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WORKSHOP READ-AHEAD MATERIAL

A Framework for Software Acquisition Early Warning Indicators

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1.0 Introduction

The acquisition of large software-intensive systems has historically been fraught with major problems, including performance deficiencies, extensive software defects, and cost and schedule overruns. This trend has continued with recent failures of high-profile acquisition reform programs due to software-related problems. On these programs, as in the past, an understanding of the extent and severity of the software problems was not achieved until very late in the development life cycle. This resulted in large unanticipated cost and schedule impacts. These emerging realities led to the "Bell-Ringing" research initiative. The goals of this research initiative are 1) to identify and classify the qualitative and quantitative factors that could influence acquisition success and 2) to develop a set of "bell-ringing" criteria that could be used as early warning indicators of actual or potential problems in the acquisition of software-intensive systems. The activation of the early warning indicators would then signal the need for additional management attention for those influencing factors. This technical report documents the research initiative results for the first goal: the framework for software acquisition early warning indicators.

The research initiative determined that acquisition success depended on many more organizational entities than just the SPO and the contractor team involved in the system acquisition. Among others, they included the DoD and Air Force acquisition organizations and the company organizations external to each contractor development team member. The research discovered that the SPO (including its FFRDC and SETA support) could be viewed as the neck of the acquisition hourglass (See Figure 1 for a representation of this hourglass). This figure identifies, at a high level of aggregation, the primary organizational entities that contribute to the success or failure of an acquisition. This discovery indicated that the qualitative and quantitative factors to be included in the "bell-ringing" criteria must encompass the impact of all of these organizations.

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Figure 1 Organizational Entities Impacting Program Success

The framework for classifying the early warning indicators of actual or potential software development problems includes both quantitative and qualitative indicators derived from the factors that influence the success of software-intensive system acquisitions. These indicators provide the foundation for defining and satisfying the realistic information needs of the acquisition manager. Within the software acquisition early warning framework, there are five top-level factors influencing the success of software-intensive system acquisitions. These five top-level factors are:

1) Acquisition Environment: influences from the acquisition environment external to the acquisition System Program Office (SPO),
2) Acquisition Program Office: influences from the acquisition SPO,
3) Contractor Environment: influences from the contractor team's management and enterprise environment,
4) Product Development: influences from the contractor team's product development activities, and
5) Unification: influences from the interrelationships among the first four areas.

Figure 2 depicts the nested relationship of these source areas and provides a brief summary of their content.

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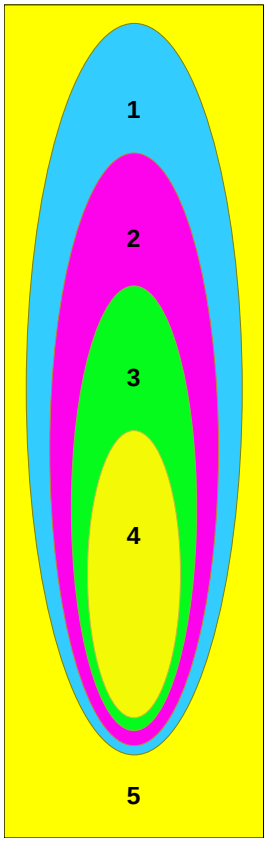

1. Acquisition Environment – Influences from acquisition-related organizations external to the SPO, including acquisition management, user/operator, independent test and certification, interfacing system, support, and Government provider (e.g., GOTS, GFE/GFI, facilities) organizations
2. Acquisition Program Office – Influences from the SPO itself, including everyone from the SPO director down through the lowest level personnel, plus Aerospace, other FFRDCs and SETA contractors that support the SPO
3. Contractor Environment – Influences from contractor team organizations external to contractor team's engineering organizations, including corporate and program management, quality assurance/software quality assurance, contracts, scheduling, and organizational process improvement groups
4. Product Development – Influences from contractor team engineering organizations, including systems engineering, software engineering, specialty engineering, test organizations, and configuration management
5. Unification – Influences from the interrelationships among the first four factors, such as customer satisfaction, communication and agreements

Figure 2 Software Acquisition Early Warning Framework Organization and Contents

The framework for software acquisition early warning indicators extends the approach to classifying indicators and measures defined by the Practical Software and System Measurement (PSM) project[1]. The PSM approach is incorporated into the fourth top-level factor containing the influences from the contractor team's product development activities. However, concepts from the PSM approach are used throughout the framework for software acquisition early warning indicators.

Ishikawa diagrams are used to document the qualitative and quantitative factors that impact acquisition success identified by this research initiative. The rationale for selecting Ishikawa diagrams and a definition of how they are used in this technical report is contained in Figure 3. The Ishikawa diagram for the five top-level factors is shown in Figure 4.

The remainder of this technical report is divided into five sections, one for each of the top-level factors. Each section begins with a detailed description of the factor and includes an Ishikawa diagram that shows the sub-factors and influences associated with the top-level factor. Following the initial factor description is a detailed description of

[1] See McGarry, John, et al. Practical Software Measurement: Objective Information for Decision Makers. Addison-Wesley, Boston, Massachusetts, 2001.

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each subfactor and its associated influences shown on the Ishikawa diagram. Finally, one or more tables are provided that identify qualitative or quantitative metrics that can be used as an indication that the associated factor, subfactor or influence needs additional management attention.

This technical report is intended to be a living document that is updated as additional software acquisition early warning indicators are identified. However, the framework itself, consisting of the factors, subfactors and influences described in the sections below, is expected to be general enough to accommodate additional software acquisition early warning indicators without requiring substantial change to the framework structure.

