

PROJECT MANAGEMENT STANDARDS  
AT THE  
IDAHO NATIONAL ENGINEERING LABORATORY

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## A) INTRODUCTION

In late 1985 EG&G Idaho, a large U.S. government contractor, launched a major effort to improve project management in the company. Within EG&G some projects had been well managed for years. On the other hand, other projects had seen cost overruns, schedule slips, and unhappy customers. Many of the problems were indeed due to inadequate project planning or lack of project control. EG&G management felt it was time to establish some minimum standard requirements for project planning and control.

In 1986 a set of standards for Project Management Planning and Control was developed at EG&G Idaho. Based on principles of effective project management, the standards were embodied in two booklets published by the company. Entitled "Policy and Standard Method for Management Plans" and "Standard Method for Management Control," the documents provided a framework and guidance for planning and controlling a wide variety of projects within the company.

This paper describes the standards developed at EG&G Idaho for all work performed by the company at the Idaho National Engineering Laboratory (INEL).

## B) INEL: MULTI-PROJECT ENVIRONMENT

The INEL is an extensive research and engineering complex located in southeast Idaho and operated by the U.S. Department of Energy (DOE). Approximately 10,000 people are employed by dozens of contractors at the INEL. Work there includes advanced nuclear energy research, nuclear waste management, environmental research, non-nuclear energy conservation, and other activities for U.S. government agencies and other customers.

As one of DOE's field labs, the INEL is now and will continue to be the location of some of the U.S. government's most visible projects. That visibility, and the continuing need to adequately manage important government work, requires INEL contractors to be prepared to plan and control a wide range of projects.

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### C) PROJECT MANAGEMENT AT EG&G IDAHO

EG&G Idaho is a prime operating contractor for the U.S. DOE at the INEL. As a prime contractor, EG&G Idaho provides a variety of programmatic and support services related to nuclear reactor design and development, nonnuclear energy development, radioactive waste management, materials testing, environmental research, and strategic defense research. EG&G Idaho also operates several research reactors at the INEL and provides all services for total site operations, including support services to other site contractors.

Due to the variety of projects at EG&G Idaho, flexibility is a major requirement for project management policies and systems used in the company. Projects range in size from tiny contracts to major multi-million dollar projects; they range in nature from major nuclear safety programs to environmental monitoring projects for the U.S. Department of Interior. With the variety of customers and contract requirements, EG&G project managers must adapt project management methods and systems as appropriate for their individual needs.

By 1985 the nature of the contract work at EG&G Idaho was changing dramatically. Large programs were being completed. More and more smaller projects were being managed. With the increasing number of projects, project managers and customers involved, EG&G management recognized the need for clearly defined project management guidelines within the company. Rather than focusing on tools and systems, however, the company chose to address the fundamentals of project planning and control. The result was a set of Standard Methods for Management Plans and Management Control.

The Standard Methods are based on the fundamentals of project planning and control and are intended to provide guidance for management of a very wide range of projects. Those projects range from research and development to construction. The Standard Methods provide a framework; it is up to individual project managers to apply them to the appropriate level of detail and rigor on their projects, depending on the type of work involved, size or length of project, and customer requirements.

### D) STANDARD METHODS APPROACH

The Standard Methods combine direction and guidance with flexibility. The basics of planning and control are required. The tools and techniques to be used are left to the discretion



of individual managers. In addition, the level of detail and degree of rigor in the application of the requirements are also the manager's responsibility.

This flexibility has allowed project managers throughout the organization to use and benefit from the standards. The standard methods provide the framework and basic requirements for planning and controlling work, whether R&D or construction. The project managers are responsible for selecting appropriate tools and techniques, and for getting the work done.

#### E) STANDARD METHOD FOR MANAGEMENT PLANS

The Standard Method for Management Plans requires that all work performed by the company must be covered by Management Plans. That is, all projects or contracts must be planned in accordance with the Standard Method. The Standard Method for Management Plans provides a standard format for management plans, consisting of fourteen elements which must be addressed during the planning process.

The fourteen standard elements of Management Plans include work scope; work breakdown structure; organization; schedules; cost estimates and budgets; Resource Allocation Plan; Quality Plan; Health, Safety and Environmental Protection Plan; Security Plan; Management, Planning and Control Plan; Reporting Requirements; Configuration Management Plan; Change Control Plan; and Appendix. Each of these elements must be addressed during the planning process.

While in many cases not all fourteen elements are necessary, the Standard Method forces each project manager to ask that question. More complete planning usually results. As can be seen, the Standard Method goes well beyond the traditional scope, schedule, cost planning to address management systems, procedures, safety, quality, security, environmental, and documentation issues.

A complete description of the Standard Method for Management Plans can be found in Appendix A.

#### F) STANDARD METHOD FOR MANAGEMENT CONTROL

The Standard Method for Management Control provides guidance for monitoring and controlling the actual performance of work. Six major processes are outlined which all project managers must plan and perform. The six standard control processes include work authorization, work direction,



performance measurement, performance evaluation, corrective action and change control, and performance reporting/documentation.

Recognizing that events seldom occur as planned, the Standard Method for Management Control provides guidance for keeping abreast of actual performance, for controlling changes, and for achieving planned objectives. The standard processes are based on proven performance measurement techniques. Again, it is left to the individual project manager to determine exactly what specific techniques, systems, or procedures will be used on his or her project.

A complete description of the Standard Method for Management Control can be found in Appendix B.

#### G) POLICY REQUIREMENTS

Early in the development of the standard methods, it was recognized that a company policy was required to establish management's position on project planning and control. Figure 1 displays the policy statement developed at EG&G Idaho.

