysis of the actual against the planned cost and scheduled milestones data. This comparison results in a difference of planned versus the actuals called "variance." Analyzing these comparisons results in conclusions relative to project performance. The results are then compared in the cost and schedules milestone matrix in Figure 11.

The cost analysis results in a cost underrun, on-target or overrun. Schedule milestones analysis provides under achievement, on-target, or over achievement. The combination of these two sets of parameters yields a performance indication.

The purpose for the variance analysis is to provide an understanding of trends or implications of performance to reduce management surprises and enable early corrections.

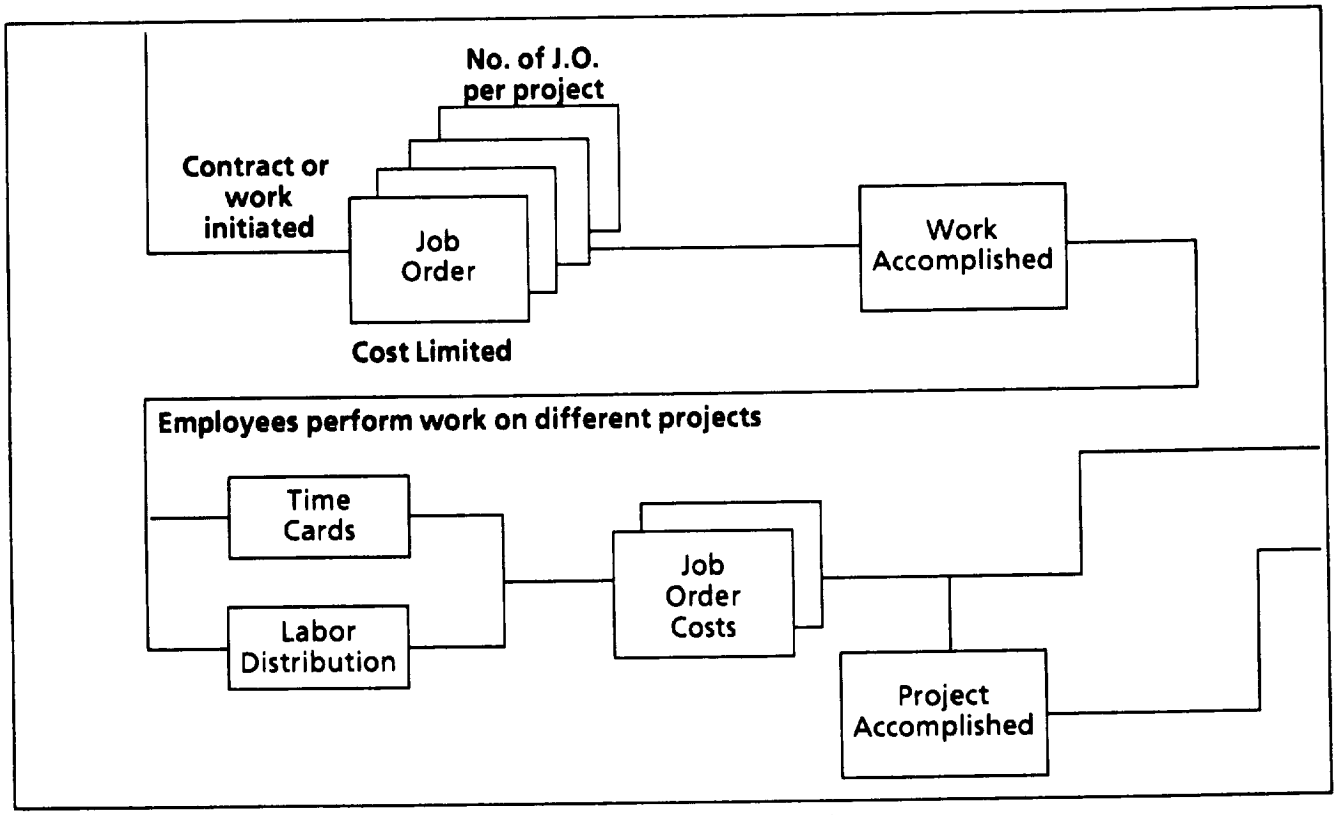

Figure 10. Implementation Phase

The matrix in Figure 11 provides the combination of cost and scheduled milestone accomplishments that translate into performance. Performance is an indicator of productivity reflected in the planning of work and its associated dollars, and measurement of actual accomplishments and costs.