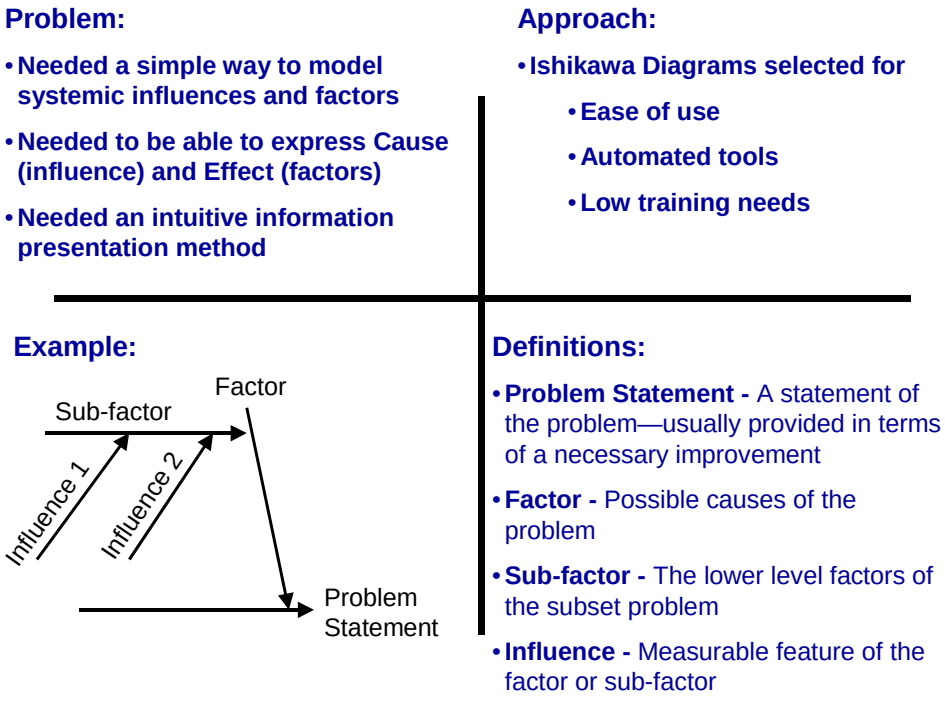

Figure 3 Ishikawa Diagram Selection Rationale and Description

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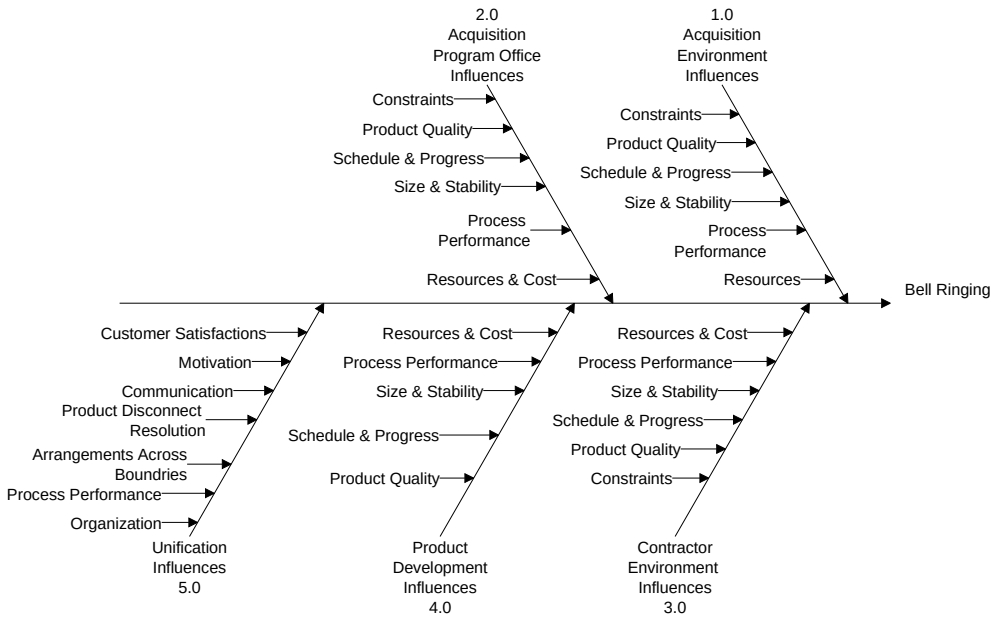

Figure 4 Framework for Software Acquisition Early Warning Indicators: Top-Level Factors

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2.0 Acquisition Environment Factor

This factor covers influences from organizations and functions external to the Acquisition Program Office. These organizations and functions are out of the scope of control of the Acquisition Program Office, but nevertheless can have significant adverse influences on the program under consideration. Only the work performed by the organizations and functions in the Acquisition Environment factor that is related to the program under consideration are included here. The influences of other work being performed by the organizations and functions in the Acquisition Environment factor are included indirectly (e.g., by sufficiency of interfacing personnel or by action item cycle time).

Influences from the following types of organizations and functions external to the Acquisition Program Office are considered under this factor:

- Acquisition management organizations
  - System Program Director (SPD) (i.e., local program management above the System Program Office (SPO) director)—depending upon scope of the assessment (See Section 3)
  - Program Executive Officer (PEO) (or equivalent level of management)
  - Office of the Undersecretary of the Air Force for Space, Director of the National Reconnaissance Office (NRO)
  - Other Air Force and Department of Defense (DoD) acquisition and policy making organizations
  - Congress
  - Staff organizations related to all of the above
  - Organizations providing tools for acquisition functions (e.g., source selection tools, risk management tools, cost performance tools)
- User/operator organizations (e.g., Air Force Space Command)
  - In some programs, the users and operators are different organizations; in other programs they are the same
- Independent test and certification organizations
  - Air Force Operational Test and Evaluation Center (AFOTEC) or other independent operational testing organizations
  - Security accreditation organizations
  - Safety certification organizations
  - Other mission-specific certification organizations (e.g., Integrated Threat Warning/Attack Assessment (ITW/AA))
  - Operations and Maintenance (O&M) validation organizations (e.g., logistics organizations responsible for validating O&M manuals/instructions and training materials)
- Interfacing system organizations
  - External systems with which the system under development must interface (may or may not be under concurrent development or upgrade)
- Government provider organizations

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    - Government Off-the-Shelf (GOTS)-software provider organizations
    - Government Furnished Equipment (GFE)/Government Furnished Information (GFI) providing organizations (e.g., other programs providing GFE hardware and/or software to be incorporated into the system under development, or Government organizations providing essential data to the system under development)
    - External technology organizations (e.g., Air Force Research Laboratories (AFRL), Naval Research Laboratory (NRL), other Government laboratories, universities) providing hardware and/or software to be incorporated into the system under development or providing essential data to the system under development
- Facility provider organizations
    - Organizations responsible for the Eastern and Western launch ranges and associated satellite/launch vehicle integration and checkout facilities
    - Organizations responsible for operating and maintaining the operational facilities in which the system under development will be installed and operated
    - Organizations responsible for operating and maintaining integration and testing facilities in which the system under development will be integrated and tested
    - Military construction organizations
- Support organizations
    - In some programs, the operator and support organizations are the same; in others, they are different (e.g., logistics organizations)
    - Organizations responsible for logistics support (e.g., hardware and software maintenance organizations, training organizations)
- Line management organizations
    - The line management chain may or may not be the same as the acquisition management chain
    - Staff organizations related to line management organizations (e.g., responsible for personnel functions, facilities, computer hardware and software resources and infrastructure)
- Program-unique external organizations and functions that influence the success (or lack thereof) of the program

The organizations and functions in the Acquisition Environment factor produce the following types of products:

- Externally imposed system requirements (e.g., capability requirements in Initial Capabilities Documents (ICDs), Capabilities Development Documents (CDDs), and Capabilities Production Documents (CPDs); user requirements (e.g., Operational Requirements Documents (ORDs); interface requirements/interface control documents; Key Performance Parameters; Acquisition Program Baseline (APB) requirements)
- Concepts of Operation (CONOPS) from user/operator organizations
- Systems with which the system under development must integrate (both pre-existing systems and those undergoing concurrent development or upgrade)
- Interface control documents (if externally generated)

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- Testing/certification requirements and test products (e.g., plans, procedures)
- Requirements imposed by facility providers (e.g., range safety requirements, facility installation requirements)
- Externally imposed requirements interpretations (documented and undocumented)
- Externally imposed program cost and schedule requirements (e.g., in the APB, Program Objectives Memorandum (POM), etc.)
- GFE/GFI provided products and information to be incorporated into the system
- Laws, regulations, policies and initiatives externally imposed on the program (e.g., by Congress, DoD, NRO, Air Force, Space and Missile Systems Center (SMC))
- Cost and schedule constraints levied on the program (e.g., by Congress, DoD, NRO, Undersecretary of the Air Force for Space, Space Command)
- Regulations and procedures governing use of facilities (e.g., for launch ranges, operational and testing facilities)
- Tools for acquisition functions (e.g., source selection tools, risk management tools, cost performance tools)

While the organizations and function in the Acquisition Environment can have large impacts on the program, generally the internal workings of the organizations in the Acquisition Environment factor will not be observable. Only the aspects of the Acquisition Environment factor directly observable by the Acquisition Program Office or contractors are evaluated under this factor.

The subfactors in the Acquisition Environment factor are shown in Figure 5. There are six subfactors that address resources, process performance, size and stability, schedule and progress, product quality, and constraints. Each subfactor contains influences shown in Figure 5 and Tables 1 and 2. Each influence contains metrics, as shown in Tables 1 and 2. The influences and metrics are described in more detail in the text below.