The policy statement clearly demonstrated that top management was focusing on the need for better project planning and control. The support and attention provided by top managers at EG&G Idaho contributed to the overall success of the program, forcing all company personnel to seriously participate in the planning and control improvement process.

#### H) DOCUMENTATION AND TRAINING

##### 1) DOCUMENTATION REQUIREMENTS

The standard methods needed to be published in some documented form. At EG&G Idaho a short booklet format was selected. Rather than establishing another manual, brief 10-page booklets were published for the two standard methods. Additional booklets were then prepared for each of the 14 standard elements of management plans, providing additional clarification and guidance. Finally a glossary of company planning and control terminology was issued.

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FIGURE 1. PLANNING AND CONTROL POLICY STATEMENT.

The planning and control booklets were widely distributed in the company. They were also used to support the planning and control training classes. Since the booklets are short and concise they have been widely accepted and used throughout the organization.

## 2) TRAINING REQUIREMENTS

As with any major new management policies or techniques, a training program was required at EG&G Idaho to ensure companywide understanding and application of the Standard Methods. A set of management planning and control classes was developed and made available to all company managers and support personnel.

The training program included both general overview classes and detailed workshops on selected subjects (i.e., WBS preparation, scheduling, cost estimating). Each class was four hours in length and taught by one of the company experts who had been involved in developing the standard methods. Attendance in the courses was voluntary, although most managers attended the general overview classes.

Approximately 200 EG&G managers attended training classes in 1986 and again in 1987. The management planning and control courses are now established in the company's overall personnel development process, with classes offered on a regular basis.

## 1) RESULTS AT EG&G IDAHO

### 1) MANAGEMENT SURVEY NO. 1

In order to determine how well accepted and how useful the Standard Method for Management Plans was, a survey of company managers was conducted in October 1986. A questionnaire was sent to the managers of all ten departments in the company, who in turn surveyed managers in their own organizations. The questionnaires included questions related to number and type of management plans, how they were used, customer reaction, usefulness of training and benefits resulting from using the standard methods.

Approximately 200 management plans had been completed or were being prepared. Responses from company project managers were the most positive; a majority of company managers thought the preparation of management plans leads to a better understanding of the work as well as reduces uncertainty.



All respondents said management plans are useful for communication. Some indicated that one of the greater values was improved communication with the customer and with other organizations who must supply manpower and equipment resources.

All respondents said that management plans were used for control purposes by the manager and, in most cases, by his or her manager. Most respondents felt that the training classes were helpful and that some form of instruction should be ongoing. The responses concerning the management plan's effect on productivity and cost efficiencies were mixed. Generally it was thought that productivity increased and efficiencies improved when management plans were used for project management control. It was also recognized that productivity and cost efficiency would improve as more experience was gained in preparing and using management plans.

## 2) MANAGEMENT SURVEY NO. 2

A second survey of company managers was conducted in April 1987, to determine which areas of the company were using and benefiting most from the Standard Methods. Again, over 200 management plans existed in the company. In addition, smaller abbreviated versions of Management Plans, based on the Standard Format, were being used extensively for managing smaller projects.

In general, management planning was being done extensively among project managers in the company. Some departments were more supportive of the standard methods than others. In order to assess quality and format, a sample of 23 management plans was collected, representing all company departments, and reviewed.

## 3) MANAGEMENT SURVEY NO. 3

Company managers were surveyed again in September 1987. This time company managers were specifically requested to identify any benefits resulting from the use of the Standard Methods for planning and controlling work. Managers were also encouraged to comment on any problems or concerns related to the standards.

The responses to the survey were overwhelmingly positive. Enough experience with using the standard methods had been gained for benefits to be identified. Individual responses ranged from improved performance and cost savings, to new business resulting from using the standard methods.

In several cases, the Standard Method for Management Plans was used during proposal activities, resulting in impressed customers and new work. Improved resource planning was identified as a benefit in the engineering organization. Several managers mentioned the improved understanding of the work and organizational buy-in when project management plans were prepared in accordance with the standard methods.

The standard methods were recognized as improving communication between project managers and functional support people throughout the company. One manager indicated he was "bringing along" potential managers in his organization by having them manage projects in accordance with the standard methods.

Finally, one manager responded as follows: Two of my project managers "impressed their customer with their quick and thorough response to a statement of work using the standard methods format; \$28 million in new business was obtained, partially as a result of the favorable impression they created using these techniques."

#### 4) MAJOR BENEFITS

The standard methods have had a dramatic impact on the organization. Consistency in project planning and control companywide has been increased. Better communication has occurred as everyone worked to the same policy and guidelines.

Performance in general has improved. Managers became better able to plan their work, then monitor and control performance against the plans. Improved company resource management has also been promoted as more accurate information was input into the company financial system.

Most significantly, the better planning and control have led to greater customer satisfaction. In several cases follow-on contracts worth millions of dollars have resulted.

#### 5) RETURN ON INVESTMENT

Determining the return on investments (ROI) of management improvement programs is a difficult and relatively subjective process. While we have not quantitatively determined ROI, EG&G Idaho management feels quite strongly that the costs have already been recovered, based on improved performance (savings) and new work.

The management planning and control upgrade at EG&G Idaho involved the efforts of many people over a two year period. Approximately \$350,000 was spent on developing the policy, standard methods, documentation and training program. In addition another 1500 hours were invested by company managers attending courses.

In some cases, the standard methods have resulted in major savings in time and expense, due to the standardization and simplification of the project planning and control processes. In other cases, however, those managers who might not have planned or controlled their projects adequately were forced to invest additional time and effort in preparation of management plans.