COST	SCHEDULED MILESTONES		
	Under Achieve	*On Target*	*Over Achieve*
Underrun	Question-able	Good	High
On Target	Weak	Good	High
Overrun	Poor	Weak	Question-able

Figure 11. Performance Matrix

The analysis of the performance matrix indicates the "underrun of cost" row is the best performance posture except in the case of under achievement of milestone accomplishment. The under achievement of milestones accomplishment and underrun of cost is a lack of performance based on the dimension of time and milestones scheduled. This underrun condition may indicate potential problems or significant cost overruns. The remaining performances in the "cost underrun" row go from good to high performance when meeting or exceeding the scheduled milestones.

The "on-target cost" row proceeds from weak to good and finally to high performance with under achievement, on-target, and over achievement of scheduled milestones. The "cost overrun" row provides a poor, weak or questionable performance when transcending from under achievement, on-target and over achievement of scheduled milestones.

The relative degree of high, good, weak, poor and questionable performance can be determined as a consequence of the detailed analysis of cost and scheduled milestone data. Examining these elements and questioning the variances from project plans provides extensive insight as to the absolute magnitude of performance. With the actual costs in the accomplishment of planned tasks, these costs can be examined at the data entry level of the personnel time card and labor distribution sheet at the job order or work request level during detailed analysis or anomaly resolution.

From the initial planning, changes in projects can and will occur. However, the initial cost plan was constructed from the original planned milestones and schedules. While maintaining the original plans, the rationale and reasonableness of variation between what was planned and what actually occurs can be assessed and determined. From this baseline, the analysis and variance explanation is understood and may be accepted without correction to the project.

A project correction may require redistribution of resources, application of additional resources, resolution of problems, etc. Acceptance without correction requires an understandable explanation of the differences in cost expenditures and achievement of milestones from what was initially planned.

Understanding that plans of all types are subject to change, the initial planning in this context is held constant for the first six months of the fiscal year. At midyear, the cost plans and milestone schedules are readjusted for the remainder of the fiscal year. The project carryover (planned and unplanned) into the next fiscal year is noted and tracked for continuity and used in establishing a credible plan for the next year. Having contingency funds available covers any uncertainties of project dollars into the new fiscal year.

The cost plans, cost actuals and milestones/schedules, both planned and actual, are documented and aggregated at the project level, then to the fund sources level in the Financial Reporting Systems (Figure 12).