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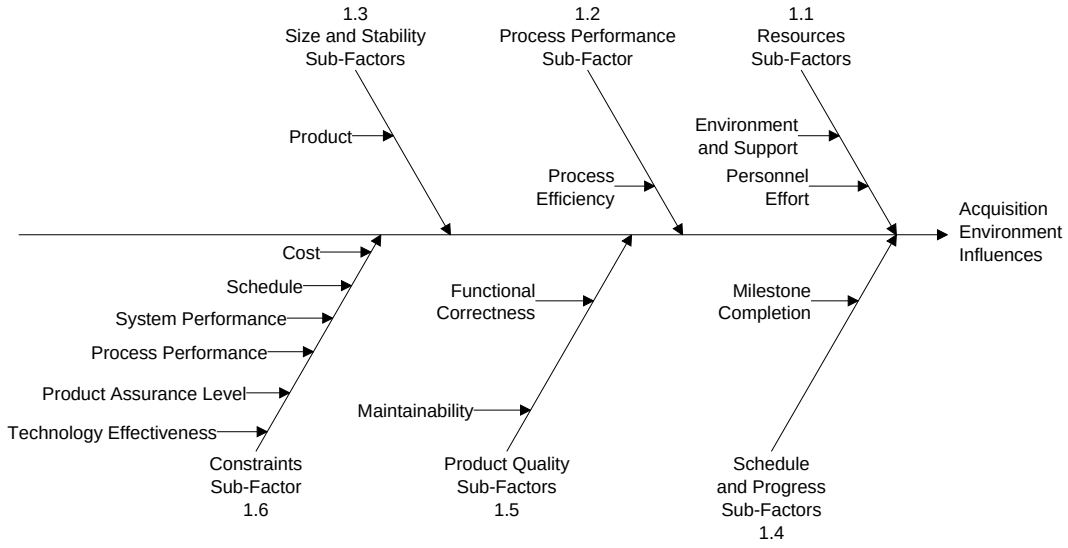

Figure 5 - Acquisition Environment Influences

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2.1. Resources Subfactor

This subfactor contains the influences of the resources associated with the organizations and functions included in the Acquisition Environment factor.

a. Personnel Effort

This influence covers the personnel effort for the people performing the functions in the Acquisition Environment factor. The personnel effort can only be observed for those people from the Acquisition Environment who interface with the Acquisition Program Office and contractors. Therefore this influence covers only what can be observed about these interfacing personnel resources.

- Staff Interface Level (Number and sufficiency of assigned personnel)
- Staff Interface Turnover (Stability of assigned personnel)

b. Environment and Support

This influence addresses the sufficiency of the infrastructure and support facilities (e.g., launch facilities, integration and testing facilities, operations facilities) needed by the program that are provided by organizations and functions in the Acquisition Environment. These infrastructure and support facilities may be dedicated to this program or shared by multiple programs.

- Quantity Needed/Available (how many and when)
- Time Needed/Available (how much and when)
- Fidelity and Quality of Resources (e.g., fidelity of integration and testing facilities needed/available, suitability of facility resources)
- Time Used

2.2. Process Performance Subfactor

This subfactor contains influences of the processes used by the organizations and functions in the Acquisition Environment factor to perform the work and produce the products for which they are responsible. Only the aspects of these processes that can be directly observed by the Acquisition Program Office or contractors are addressed here.

a. Process Efficiency

This influence relates to the efficiency of the processes used by the organizations and functions in the Acquisition Environment factor to do their work. Only the efficiency of the processes used in the Acquisition Environment factor that can be observed externally are addressed here.

- Cycle Time (for action items or change requests originated by the Acquisition Program Office and contractors)

2.3. Size and Stability Subfactor

This subfactor addresses the size and stability of the products produced by the organizations and functions in the Acquisition Environment factor.

a. Product

This influence addresses the size and stability of the products produced by the organizations and functions in the Acquisition Environment factor that are used by the Acquisition Program Office and contractors.

- Products (Number of products, size of products (e.g., number of pages, number of requirements))

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- Product Changes (Number of additions, number of deletions, number of changes to products across time)

2.4. Schedule and Progress Subfactor

This subfactor addresses the schedule and progress of the work performed by the organizations and functions in the Acquisition Environment factor.

a. Milestone Completion
   This influence addresses the Milestone Completion for the work performed by the organizations and functions in the Acquisition Program Office factor for those milestones that affect the program under consideration and that can be observed externally by the Acquisition Program Office or the contractors.
   - Milestone Dates (Planned and actual; number of days slipped)

2.5. Product Quality Subfactor

This subfactor addresses the quality of the products produced by the organizations and functions in the Acquisition Environment factor that are used by the Acquisition Program Office or contractors.

a. Functional Correctness
   This influence addresses the functional correctness of the products produced by the organizations and functions in the Acquisition Environment factor that are used by the Acquisition Program Office or contractors.
   - Completeness (Number of To Be Determined's (TBDs))
b. Maintainability
   This influence addresses the complexity of the products produced by the organizations and functions in the Acquisition Environment factor that must be used by the Acquisition program office or contractors.
   - Complexity

2.6 Constraints Subfactor

This subfactor addresses the various constraints imposed by the organizations and functions in the Acquisition Environment factor on work performed by the Acquisition Program Office and contractors.

a. Cost
   This influence addresses cost constraints imposed on the Acquisition Program Office and contractors by the organizations and functions in the Acquisition Environment factor. It also addresses volatility in the cost constraints.
   - Total Dollars Profile (by color of money and total)
   - Fiscal Year Dollar Profile (by color of money and total, e.g., from the Future Years Defense Program (FYDP))
   - Volatility (Changes in cost constraints)
b. Schedule
   This influence addresses schedule constraints imposed on the Acquisition Program Office and contractors by the organizations and functions in the Acquisition Environment factor. It also addresses volatility in the schedule constraints.
   - Fixed Milestone Dates
   - Volatility (Changes in schedule constraints)
c. System Performance

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This influence addresses system performance constraints imposed on the Acquisition Program Office and contractors by the organizations and functions in the Acquisition Environment factor. It also addresses volatility in the system performance constraints. The following list includes examples of system performance constraints.

- Timing
- Accuracy
- Reliability/Availability (e.g., Mean Time Between Failure (MTBF), A_o)
- Maintainability (e.g., Mean Time to Restore (MTTR), Mean Time to Repair (MTR)
- Measures of Effectiveness (MOEs)/Measures of Performance (MOPs)
- Quantitative Performance Requirements (QPRs) from Interfacing Systems
- Volatility (Changes in system performance constraints)

d. Process Performance

This influence addresses the process performance constraints imposed on the Acquisition Program Office and contractors by the organizations and functions in the Acquisition Environment factor. It also addresses volatility in the process performance constraints.

- Capability Maturity Model® for Software (CMM®) / Capability Maturity Model® Integration℠ (CMMI®) Goals[2]
- Processes (Number, size of imposed processes)
- Volatility (Changes in process performance constraints)

e. Product Assurance Level

This influence addresses the level of product assurance imposed on the Acquisition Program Office and contractors by the organizations and functions in the Acquisition Environment factor. It also addresses volatility in the product assurance level constraints. The following list includes examples of types of product assurance level constraints.

- Safety
- Security
- Quality (e.g., Independent Operation Test and Evaluation (OT&E))
- Independent Verification and Validation (IV&V)
- Volatility (Changes in product assurance constraints)

f. Technology Effectiveness

This influence addresses the influence of technologies imposed on the Acquisition Program Office and contractors by the organizations and functions in the Acquisition Environment factor. It also addresses volatility in the technology effectiveness constraints.

- Suitability
- Readiness (Technology Readiness Levels (TRLs))
- Volatility (Changes in technology effectiveness constraints)

[2] Capability Maturity Model, CMM®, and CMMI® are registered in the U.S. Patent and Trademarks Office by Carnegie Mellon University. Capability Maturity Model Integration is a Service Mark (SM) of Carnegie Mellon University.