On the other hand, among those company managers utilizing the standard methods, there have been no significant cost, schedule or performance problems since the program was initiated. Customers have been very happy with the approach, and several major new contracts have resulted.

#### J) CONCLUSION

The standards for project planning and control at EG&G Idaho and the associated documentation and training, represented a major effort by many people. The focus was on the "basics" of project planning and control. The approach provided guidance while allowing managers the flexibility to respond to individual project and customer requirements.

The approach may be valid for any organization dealing with a wide variety of projects, customers and requirements. At EG&G Idaho the return on investment has been considerable--in terms of productivity improvement, new business and successful project managers.



## APPENDIX A STANDARD METHOD FOR PROJECT MANAGEMENT PLANS

The following paragraphs describe the Standard Methods at EG&G. The wording is similar to that found in the actual documents. Again, the intent is to provide guidance and direction, a framework for project planning.

### 1) OVERVIEW

Management plans should be prepared for all projects. Each project management plan should include the following elements:

- Work Scope
- Work Breakdown Structure (WBS)
- Organization, Responsibilities, and Authority
- Schedules
- Budgets and Cost Estimate Basis
- Resource Allocation Plan
- Quality Program Plan (QPP)
- Health, Safety & Environmental Protection Plan
- Security Plan
- Management, Planning, and Control Plan
- Reporting Requirements
- Configuration Management Plan (CMP)
- Change Control Plan
- Appendix.

All elements should be addressed, even though for smaller activities elements may be simplified (e.g., one page, two-level WBS). If any of the elements is not applicable, the heading should be included with the statement, "This section not applicable."

In general, the body of a management plan contains summary information, with detailed or referenced material included in the Appendix. A management plan is intended to provide a formally documented cost, schedule, and scope of work. It establishes the requirements for technical performance, as well as for the management, planning, and controlling of that work.

The following paragraphs provide descriptive information on each of the standard elements of management plans. The information is intended to clarify concepts and provide summary guidance for implementation.

## 2) WORK SCOPE

The scope of work should be clearly and completely defined and documented. The statement of work scope should contain enough information to allow for development of the work breakdown structure (WBS), schedules, and cost estimates, as well as assignment of responsibilities.

The work scope is a narrative description of the work and should clearly identify the products or services to be provided to a customer. The work scope section of a management plan should address each of the following:

- purpose and background
- objectives
- scope (work definition)
- deliverables/end products
- key milestones
- requirements
  - technical requirements
  - facilities requirements
  - functional operational requirements
  - data requirements
  - special instructions
- constraints
  - technical constraints

- schedule constraints
- financial constraints
- key assumptions
- specifically excluded scope.

Summary scope statements, requirements, and other descriptive information may be included, with detailed information provided in the Appendix or by reference. Scope material should be prepared by the activity manager, program manager, or project management office, and should be updated as more definitive information becomes available.

### 3) WORK BREAKDOWN STRUCTURE

The Work Breakdown Structure (WBS) is a product-oriented hierarchy of the scope of work, and is embodied in a numbering structure that provides a system for organizing the scope in a logical manner. The WBS should be prepared in conjunction with the scope of work, should include the entire scope of work, and should be developed to the level of detail where responsibility for work performance is assigned. Responsibility for each element of a WBS should be established.

A properly prepared WBS will facilitate the following:

- ensuring better understanding of work
- planning of all work
- identifying end products and deliverables
- defining work in successively greater detail
- relating end items to objectives
- assigning responsibility for all work
- estimating costs and schedules
- planning and allocating Company resources
- integrating scope, schedule, and cost
- monitoring cost, schedule, and technical performance



- summarizing information for management and reporting
- providing traceability to lower levels of detail
- controlling changes.

The WBS provides a common framework for planning and controlling the work to be performed. It provides a common, ordered framework for summarizing information, and for quantitative and narrative reporting to customers and management.

#### 4) ORGANIZATION, RESPONSIBILITIES, AND AUTHORITY

Management plans shall identify the management organization structure and the positions or people responsible for the work. Interface requirements should also be defined. The authority of each position should be defined consistent with the responsibility of that position.

The authority and responsibility levels must be stated for functions. Organization charts are helpful but not sufficient. These responsibilities and authorities should be based upon the degree of risk assumed and centralization desired by the manager. A matrix may be used to display these relationships.

Similar statements of authority and responsibility should be established between interface organizations, including customers. These agreements shall be mutually approved.

Organizational authority and responsibilities established for short-term projects, tasks or other activities should be clearly defined. Responsibility should be assigned for all work identified on the WBS.

#### 5) SCHEDULES

All work must be scheduled. A management summary schedule that encompasses major customer and management requirements should be developed. The management summary schedule should correspond to the upper levels of the WBS, and should identify key and major milestones.

Additional levels of schedules should be developed as required, and should all be compatible with each other, the management summary schedule, and the WBS. Schedules should provide enough information to permit cost estimates for the work. Schedules should not be finalized until resource requirements (estimates) have been identified and resource allocation plans prepared.

A "baseline" schedule should be established and used as a basis for measuring schedule performance and physical accomplishment of work. Baseline schedules should always correspond to time-phased budgets prepared for the work.

Milestone schedules, networks, bar charts and activity listings are frequently required, and should be included as necessary. Detailed schedules may be provided in the Appendix, and maintained to reflect current working plans.

All schedules should be based on critical path planning and analysis. Whenever possible, schedules should identify critical activities.

#### 6) BUDGETS AND COST ESTIMATE BASIS

Budgets should be established for each element of the WBS. All budgets should be time-phased, corresponding with the planned allocation of resources, in accordance with approved schedules.