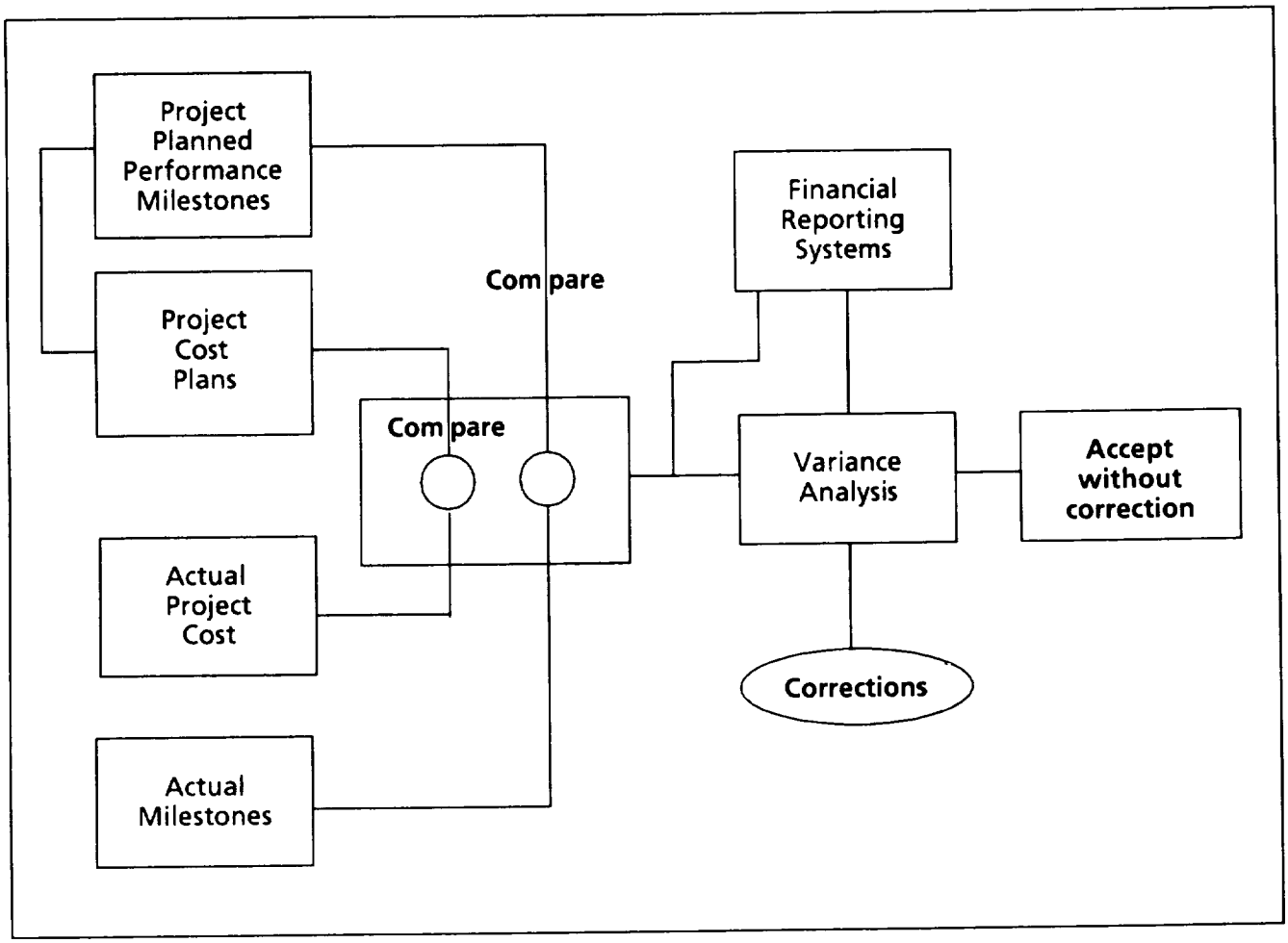

Figure 12. Analysis

Documentation

The records of plans and actuals from the detailed level through the aggregation at the division level, directorate level, Center level and finally a summary to the Headquarters level, constitute documentation of CAPS. All data, regardless of the level of summary or details, are definable to the lowest level in the process. Variance explanations are summarized and carried through all levels of aggregation.

Summary

CAPS is an automated system used from the planning phase through implementation to analysis and documentation. Data is available or retrievable for analysis of cost versus performance anomalies. CAPS provides a uniform system across intra- and inter-organizational elements. A common system is recommended throughout an entire cost or profit center. Data can be easily accumulated and aggregated into higher levels of tracking and reporting of cost and performance.

For effective program management and control to exist, an environment of accountability of organizational elements and individuals must exist. The implication is that the level and quality of performance or productivity is indicated in the CAPS model and its process. Management overview and the monthly reporting and analysis provides a mechanism for management change, redirection or support of the project's progress.

The CAPS model provides the necessary "decision" information and insight to the principal investigator/project engineer for a successful project management experience. In

fact, CAPS provides all levels of management with the appropriate detailed level of data.

The CAPS model is a disciplined process for obtaining required feedback necessary for measuring performance on programs and projects. It is recommended for cost and performance tracking for any size or number of projects. The results indicate productivity/performance and successful project management.

CAPS has been implemented utilizing different software and hardware systems. It is currently residing on a PC-based system and an institution minicomputer. The concept and system are adaptable to any high level database and project networking software. Depending on the number of projects, in most cases CAPS can be handled by PC hardware and software.

The CAPS model provides for planning, implementation, analysis and tracking of projects. Projects utilizing this system at SSC range from several thousand dollars a year to over a million dollars per year. SSC also uses the system for multimillion dollar projects. The principal investigator or project engineer has the responsibility and authority to implement the project. CAPS provides a consistent and uniform system to plan, implement, analyze and track a project.

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