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Table 1 - Acquisition Environment (Part 1)

Factor	Sub-Factor	Influence (Issue)	Metric
Acquisition Environment	Resources	Personnel Effort	Staff Interface Level Staff Interface Turnover
		Environment and Support	Quantity Needed/Available Time Needed/Available Fidelity & Quality of Resources Time Used
	Process Performance	Process Efficiency	Cycle Time
	Size and Stability	Product	Products Product Changes
	Schedule & Progress	Milestone Completion	Milestone Dates
	Product Quality	Functional Correctness	Completeness
		Maintainability	Complexity

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Table 2 - Acquisition Environment (Part 2)

Factor	Sub-Factor	Influence (Issue)	Metric
Acquisition Environment	Constraints	Cost	Total Dollars Profile Fiscal Year Dollar Profile Volatility
		Schedule	Fixed Milestone Dates Volatility
		System Performance	Timing Accuracy Relability/Availablity Maintainability MOE/MOP QPR's from Interfacing systems Volatility
		Process Performance	CMM/CMMI Goals Processes Volatility
		Product Assurance Level	Safety Security Quality IV&V Volatility
		Technology Effectiveness	Suitability Readiness (TRL) Volatility

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3.0 Acquisition Program Office Factor

This factor covers influences of the Acquisition Program Office organization and functions. The Acquisition Program Office organization includes the SPO itself, from the SPO director down to the lowest level SPO personnel, plus Aerospace, other Federally Funded Research and Development Centers (FFRDCs) and Systems Engineering and Technical Assistance (SETA) contractors that support the SPO. For Aerospace, it includes the dedicated program office personnel, plus the engineering group personnel that support the program (usually part-time). For the SPO, it also includes Government support personnel from staff matrix organizations that are assigned to the program (e.g., contracting personnel such as the Procuring Contracting Officer (PCO) and buyers).

The functions covered by this factor include all work performed by the Acquisition Program Office organization in support of the program. Other work performed by people in the Acquisition Program Office organization that might adversely influence acquisition success is covered either directly in another factor or indirectly in this factor (e.g., via dependencies or constraints). An example of possible adverse influences of other work covered directly in another factor is line management functions, which are included in the Acquisition Environment factor. An example of possible adverse influences of other work covered indirectly in this factor is overloading of part-time engineering support personnel, which makes their available effort less than the effort that is needed from them.

In the simplest program office organizational structure, there is a single SPO director for the program, with all Government personnel working on the program reporting to him/her. However, some programs have multiple organizations with managers at the same level performing different parts of the program, each reporting to the SPD. In this case, there may not be a single SPO director in charge of all aspects of the program. What parts of the program office are covered by this factor versus what parts are covered by the Acquisition Environment factor depends upon the context for which the framework is being used, i.e., the scope of the assessment and who the customer is.

The organizations/functions in the Acquisition Program Office Factor are responsible for producing the following types of products:

- System Requirements
  These are the contractual requirements developed by the SPO to be put on contract for building the system. They are captured in documents such as Draft System Specifications (DSSs), Technical Requirements Documents (TRDs), and System Performance Specifications (SPSs).
- Interface Requirements
  These are the contractual requirements for external interfaces. They are captured in documents such as Interface Requirements Specifications (IRSs) and Interface Control Documents (ICDs). Sometimes these documents are prepared by the Acquisition Program Office organization, sometimes by organizations external to the Acquisition Program Office (e.g., interfacing system organizations) and sometimes by the contractor. They are included here only if prepared by the Acquisition Program Office.

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- Acquisition Products
  These are the acquisition products prepared by the program office. This includes contractual products, such as the Request for Proposal (RFP) package. It also includes documentation that must be prepared for program milestone/Key Decision Point (KDP) reviews, such as the acquisition strategy briefings and the Integrated Program Summary (IPS).
- Test and Evaluation (T&E) Products
  These are products that relate to the program's test and evaluation strategy. The principal product is the Test and Evaluation Master Plan (TEMP), but programs with complex test strategies may have additional program-unique documents.
- Cost and Schedule Products
  These are products that document the program office's independent cost and schedule estimates for the program. These can be documented in various ways (e.g., the Cost Analysis Requirements Document (CARD), Microsoft Project schedules, Excel spreadsheets for cost models)
- Technical Studies
  These are products produced as a result of conducting technical studies. They support the preparation of the other products listed here.
- Management Reports
  These are briefings or other types of reports both to management within the SPO itself (e.g., to the SPO director) and to the external acquisition management chain (e.g., the PEO, Undersecretary of the Air Force for Space). They also include the periodic reports required by acquisition regulations.
- Processes
  These are processes defined by the Acquisition Program Office organizations for their internal use (e.g., risk management process, configuration management process, requirements management process).
- Training
  These are training products for which the Acquisition Program Office organizations and functions are responsible. Examples are training in Acquisition Program Office processes and program orientation training for new personnel.

The subfactors in the Acquisition Program Office factor are shown in Figure 6. There are six subfactors that address resources and cost, process performance, size and stability, schedule and progress, product quality, and constraints. Each subfactor contains influences shown in Figure 6 and Tables 3 and 4. Each influence is characterized by metrics, as shown in Tables 3 and 4. The influences and metrics are described in more detail in the text below.

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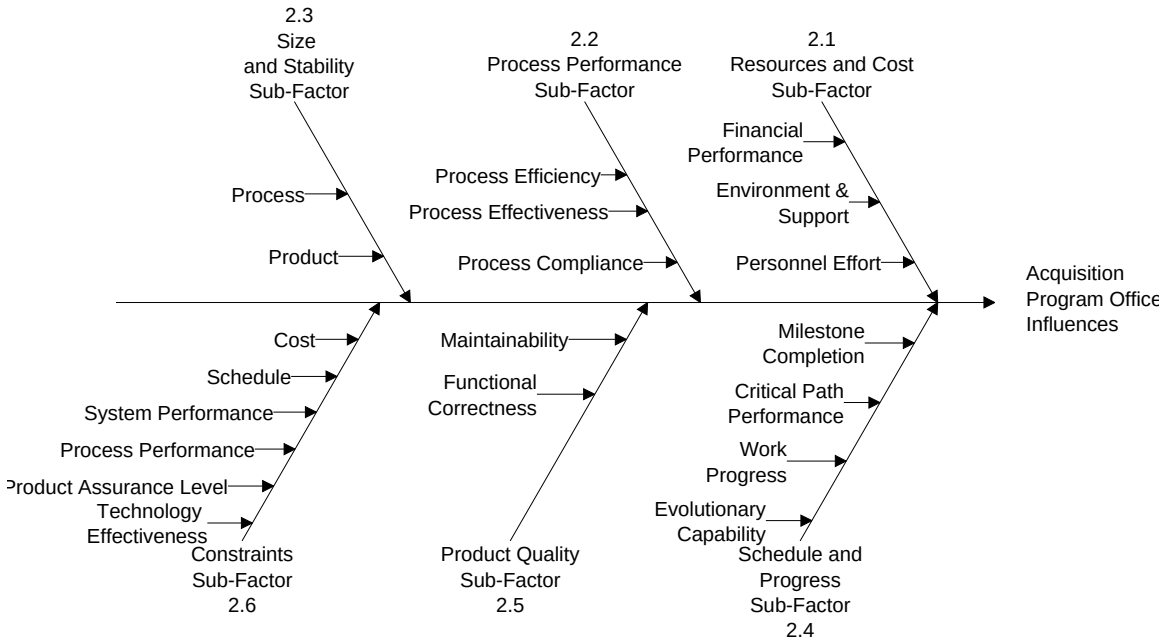

Figure 6 - Acquisition Program Office Influences

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3.1. Resources and Cost Subfactor

This subfactor contains the influences of the resources and costs associated with the organizations and functions included in the Acquisition Program Office factor. Included in this subfactor are the program-specific personnel resources responsible for performing the work within this factor and the Acquisition Program Office infrastructure, facilities and other resources required to execute the program.

a. Personnel Effort

This influence covers the personnel effort for the people performing the functions in the Acquisition Program Office factor.