Budgets should also be based on detailed estimates developed with performing organizations. Detailed cost estimates should identify individual Company resources required (i.e., labor by discipline or craft, hot shop, computer, materials, etc.) in order to facilitate resource planning.

Detailed work package planning should be used so that detailed work scope and the basis for cost and schedule estimates are documented. Commitments from performing functional organizations should be obtained before budgets are finalized.

Management reserves, undistributed budgets, and contingencies should be identified, as appropriate. All cost estimates and budgets should be summarized and reconciled to fiscal year funding, both current and projected, at appropriate levels.

Funding sources for all work must be identified. Funding categories (i.e., operating, capital equipment, construction, work-for-others, etc.) must also be identified for all work. Budget authority must be received from the customer before expenditure of funds can be initiated.

#### 7) RESOURCE ALLOCATION PLAN

All resources required to accomplish the work described in the work scope must be clearly identified and scheduled. Detailed resource requirements, and availability of

those resources, must be identified before schedules and budgets are finalized, and commitments are made.

Examples of resources include the following:

- labor (by discipline, skill, or organization number)
- equipment (by type)
- computer (including any special software)
- materials and supplies
- physical facilities
- support services (i.e., recruiting, training, administrative)
- subcontract labor
- other (i.e., cost elements identified by accounting).

Resource planning should be based on detailed cost estimates coordinated with performing organizations. Resource planning provides the basis for establishing final schedules and budgets for program/project managers, as well as functional organization managers.

Resource requirements must be input into the Company financial planning system to facilitate companywide resource planning. Individual resource plans should be documented and communicated to Company organization (resource) managers so that total Company resource requirements can be planned more effectively.

#### 8) QUALITY PROGRAM PLAN

All work should be subject to quality considerations. Each project should prepare a quality program plan (QPP) which describes how the Company's quality system will be applied to that particular project.

QPPS are usually written by or for the cognizant manager to cover a specific program or project. They can, however, be written to encompass several programs or projects that must meet identical or very similar requirements. In general, a QPP:



- Identifies quality-related codes, standards, and regulations applicable to the activity
- Identifies organizational authorities, responsibilities, and interfaces of the participants as related to QA.
- States which elements of the company's quality system apply
- Identifies the procedures that fulfill the requirements and implements a Quality Assurance program
- Identifies the quality records to be generated and the controls on their retention.

The QPP may modify specific requirements from the Company's Quality System or requirements, as appropriate.

#### 9) HEALTH, SAFETY & ENVIRONMENTAL PROTECTION PLAN

Health, safety and environmental protection requirements should be planned for all work, including the following:

- safety documentation requirements
- interface with safety organizations
- safety evaluation of job scheduling
- hazard analysis
- preventive measures
- employee selection and training
- environmental impact
- ongoing evaluation and closeout procedures.

Any special health, safety, or environmental protection requirements should be clearly defined and methods for satisfying those requirements completely planned.

## 10) SECURITY PLAN

All work should meet appropriate security requirements. Each program or project that involves special nuclear material (SNM), classified information, or automated data processing (ADP) equipment that processes classified or sensitive information, shall prepare an appropriate security plan. The security plan for a given program or project should describe the security measures implemented to protect that program or project.

All other activities, including Company functional organizations not directly related to classified or sensitive programs or projects, should still include a security plan in their management plan. The security plan should consist of descriptive paragraphs that address work location, security education, access authorization levels, and any specific security procedures or practices for government and Company property or information protection.

## 11) MANAGEMENT, PLANNING, AND CONTROL PLAN

Each management plan should contain a description of the methods used to manage, plan, and control cost, schedule, and technical performance. This section should address documentation (including procedures), levels of management responsibility, and any contract or customer requirements. Existing procedures, systems, or documentation to be used should be referenced as appropriate.

### a) MANAGEMENT

The general approach and methods of managing the work should be described. Methods to be used for management of the tasks rather than the organization structure should be described. Specific responsibilities such as preparing work packages, authorizing work, approving changes, and collecting data for progress evaluation should be identified. Management responsibilities relating to customer interfaces should also be described. Special boards, committees, or working group charters should be discussed along with their relationship to management.

If an organization or project has procedures in place for management, these may be referenced or included as appropriate.

## b) PLANNING

This section should address the following major elements:

- cost accounts/work packages
- baselines
- technical performance plans
- review of plans.

Cost Accounts and work packages are used for detailed planning and budgeting of work. Each management plan will include one or more cost accounts and work packages (as identified in the WBS). Cost Account and Work package planning responsibilities and procedures should be described or referenced in this section.

Baselines should be established for performance measurement and reporting purposes and should be clearly defined or referenced in each management plan. Baselines should include scope, schedules, and budgets for designated WBS accounts.

Technical performance plans should also be defined, if not already included in the QPP. Technical plans should include any technical or quality criteria or requirements for the work.

Plans should be thoroughly reviewed before they are finalized or transmitted to customers. The review process should be described.

## c) CONTROL

The Standard Method for Management Control provides the policy and framework for establishing methods to be used for controlling work. The Management, Planning, and Control Plan should describe how the Standard Method for Management Control will be applied. That is, techniques, tools, and systems to be used for management control should be identified and described in the management plan.

## 12) REPORTING REQUIREMENTS

Reporting requirements for customers and Company Management should be described in the management plan. Specific reports to be prepared should be identified. Weekly, monthly, and any special reporting requirements should be outlined.

When reports, and their level of detail, have been established, a description should be prepared for the management plan which communicates content and format of the management reports. Responsibilities for generating report data, preparation of the reports, and their publication should be identified. The frequency of report publication, along with dates of when data are needed for preparation, must be included. Finally, the approval requirements and distribution list should be identified.

### 13) CONFIGURATION MANAGEMENT PLAN (CMP)

Configuration management is the process of keeping hardware, software, or other products (including systems) and related documentation in agreement. Configuration management involves establishing defined baselines, controlling changes to those baselines, and reporting status to those needing the information.

A configuration management plan (CMP) should be prepared for each major program or project. In general, each CMP should include the following elements:

- introduction
- requirements
- configuration identification
- configuration control
- reporting and status accounting.

Research activities, service functions, and other non-hardware related activities may tailor a CMP to their needs, or may make a statement as to why it is not required for the activity being planned.

### 14) CHANGE CONTROL PLAN

The methods to be used for controlling changes to the scope, schedule, and budget should be described. The following key aspects of change control should be addressed:

- documentation requirements
- procedures
- responsibilities and approval requirements



- reconciliation to baselines (baseline maintenance).

Change control can be utilized for all elements of a management plan.

## 15) APPENDIX

The Appendix may include any of the following:

- referenced technical data (i.e., technical specifications, test requirements, etc.)
- support exhibits (i.e., detailed WBS)
- detailed schedules
- detailed cost estimate support data
- work package documentation
- procedures
- example reports
- change control board (CCB) charter
- current working plans.

In general, the Appendix may include information supporting all other sections of the management plan. When management plans are expected to change frequently, the Appendix may include more information than otherwise. No more, however, should be included in the Appendix than necessary.

## APPENDIX B STANDARD METHOD FOR MANAGEMENT CONTROL

### 1) OVERVIEW

Management control addresses monitoring and management of ongoing work, after planning has been performed. In general, management control means directing and measuring work performance, comparing that performance to plans, identifying and analyzing variances, and taking corrective action as required.

Other management activities are also necessary to ensure thorough and effective control of work over the life of the activity. For instance, the start of work normally is controlled through use of a work authorization process. This ensures effective communication, controls charges, and promotes commitment to budgets and schedules. Additional analysis of performance may be required to provide a better basis for corrective actions or revisions to plans. Effective progress reporting, documentation, and change control are frequently critical to a manager's success.

The Standard Method for Management Control and the descriptive information that follows provide a framework for addressing those key aspects of monitoring and controlling work. The information is intended primarily for guidance. Each manager is responsible for selecting appropriate techniques for monitoring and controlling his or her work and describing them in a management plan.

### 2) STANDARD METHOD FOR MANAGEMENT CONTROL

All work must be monitored and controlled. Management control includes the following activities:

- work authorization
- work direction
- performance measurement
- performance evaluation
- corrective action and change control
- performance reporting and documentation.

Each of these activities must be planned and performed. A general flow diagram of the management control process is shown in Figure 2.

Specific methods and techniques for accomplishing management control activities should be selected based on the size and nature of the work, individuals involved, and tools, systems, and procedures in use within the Company. The techniques, tools, and systems to be used for management control should be identified and described in the management plan prepared for the work.

Each manager is responsible for ensuring that his work is fully planned and controlled. Effective management control will ensure that work is authorized and performed in accordance with approved plans, that performance is adequately monitored and analyzed, and that deviations from plans are identified early so that corrective actions or changes are possible. It can also ensure that those actions and changes are controlled in a systematic manner, and that performance is adequately communicated to those with a need to know.

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FIGURE 2. MANAGEMENT CONTROL PROCESS.

### 3) WORK AUTHORIZATION

All work should have an authorizing document. This applies to agreements with outside entities (external authorizations) as well as work to be performed within the Company.

#### a) EXTERNAL WORK AUTHORIZATION

Figure 3 provides a summary of the flow and type of documents used at EG&G Idaho for proposing new work scope and receiving authorization. As shown, various documents are used in this process depending on the source of funds.

Work should not start until an authorizing document is received. Under no circumstances can actual program or project work be charged to an unauthorized account, pending receipt of funding.

#### b) INTERNAL WORK AUTHORIZATION

Once official external authorization to start work is received internal work authorizations can be prepared. Documented work authorizations are required for formalizing agreements between performers and requestors within the company.

At EG&G Idaho cost account and work package documentation provides the formal basis for authorizing work. Cost accounts and work packages correspond to low levels of the project WBS, where performance responsibility is established. In addition, "Work Releases" are used to document agreements between internal company organizations involved in requesting and performing work.

Cost account, work package and work release documentation formally establish scope, schedule, and budget at the level where work is performed.

By using work authorization procedures, requestors and performers of services have a system for authorizing and accepting work scope, a basis for comparison to measure work progress, and a reference point for negotiating changes to original agreements. With this formal system, accountability and performance are improved.



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FIGURE 3. EXAMPLE OF EXTERNAL WORK AUTHORIZATIONS.

#### 4) WORK DIRECTION

Managers must ensure that all work is performed in accordance with work authorizations and management plans. Managers should be involved to the extent necessary to ensure that the work is performed in a smooth, productive manner rather than a reactive mode that eventually may require corrective actions and revisions.

Directing work generally involves such activities as supervising, motivating, and coordinating those individuals performing the work. Several methods that have contributed to successful work completion at EG&G are discussed below.

#### a) PERFORMER BUY-IN

Successful completion of a task or delivery of an end product is dependent on work accomplished by performers. Without their knowledge of and buy-in to the task, schedule, and end product, the best project management plan may be useless.

Input from performers should be obtained during the planning stage, not after work gets to the field where changes, corrections, and improvements will have a larger impact on cost and schedule. Up-front involvement of performing organizations better ensures availability of required resources (such as number and types of people and equipment) and can provide valuable input based on expertise and experience.