- Staff Level (Number and sufficiency of assigned personnel)
- Effort (Planned and actual effort)
- Experience Level (Experience/qualifications of assigned personnel, training of assigned personnel)
- Staff Turnover (Stability of assigned personnel)
- Overload (Percent of time available/needed, percent overloaded, paid/unpaid overtime, ratio of support contractor personnel (Aerospace, other FFRDCs, SETAs) to Government personnel, ratio of part-time to full-time personnel)
- Unplanned tasking (Number, amount of effort, number of tasks per person)

b. Financial Performance

This influence addresses the financial performance of organizations and functions in the Acquisition Program Office factor. Budgets and costs for personnel may be measured in effort (e.g., STE, FTE) in addition to, or instead of, dollars.

- Budget (total and by fiscal year and by Government/support contractors)
- Cost (Planned and actual amounts (total and by fiscal year and by Government/support contractors))

c. Environment and Support

This influence addresses the sufficiency of the Acquisition Program Office infrastructure and support facilities (e.g., lab facilities, simulations facilities, classified data access facilities) needed by the program. This covers the support facilities shared among multiple programs (e.g., Aerospace laboratories, simulation facilities, Concept Design Center, STARS facility).

- Quantity Needed/Available (how many and when)
- Time Needed/Available (how much and when)
- Fidelity and Quality of Resources (e.g., fidelity of simulation capability needed/available, suitability of facility resources)
- Time Used

3.2 Process Performance Subfactor

This subfactor contains influences of the processes used by the organizations and functions in the Acquisition Program Office factor to perform the work and produce the products for which they are responsible.

a. Process Compliance

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This influence relates to the degree to which the organizations and functions in the Acquisition Program Office factor comply with their processes, based on appraisals or audits of use of those processes.

- Reference Maturity Profile (e.g., for SMC SPOs, via appraisals using the SMC CMMI®-A tailored model)
- Process Audit Findings

b. Process Efficiency

This influence relates to the efficiency of the processes used by the organizations and functions in the Acquisition Program Office factor to do their work.

- Productivity
- Cycle Time

c. Process Effectiveness

This influence relates to the effectiveness of the processes for producing the products developed by the organizations and functions in the Acquisition Program Office factor.

- Defects Contained
- Defects Escaped (Number of “escapes”, ratio of “escapes” to “saves” (e.g., ratio of number of defects that escaped detection before product is passes its final quality gate to defects caught before product passes its final quality gate))
- Rework Effort (Due to externally driven changes versus due to internally driven changes; due to defects versus changes; and total)
- Rework Components (Number of work components undergoing rework)

3.3 Size and Stability Subfactor

This subfactor addresses the size and stability of the processes used and of the products produced by the organizations and functions in the Acquisition Program Office factor.

a. Process

This influence addresses the size and stability of the processes used by the organizations and functions in the Acquisition Program Office factor.

- Processes (Number of processes, size of processes (e.g., number of pages, number of steps))
- Process Changes (Number added, number deleted, number changed across time)

b. Product

This influence addresses the size and stability of the products produced by the organizations and functions in the Acquisition Program Office factor.

- Products (Number of products, size of products (e.g., number of pages, number of requirements, ratio of number of contractual requirements to number of user capabilities))
- Product Changes (Number of additions, number of deletions, number of changes to products across time)

3.4 Schedule and Progress Subfactor

This subfactor addresses the schedule and progress of the work performed by the organizations and functions in the Acquisition Program Office factor.

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a. Milestone Completion

This influence addresses the Milestone Completion for the work performed by the organizations and functions in the Acquisition Program Office factor.

- Milestone Dates (Planned and actual; number of days slipped)
- Schedule Compression Ratio

b. Critical Path Performance

This influence addresses the Critical Path Performance for the work performed by the organizations and functions in the Acquisition Program Office factor. Note that multiple critical paths are possible.

- Slack Time

c. Work Progress

This influence addresses the Work Progress for work performed by the organizations and functions in the Acquisition Program Office factor.

- Requirements Traced/Untraced (Bidirectional trace of contractual requirements to user capabilities)
- Action Items Opened/Closed ("Action items" here is a broad term including all types of issues and actions.)
- Change Requests Opened/Closed

d. Evolutionary Capability

This influence addresses the achievement of evolutionary acquisition goals by the Acquisition Program Office factor.

- Capabilities Fielded (Planned versus actual numbers of functional capabilities, performance capabilities, total)
- Interfaces Integrated (Planned versus actual)

3.5 Product Quality Subfactor

This subfactor addresses the quality of the products produced by the organizations and functions in the Acquisition Program Office factor.

a. Maintainability

This influence addresses the ease with which the products produced by the organizations and functions in the Acquisition Program Office factor can be maintained.

a. Complexity

b. Functional Correctness

This influence addresses defects in the products produced by the organizations and functions in the Acquisition Program Office factor. The defects include defects identified by any organization (e.g., contractor/subcontractor engineering, contractor/subcontractor management, Acquisition Program Office (Government, Aerospace, other FFRDC, SETA) personnel, Acquisition Environment organizations). Defects can be identified using a variety of different mechanisms, such as action items, discrepancy/problem reports and written comments.

- Defects (Discovered/Resolved, for each product or class of products)
- Age of Defects (For each product or class of products)
- Completeness (Number of TBDs, number of undefined critical processes, ratio of defined critical processes to total critical processes identified)
- Estimating Accuracy (e.g., for cost, schedule, performance)

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3.6 Constraints Subfactor

This subfactor addresses the various constraints imposed by the organizations and functions in the Acquisition Program Office factor on all types of work (engineering, management, support) being performed by the contractor on the program.

a. Cost
   This influence addresses cost constraints imposed on the contractor by the organizations and functions in the Acquisition Program Office Factor. It also addresses volatility in the cost constraints.
   - Contract Dollars Profile (by color of money, total)
   - Fiscal Year Dollar Profile (by color of money, total)
   - Volatility (Changes in cost constraints)
b. Schedule
   This influence addresses schedule constraints imposed on the contractor by the organizations and functions in the Acquisition Program Office factor. It also addresses volatility in the schedule constraints.
   - Fixed Milestone Dates
   - Volatility (Changes in schedule constraints)
c. System Performance
   This influence addresses system performance constraints imposed on the contractor by the organizations and functions in the Acquisition Program Office factor. It also addresses volatility in the system performance constraints. The following list includes examples of system performance constraints.
   - Timing
   - Accuracy
   - Reliability/Availability
   - Maintainability
   - Program-Specific Quantitative Performance Requirements (QPRs)
   - Volatility (Changes in system performance constraints)
d. Process Performance
   This influence addresses the process performance constraints imposed on the contractor by the organizations and functions in the Acquisition Program Office factor. It also addresses volatility in the process performance constraints.
   - CMM®/ CMMI® Goals
   - Processes (Number, size of imposed processes)
   - Volatility (Changes in process performance constraints)
e. Product Assurance Level
   This influence addresses the level of product assurance imposed on the contractor by the organizations and functions in the Acquisition Program Office factor. It also addresses volatility in the product assurance level constraints. The following list includes examples of types of product assurance level constraints.
   - Safety
   - Security
   - Quality (e.g., Independent evaluations by Defense Contract Management Agency (DCMA), defect rates or defect density mandated as Technical Performance Measures (TPMs))
   - IV&V
   - Volatility (Changes in product assurance constraints)
f. Technology Effectiveness

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This influence addresses the influence of technologies imposed on the contractor by the organizations and functions in the Acquisition Program Office factor. It also addresses volatility in the technology effectiveness constraints.