As a minimum, performers must be involved when work performance is initiated. Size, complexity, or schedule constraints of a task may determine the methods used to disseminate information and achieve performer buy-in. Small tasks with minimal complexity and schedule constraints may be handled with descriptive work package or work release documentation. Complex tasks with tight schedules, however, may require an initial meeting and follow-up sessions with the performers to maintain information flow and performance levels.

#### b) IN-THE-FIELD ASSISTANCE

Work performance can be handicapped when ready access to technical assistance is limited, particularly in complex tasks performed by functional or service groups. The assignment of a technical representative to follow the work, provide advice and assistance where necessary or requested, make field changes, coordinate with other areas of expertise, and provide a single point of contact for performers may greatly enhance the work performance.

#### c) CLEARLY DEFINED RESPONSIBILITIES AND AUTHORITY

Responsibilities and authority should be well defined during the planning stage. Performers, however, may not see the planning document. This information needs to be conveyed to the performing groups. Again, complexity of the task may determine the method of disseminating this information. Generally, it can be communicated via work release

or work package documents. As a minimum, one level of responsibility and authority above the performer should be identified.

#### d) MANAGEMENT BY WALKING AROUND (MBWA)

Open communication with performers is often a key to success. Management By Walking Around (MBWA) can help achieve that communication. During work performance, managers should practice MBWA, maintaining direct contact with performers. Not only does this open and maintain communication channels, but it also demonstrates the manager's interest and desire for successful completion of the work. Practice of this concept directly supports the other methods of directing work performance discussed above, i.e., achieves better performer buy-in, provides additional in-the-field assistance, and better identifies responsibility and authority.

#### 5) PERFORMANCE MEASUREMENT

To ensure that objectives are attained, management must periodically measure cost, schedule and technical performance against the authorized baseline. Status should be measured at the level where work is performed and summarized to appropriate levels of the WBS. Performance measurement data are essential for communicating progress and status to management and customers during periodic work reviews. Good performance measurement also provides the basis for other management activity (i.e., corrective actions, replanning, reporting) over the life of the activity.

##### a) COST/SCHEDULE PERFORMANCE MEASUREMENT

COST/SCHEDULE BASELINE. Measurement of cost and schedule performance is vital in determining work progress. During early management planning, a cost and schedule baseline must be established. This baseline is the planned cost and schedule performance against which the actual cost and schedule performance are compared.

It is important during the planning process that work is sufficiently subdivided into increments having milestones and/or end products so that completion of work can be readily identified and a cost and schedule assigned to it. Long work increments (tasks or activities) spanning several months with no intermediate milestones should be avoided, as measurement of progress in those cases is difficult.

Cost Collection. All cost data are collected by the Company's Cost Accounting System. Included in these data are labor



charges, computer billings, subcontracts, material charges, and other resources used in completing a job. Cost reports that display the actual cost of work charged against a job on weekly and monthly intervals, and the year-to-date accumulated costs charged to that job should be available.

Schedule Status. Schedule status should be measured at least monthly for all work. The objectives of schedule status are not just to measure work progress, but to identify any scheduling problems that may require management action. Schedule status can be reported by such methods as networks, bar charts, milestone reports, activity reports, and earned value. Regardless of the technique selected, the critical path should be monitored and impacts to it identified.

The complexity of performing a schedule status is often dependent upon the size of a task, interrelationships of the activities, or the task duration. Schedule statusing can be done manually or by use of automated computer systems. On small projects, it is possible to manually status a task using a single technique. On large projects, an automated system and a combination of scheduling techniques (e.g., earned value, networks, milestone charts) should be used to ensure complete schedule status.

Earned Value. The earned value technique can be used to obtain cost and schedule status. Earned value is defined as the budget applicable to the work actually accomplished. It is generally termed the budgeted cost of work performed (BCWP).

The traditional method of measuring work progress has been to compare the actual cost of work performed (ACWP), obtained from cost reports, against the budgeted cost of work scheduled (BCWS), obtained from the baseline. This method compares actual costs against expected costs but is deficient in that it does not account for work actually accomplished.

For earned value to be effective, the baseline must be prepared in sufficient detail to allow accurate measurement of work progress, as well as the ability to determine the budgeted costs of each increment of work statused. If this is properly done, both cost and schedule variances can be obtained as follows:

$$\begin{aligned} \text{Cost variance (CV)} &= \text{BCWP minus ACWP} \\ \text{Schedule variance (SV)} &= \text{BCWP minus BCWS.} \end{aligned}$$

Performance can be measured in other ways using earned value data. One of the more popular ways is to use performance



indices (PI) which measure the efficiency at which work is being performed. Both cost and schedule can be measured using the following relationships:

$$\text{Cost Performance Index (CPI)} = \frac{\text{BCWP}}{\text{ACWP}}$$

$$\text{Schedule Performance Index (SPI)} = \frac{\text{BCWP}}{\text{BCWS}}$$

Calculations of CV, SV, CPI, and SPI are shown in Figure 4. Basic earned value data elements in graphic form are shown in Figure 5.

Earned value can be used to obtain performance measurement data on cost and schedule, but should not be used exclusively. The schedule variance contains no critical path or milestone status. The cost variance should also be reviewed carefully if labor and material dollars have not been separated.

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FIGURE 4. CALCULATION OF VARIANCES AND PERFORMANCE INDICES USING EARNED VALUE DATA.

XX

XX

FIGURE 5. COST/SCHEDULE PERFORMANCE CHART WITH  
VARIANCES IDENTIFIED.

#### b) TECHNICAL PERFORMANCE MEASUREMENT

Technical performance measurement (TPM) should be used as a supplement to cost and schedule performance measurement. If only cost and schedule performance are measured, the adequacy of the technical performance to meet the requirements is often assumed. Unfortunately, this may not be true.

TPM assesses technical characteristics of a system, facility, or product and identifies problems through review, analysis, or tests that compare performance achieved with performance criteria. TPM criteria can be found in many documents. Design,

procurement, or construction specifications are the most likely places for such information. These documents provide specific criteria, limits, and tolerance bands to which performance can be compared. TPM criteria should be identified in the management plan.

## 6) PERFORMANCE EVALUATION

All performance should be evaluated on a routine basis by management. Performance evaluation is a process of assessing performance measurement information, forecasting future performance, and determining necessary actions. Evaluation generally means assessing any significant variances or trends and determining what, if any, action is required.

### a) VARIANCE ANALYSIS

Significant cost, schedule and technical variances must be identified as early as possible. Variances are deviations from agreed upon plans (baselines). Significant variances are those deviations exceeding an agreed upon threshold. therefore requiring formal evaluation and, perhaps, corrective action.

Variance analysis must be performed on a routine basis and is generally accomplished in conjunction with performance measurement. In general, variance analysis addresses:

- variance identification
- causes of variance
- impact of variance
- corrective action.

### b) VARIANCE IDENTIFICATION

Cost variances can be identified when cost/schedule status has been measured and actual costs are available. True cost variance identification requires that performance be planned and measured such that the actual cost can be compared to budgeted costs for work actually accomplished. Earned value is the preferred method for identifying true cost variances.



Spending variances are similar to cost variances but are comparisons of costs based on time periods rather than work accomplished. Identification of spending variances is important for monitoring expenditure rates and impacts on funding. Spending variances may reflect cost variances, schedule variances, or both.

Schedule variances should also be identified and assessed on a routine basis. When actual schedule status of work is measured, it can be compared to planned schedule status. Generally, schedule variances should identify time ahead or behind schedule. Assessment of critical path can be important for addressing schedule variances on an exception basis, where variances of critical activities become the most important. Schedule variances can also be identified in terms of value of work ahead or behind schedule, when earned value methods are used for performance measurement.

Variances at completion (VAC) are based on comparisons of estimates at completion (EAC) to budgets at completion (BAC) for an activity or time period. VAC generally refers to expected cost variances, but may also refer to expected completion schedules. For instance a schedule VAC may mean a task is expected to be completed sooner or later than planned.

Technical variances can frequently be identified when evaluating cost or schedule variances, especially when quantities are involved. Variances in technical quality, however, should also be identified based on planned comparisons to specifications, requirements or other technical baselines. Technical variances frequently have cost and schedule implications.

### c) CAUSE OF VARIANCE

Significant cost, schedule, and technical variances should be evaluated and understood. Generally, explanations of significant variances are also required in progress reports along with a description of a corrective action plan.

In all cases the physical and/or technical cause of a variance should be identified and explained. That is, specific reasons should be addressed in explaining variances. For instance, an unplanned technical complication may explain why additional hours were required to complete an activity. In another case, late delivery of equipment may be due to problems in fabricating certain components.

When specific causes are identified, corrective actions can result. If variances are not well explained or understood, it becomes difficult for management or performers to determine necessary actions.

#### d) IMPACT OF VARIANCES

Cost, schedule and technical variances may have a variety of impacts on other work. A critical schedule variance may delay an entire project, or may impact a major milestone. Significant cost variances may offset one another, or may have a major impact on funding. A technical variance or problem may significantly impact the quality of the product, the cost or the completion date. The impact of significant variances should always be addressed so that potential problems are not overlooked.

#### e) TREND ANALYSIS

Trend analysis generally involves identification of significant trends and forecasting of final cost or schedule conditions based on those trends. Significant cost or schedule performance trends should be identified as early as possible in the life of an activity.

Performance trends can be identified and evaluated by reviewing performance variances over a period of time, i.e., several weeks, months, or years. Trends can also be analyzed by performing statistical analysis of performance data.

#### f) FORECASTING

Forecasting of cost and schedule performance refers to the process of calculating, estimating, or predicting future events or performance, based on past or present performance information. Both estimates to complete (ETC) and EACs should be reviewed on a regular basis and updated to reflect significant changes. Good forecasting should enable managers to resolve problems and meet commitments to sponsors for customers.

EAC Updates. EACs may be evaluated and updated using either manual or statistical methods. Generally, EACs should involve either manual preparation or review, to ensure that known future events are adequately considered.

Routine (monthly) reviews of EACs should normally involve review of performance to date (including variance analysis), assessment of work remaining, and evaluation of projected at-completion conditions. For instance, if detailed EACs are revised, impact on total cost, management reserves, or funding should be evaluated.

For many programs and projects, detailed bottoms-up forecasting of work remaining is conducted every six months. This represents an opportunity to verify ETCs and EACs for all work.

Forecasting, however, is not the same as rebaselining and does not mean budgets should be changed. Budget changes must be formally approved and affect baselines used for measuring performance. Forecasting is a routine management control activity related to estimating what final costs and schedules will be.

Statistical Forecasting. Statistical methods may be used to calculate EACs, based on performance and trend information. The most common method involves use of earned value data to extrapolate past performance into the future. Other methods involve factoring for future performance. If statistical methods are used, they should be reviewed very carefully, or should only be used as indicators, for comparison with manually prepared EACs.

#### g) REVIEW MEETINGS

Periodic participative review meetings can be extremely beneficial for evaluating performance, communicating information, and obtaining commitment to corrective actions.