- Suitability
- Readiness (Technology Readiness Levels (TRLs))
- Volatility (Changes in technology effectiveness constraints)

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Table 3 - Acquisition Program Office (Part 1)

Factor	Sub-Factor	Influence (Issue)	Metric
Acquisition Program Office	Resources & Cost	Personnel Effort	Staff Level Effort Experience Level Staff Turnover Overload Unplanned Tasking
		Financial Performance	Budget Cost
		Environment and Support	Quantity Needed/Available Time Needed/Available Fidelity & Quality of Resources Time Used
	Process Performance	Process Compliance	Reference Maturity Profile Process Audit Findings
		Process Efficiency	Productivity Cycle Time
		Process Effectiveness	Defects Contained Defects Escaped Rework Effort Rework Components
	Size & Stability	Process	Processes Process Changes
		Product	Products Product Changes
	Schedule & Progress	Milestone Completion	Milestone Dates Schedule Compression Ratio
		Critical Path Performance	Slack Time
		Work Progress	Requirements Traced/Untraced Action Items Opened/Closed Change Requests Opened/Closed
		Evolutionary Capability	Capabilities Fielded Interfaces Integrated

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Table 4 - Acquisition Program Office (Part 2)

Factor	Sub-Factor	Influence (Issue)	Metric
Acquisition Program Office	Product Quality	Maintainability	Complexity
		Functional Correctness	Defects Age of Defects Completeness Estimating Accuracy
	Constraints	Cost	Contract Dollars Profile Fiscal Year Dollar Profile Volatility
		Schedule	Fixed Milestone Dates Volatility
		System Performance	Timing Accuracy Reliability/Availability Maintainability Program Specific QPRs Volatility
		Process Performance	CMM/CMMI Goals Processes Volatility
		Product Assurance Level	Safety Security IV&V Quality Volatility
		Technology Effectiveness	Suitability Readiness (TRL) Volatility

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4.0 Contractor Environment Factor

This factor covers the influences of all contractor organizations and functions that do not directly involve the performance of the engineering work on the contract but can adversely affect the successful accomplishment of the engineering work. This factor addresses influences from the following types of contractor organizations and functions:

- Within the program
  - Program Management—provides non-technical management of the program. Oversees the management of the business and technical aspects of developing a product. Responsible for ensuring that the program cost, schedule and performance objectives are met. Most importantly, manages the political aspects of the contract, both internal and external to the corporation. The people performing this function are usually dedicated to a single program.
  - Quality Assurance (QA)—provides an independent reporting chain to program management regarding the quality aspects of the product under development. Also provides an external independent reporting chain to senior management of the corporation, if necessary. Software Quality Assurance (SQA) is part of this organization.
  - Contracts—provides the day-to-day work associated with establishing and maintaining contracts and with performing contract modifications. Manages any issues associated with contracts that arise throughout the life cycle.
  - Scheduling—provides the day-to-day work associated with keeping accurately updated schedules and cost account data. Manages any associated issues that arise during the development of the product.
  - Process Improvement Initiatives—Process improvement initiatives may be embraced to improve bottom line cost, schedule or productivity for the program. These initiatives often cause additional activities within the program. These activities compete with the activities of product development and must be managed appropriately. The organizations responsible for these initiatives are usually the program-level Software Engineering Process Group (SEPG) or Engineering Process Group (EPG).
- Within the corporation
  - Line Management (upper and matrix management)—provides management of the business enterprise. Oversees resource sharing among competing programs. Ensures the appropriate facilities and resources are in place for future contracts.
  - Quality Assurance—provides an independent reporting chain to enterprise senior management.
  - Corporate Audits—performs the auditing activities of the enterprise. Audits corporate facilities and resources to ensure appropriate utilization across the enterprise.
  - Contracts—manages the corporate infrastructure associated with establishing and maintaining contracts. Defines corporate policy associated with contracts.

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- ❖ Scheduling—manages the corporate infrastructure associated with scheduling and cost account reporting through all levels of management. Defines corporate policy associated with scheduling and cost account reporting.
- ❖ Corporate Process Improvement Initiatives—At times process improvement initiatives may be embraced to improve bottom line cost, schedule or productivity for the enterprise. The organizations responsible for these initiatives are usually the corporate-level Software Engineering Process Group (SEPG) or Engineering Process Group (EPG).
- ❖ Corporate Policy—provides coordination for all policies governing the operation of the organization.

This factor is replicated for the prime contractor and each team member performing software or systems engineering work on the contract. Examples of team member are subcontractors, subcontractors of subcontractors, intra-corporate organizations and vendors. Examples of the types of agreements among these team members are subcontracts, work authorization documents, intra-corporate agreements, and memoranda of agreement or understanding. Team members performing systems engineering are included in the framework since systems engineering strongly influences the success of software development. On the other hand, the influences of hardware development on software development are indirectly included in the framework as software dependencies and constraints. Team members performing solely hardware functions, therefore, are not included in the framework for software acquisition early warning indicators. In addition, any strictly hardware portion of work performed by software or systems engineering team members is not directly included in the framework.

Note that the prime contractor has responsibility for both its own work on the contract and for overseeing the performance of all of the team members to ensure total contract objectives are met. Thus, additional influences are related to the prime contractor role. This also extends to team members who themselves have subordinate team members, e.g., subcontractors or intra-corporate organizations. Such team members are responsible for their own work in addition to being responsible for overseeing the performance of their subordinate team members to ensure their overall contract objectives are met.

The organizations/functions in this factor are responsible for producing the following types of products:

- Example program-specific products
  - ❖ Integrated Management Plan (IMP)
  - ❖ Integrated Management Schedule (IMS)
  - ❖ Contractor Work Breakdown Structure (CWBS)
  - ❖ Contractor Statement of Work (CSOW)
  - ❖ Contract and modifications to the contract
  - ❖ Subcontracts/other agreements and modifications to subcontracts/other agreements
  - ❖ Subcontractor CWBSs, CSOWs, schedules
  - ❖ Processes tailored for the program
  - ❖ QA and SQA plan and procedures
  - ❖ QA/SQA audit reports
  - ❖ Program SEPG/EPG reports

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  - Program financial reports, schedule reports
  - Program Management Reviews and other management reports
- Example corporate products
  - Corporate policies
  - Corporate processes for all management functions
  - Corporate SEPG/EPG reports
  - Corporate processes for engineering functions (e.g., CMM®, CMMI®)
  - Corporate process tailoring instructions
  - Corporate process improvement plans
  - Corporate process asset library and historical data
  - Corporate audit reports
  - Corporate facility/infrastructure plans and policies
  - Corporate infrastructure and facilities (e.g., lab facilities, test facilities, simulation facilities, corporate networks and computing infrastructure)
  - Corporate-provided tools for management, engineering or support functions (e.g., scheduling and cost account management tools, systems and software engineering tools, discrepancy reporting tools)

The subfactors in the Contractor Environment factor are shown in Figure 7. There are six subfactors that address resources and cost, process performance, size and stability, schedule and progress, product quality, and constraints. Each subfactor contains influences shown in Figure 7 and Tables 5, 6 and 7. Each influence is characterized by metrics, as shown in Tables 5, 6 and 7. The influences and metrics are described in more detail in the text below.