Management plans should be used as a basis for evaluation and discussion. Key technical issues, milestones, and cost performance should be reviewed with responsible performers. Variances and trends should be discussed, causes determined, and corrective action plans communicated.

Periodic review meetings are often requested by customers. If performance has been thoroughly evaluated, review meetings with customers can be an effective means of demonstrating management control as well as communicating status. Meetings offer an opportunity for discussing issues that may arise from progress reports.



## 7) CORRECTIVE ACTION AND CHANGE CONTROL

The management plan is the manager's attempt to forecast the future. However, rarely do events go exactly as planned. Delays, unanticipated activities, requirements to change schedule, and other events are the reality in which the manager's plan is implemented. The management plan becomes the baseline against which performance is measured. Having measured and evaluated performance against the baseline, periodic mid-course corrective actions may be required. Corrective actions must be well planned, controlled, and documented in accordance with the change control requirements of the management plan.

### a) CORRECTIVE ACTION

Corrective action depends upon the degree and nature of variance from the baseline, revealed during performance evaluation. If the work is proceeding as planned, little or no corrective action may be required. The response to an ahead-of-schedule, under-budget condition will be different than to a behind-schedule, over-budget condition. A major problem may require significant and substantial corrective action which takes the form of a recovery plan. Behind-schedule, over-budget corrective action is directed at getting back on the baseline.

Corrective action is not, in itself, a change to the baseline. While rebaselining may be appropriate and required at times, corrective action and rebaselining are separate activities. The baseline is a commitment to customer and/or management and should only be changed in accordance with approved change control methods.

Corrective actions can range in degree of formality from the day-to-day adjustments in resources, schedule, and direction to major recovery plans. The management plan cannot anticipate all corrective actions that may arise in the course of its implementation; however, the plan's Management, Planning and Control Section should govern the methods of performance measurement, evaluation, corrective action, and change control.

The management plan itself may require revision to reflect changes in the work scope and management methods. The management plan should be a useful living document and should be maintained to reflect current conditions.



## b) REPLANNING

The need for replanning may arise from a change of work scope, funding, or schedule requirements, or a departure of actual performance from plans, which requires corrective action. The distinction can be important for maintaining the integrity of baseline commitments and to ensure accountability. The baseline must be controlled and change control procedures utilized at all times.

A corrective action plan will often require replanning of the budget and schedule for the affected work. Work packages, work authorizations, and other affected documents should be revised. Replanning will involve most or all of the thought processes and communication steps involved in the original planning. Good communication should drive the documentation requirements of the replanning effort. Anyone directly affected by the changes should participate in development of the new plan. Replanning should include an assessment of the management plan to see if essential requirements are affected. Sections of the management plan most likely to be affected by replanning are work scope, WBS, schedules, budgets, and resource allocations.

Other sections of the management plan may also be affected and should be reviewed or revised as required. All replanning must be reconciled with funding, baseline budgets, and schedules. Replanning should not include attempts to modify history, but should be oriented toward remaining work.

## c) CHANGE CONTROL

All changes, whether associated with rebaselining or corrective action replanning, should be closely controlled. Change control generally means an appropriate documentation, review, and approval process. Change control procedures to be used should be clearly defined in the management plan.

Change control regarding the use and commitment of management reserve may be required in the course of planning and implementing corrective action. Procedures for use of management reserve, including authority and documentation, should be covered in the management plan.

## d) MAINTENANCE OF PLANS

Management plans and work packages should be kept current, reflecting approved changes in work scope, schedules, and budgets. Incorporation of corrective action plans into the

management plan may also aid in establishing visibility for responsibility and tracking of the corrective actions. Unique aspects of a corrective action may require supplemental reporting until work is back on track. Any additional reporting requirements should be part of the corrective action plan.

## 8) PERFORMANCE REPORTING AND DOCUMENTATION

The project management plan should identify the reports and major documents required. Periodic progress reports should be identified and the frequency, content, and format described in detail.

Documents ultimately become records, and retention and storage requirements should be described or referenced. If a project has unusual documentation requirements, this must be communicated to the people involved. Reports and other documentation are expensive to prepare and their use should be carefully planned and controlled.

Reports and other documentation may be both products and management tools. Progress reports contain information used to perform analyses and ascertain status of the work. Reports are also used to document historical aspects of the work and have value for follow-on operations and future modifications.

### a) PROGRESS REPORTS

Periodic progress reports should be prepared for all programs and projects and should address the major subjects discussed in the following sections.

Technical Progress. Each progress report should describe accomplishments for the period being reported. The technical progress report describes completed tasks and tasks in progress. The report should permit task by task comparison with the WBS.

Cost/Schedule Status. Each progress report should include schedule status and a cost report. These may be displayed graphically, or as tabular schedule and cost reports. These may be combined with the technical progress information to produce an earned value performance report which also may be displayed in either tabular or graphic form. Cost and schedule status reporting should always be compared to an established plan and dated to a time-now point.

Variations and Problems. Significant variations should be identified in progress reports and fully explained. The cause and impact of variations should be included. Any major problem or potential problem should be discussed. Hiding problems from customers or management can frequently result in lost credibility or failure to take timely corrective action. Early identification of variations and problems allows managers more time to plan and execute corrective actions (recovery plans).

Use of Progress Reports. Know your customer and use reports that meet his or her needs as well as your own. Reports cost money and should be used only if necessary. Reports must also be accurate and timely. Managers must ensure the accuracy of reported information before taking corrective action.

#### b) DOCUMENTATION

Documentation requirements must be explicitly specified at the start of the task. Management must then make sure that documentation is completed along with other aspects of the job. Normally the documentation to be controlled will be addressed in a Configuration Management Plan (or section of the Project Management Plan).