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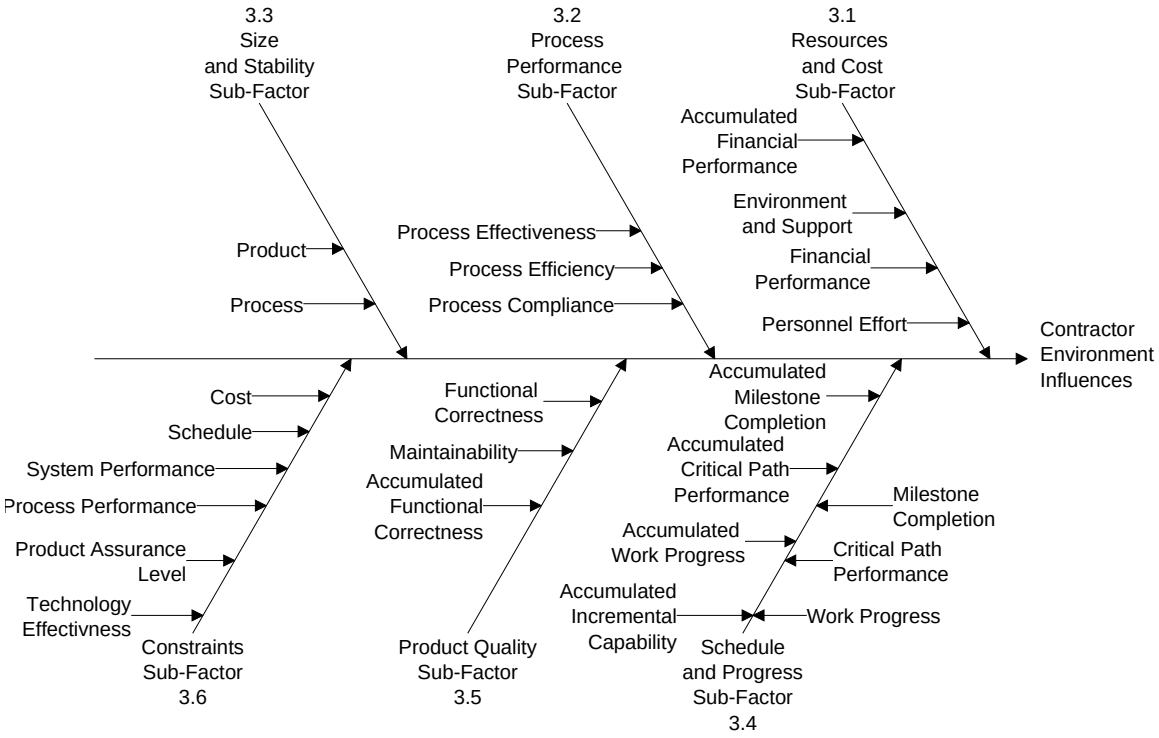

Figure 7 - Contractor Environment Influences

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4.1 Resources and Cost Subfactor

This subfactor contains the influences of the resources and costs associated with the organizations and functions included in the Contractor Environment factor. Included in this subfactor are the program-specific and corporate personnel resources responsible for performing the work within this factor and the program-specific and corporate infrastructure, facility and other resources required to execute the program. In addition, this subfactor includes the accumulated (i.e., "rolled-up") cost influences on the program.

a. Personnel Effort
   This influence covers the personnel effort for the people performing the functions in the Contractor Environment factor. Some of these functions are program-specific, while others are at the corporate level.
   - Staff Level (Number and sufficiency of assigned personnel)
   - Experience Level (Experience/qualifications of assigned personnel)
   - Effort (Planned and actual effort)
   - Staff Turnover (Stability of assigned personnel)
   - Overload (Percent of time available/needed, percent overloaded; paid/unpaid overtime)
   - Unplanned Tasking (Number, amount of effort, number of tasks per person)

b. Financial Performance
   This influence addresses the financial performance of the work being performed by this contractor on this program. This includes all costs for this contractor to perform the work on this program, but does not include the costs for subordinate team members (covered under 4.1.d below). This influence does not apply to the corporate organizations/functions in this factor.
   - Earned Value (Budgeted Cost of Work Scheduled (BCWS), Budgeted Cost of Work Performed (BCWP), Actual Cost of Work Performed (ACWP))
   - Budget
   - Cost

c. Environment and Support
   This influence addresses the sufficiency of the infrastructure and support facilities (e.g., lab facilities, test facilities, simulations facilities) needed by the program. This covers the corporate infrastructure and support facilities shared among multiple programs. It also covers program-specific infrastructure and support facilities managed by this contractor but shared among multiple team members or among multiple engineering organizations within one team member. This influence also addresses other types of support provided, such as that provided by organizational or program SEPGs or EPGs.
   - Quantity Needed/Available (how many and when)
   - Fidelity and Quality of Resources (e.g., fidelity of simulation capability needed/available, suitability of facility resources)
   - Organizational Process Maturity Profile (CMM®/CMMI®)
   - Time Needed/Available (how much and when)
   - Time Used

d. Accumulated Financial Performance

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This influence addresses the accumulated (i.e., "rolled-up") financial performance of all of the work for which this contractor is responsible on this program, independent of which team member performs the work. Thus, for the prime contractor, the accumulated financial performance is the financial performance of the entire program. For a subcontractor that has subordinate team members, the accumulated financial performance consists of the total financial performance of that subcontract, independent of which team member performs the work. This influence does not apply to team members who do not have subordinate team members. This influence also does not apply to corporate organizations or functions.

- Earned Value (BCWS, BCWP, ACWP)
- Budget
- Cost

4.2 Process Performance Subfactor

This subfactor contains influences of the processes used by the organizations and functions in the Contractor Environment factor to perform the work and produce the products for which they are responsible. It applies to both program-specific and corporate organizations/functions.

a. Process Compliance
   This influence relates to the degree to which the organizations and functions in the Contractor Environment factor comply with their processes, based on appraisals or audits of use of those processes.
   - Process Audit Findings

b. Process Efficiency
   This influence relates to the efficiency of the processes used by the organizations and functions in the Contractor Environment factor to do their work.
   a. Productivity
   b. Cycle Time

c. Process Effectiveness
   This influence relates to the effectiveness of the processes for producing the products developed by the organizations and functions in the Contractor Environment factor.
   - Defects Contained
   - Defects Escaped
   - Rework Effort
   - Rework Components (Number of work components undergoing rework)

4.3 Size and Stability Subfactor

This subfactor addresses the size and stability of the processes used and of the products produced by the organizations/functions in the Contractor Environment factor.

c. Process
   This influence addresses the size and stability of the processes used by the organizations and functions in the Contractor Environment factor.

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- Processes (Number of processes, size of processes (e.g., number of pages, number of steps))
- Process Changes (Number added, number deleted, number changed across time)

d. Product

This influence addresses the size and stability of the products produced by the organizations and functions in the Contractor Environment factor.

- Products (Number of products, size of products (e.g., number of pages, number of WBS elements, number of SOW paragraphs, number of corporate policies, number of audit reports))
- Product Changes (Number of additions, number of deletions, number of changes to products across time)

4.4 Schedule and Progress Subfactor

This subfactor addresses the schedule and progress of the work performed by the organizations and functions in the Contractor Environment factor. In addition, it addresses the accumulated (i.e., "rolled-up") schedule and progress of the work for which this contractor is responsible for the program. The accumulated schedule and progress here cover all of the work performed by this contractor and by all of this contractor's subordinate team members.

a. Milestone Completion

This influence addresses the Milestone Completion for the work performed by the organizations and functions in the Contractor Environment factor.

- Milestone Dates (Planned and actual; number of days slipped)
- Schedule Compression Ratio

b. Critical Path Performance

This influence addresses the Critical Path Performance for the work performed by the organizations and functions in the Contractor Environment factor. Note that multiple critical paths are possible.

- Slack Time

c. Work Progress

This influence addresses the Work Progress for work performed by the organizations and functions in the Contractor Environment factor.

- Action Items Opened/Closed ("Action items" here is a broad term including all types of issues and actions.)
- Change Requests Opened/Closed
- Corrective Actions Opened/Closed
- Audits Scheduled/Completed

d. Accumulated Milestone Completion

This influence addresses the accumulated (i.e., "rolled-up") Milestone Completion for all work performed by this team member and all of its subordinate team members on this program. This influence does not apply to team members who do not have subordinate team members. This influence also does not apply to corporate organizations or functions.

- Milestone Dates (Planned and actual; number of days slipped)
- Schedule Compression Ratio

e. Accumulated Critical Path

This influence addresses the accumulated (i.e., "rolled-up") Critical Path for all work performed by this team member and all of its subordinate team members

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on this program. Note that multiple critical paths are possible. This influence does not apply to team members who do not have subordinate team members. This influence also does not apply to corporate organizations or functions.

- Slack Time

f. Accumulated Work Progress
This influence addresses the Accumulated (i.e., "rolled-up") Work Progress for all work performed by this team member and all of its subordinate team members on this program. The following are examples of work progress that should be accumulated across all work for which this team member is responsible. This influence does not apply to team members who do not have subordinate team members. This influence also does not apply to corporate organizations or functions.

- Action Items Opened/Closed ("Action items" here is a broad term including all types of issues and actions.)
- Change Requests Opened/Closed
- Problem Reports Opened/Closed
- Audits Scheduled/Completed
- Requirements Coverage (e.g., Allocated/Implemented, planned versus actual)
- Requirements Verified (Planned versus actual)
- Architecture Views Completed (Planned versus actual)
- Architecture Components Designed (Planned versus actual)
- Units Designed/Coded/Tested/Integrated (Planned versus actual)
- Test Cases Attempted/Passed (Planned versus actual for integration and qualification test cases)

g. Accumulated Incremental Capability
This influence addresses the Accumulated (i.e., "rolled-up") Incremental Capability for the work performed by this team member and all of its subordinate team members on this program. This influence does not apply to team members who do not have subordinate team members. This influence also does not apply to corporate organizations or functions.

- Components Integrated
- Functionality Integrated

4.5 Product Quality Subfactor

This subfactor addresses the quality of the products produced by the organizations and functions in the Contractor Environment factor. It also addresses the accumulated (i.e., "roll-up") product quality for all products (e.g., engineering, management, support) produced by a contractor and its subordinate team members.

a. Functional Correctness
This influence addresses defects in the products produced by the organizations and functions in the Contractor Environment factor. The defects include defects identified by any organization (e.g., contractor/subcontractor engineering, contractor/subcontractor management, program office (Government, Aerospace, other FFRDC, SETA) personnel). Defects can be identified using a variety of different mechanisms, such as action items, discrepancy/problem reports, and written comments.

- Defects (Discovered/Resolved, for each product or class of products)

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- Age of Defects (For each product or class of products)
- Estimating Accuracy (e.g., for cost, schedule)

b. Maintainability
This influence addresses the ease with which the products produced by the organizations and functions in the Contractor Environment factor can be maintained.
- Complexity

c. Accumulated Functional Correctness
This influence addresses the accumulated (i.e., "rolled-up") functional correctness of program-specific products across the contractor and any subordinate team members. For the prime contractor, this covers the accumulated functional correctness of the program-specific products across all team members on the program. Here, the products addressed include all products (e.g., engineering, management, support) produced on the program. The defects include defects identified by any organization (e.g., contractor/subcontractor engineering, contractor/subcontractor management, program office (Government, Aerospace, other FFRDC, SETA) personnel). Defects can be identified using a variety of different mechanisms, such as action items, discrepancy/problem reports, and written comments. This influence does not apply to team members who do not have subordinate team members. This influence also does not apply to corporate organizations or functions.
- Defects (Discovered/Resolved, for each product or class of products)
- Age of Defects (For each product or class of products)
- Technical Performance Level (e.g., Actual versus required performance for each TPM)
- Requirements Traceability (e.g., Number traced/untraced, number traced incorrectly, ratios of traced to untraced and correctly traced to incorrectly traced)
- Estimating Accuracy (e.g., for cost, schedule)

4.6 Constraints Subfactor

This subfactor addresses the various constraints imposed by the organizations and functions in the Contractor Environment factor on all types of work (engineering, management, support) being performed on the program. This subfactor does not apply to the corporate organizations or functions in this factor.

a. Cost
This influence addresses cost constraints imposed on the program by the organizations and functions in the Contractor Environment factor. It also addresses volatility in the cost constraints.
- Must Cost to Will Cost Ratio
- Productivity Goals
- Volatility (Changes in cost constraints)

b. Schedule
This influence addresses schedule constraints imposed on the program by the organizations and functions in the Contractor Environment factor. It also addresses volatility in the schedule constraints.
- Fixed Milestone Dates
- Volatility (Changes in schedule constraints)

c. System Performance

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This influence addresses system performance constraints imposed on the program by the organizations and functions in the Contractor Environment factor. It also addresses volatility in the system performance constraints. System performance constraints are usually monitored as TPMs. The following list includes examples of system performance constraints.

- Throughput
- Resource Utilization
- Growth Capacity
- Processing Speed
- Size
- Weight
- Power
- Mean Time to Restore
- Mean Time Between Failure
- Volatility (Changes in system performance constraints)

d. Process Performance
This influence addresses the process performance constraints imposed on the program by the organizations and functions in the Contractor Environment factor. It also addresses volatility in the process performance constraints.

- CMM®/CMMI® Goals
- Processes (Number, size of imposed processes)
- Volatility (Changes in process performance constraints)

e. Product Assurance Level
This influence addresses the level of product assurance imposed on the program by the organizations and functions in the Contractor Environment factor. It also addresses volatility in the product assurance level constraints. The following list includes examples of types of product assurance level constraints.

- Safety
- Security
- Quality (e.g., Corporate objectives, quantitative management goals)
- IV&V (e.g., Internal independent audits)
- Volatility (Changes in product assurance constraints)

f. Technology Effectiveness
This influence addresses the influence of technologies imposed on the program by the organizations and functions in the Contractor Environment factor. It also addresses volatility in the technology effectiveness constraints.

- Suitability
- Readiness (TRLs)
- Volatility (Changes in technology effectiveness constraints)

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Table 5 - Contractor Environment (Part 1)

Factor	Sub-Factor	Influence (Issue)	Metric
Contractor Environment	Resources & Cost	Personnel Effort	Staff Level Experience Level Effort Staff Turnover Overload Unplanned Tasking
		Financial Performance	BCWS, BCWP, ACWP Budget Cost
		Environment and Support	Quantity Needed/Available Fidelity & Quality of Resources Organization Process Maturity Profile Time Needed/Available Time Used
		Accumulated Financial Performance	BCWS, BCWP, ACWP Budget Cost
	Process Performance	Process Compliance	Process Audit Findings
		Process Efficiency	Productivity Cycle Time
		Process Effectiveness	Defects Contained Defects Escaped Rework Effort Rework Components
	Size & Stability	Process	Processes Process Changes
		Product	Products Product Changes

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Table 6 - Contractor Environment (Part 2)

Factor	Sub-Factor	Influence (Issue)	Metric
Contractor Environment	Schedule & Progress	Milestone Completion	Milestone Dates Schedule Compression Ratio
		Critical Path Performance	Slack Time
		Work Progress	Action Items Opened/Closed Change Requests Opened/Closed Corrective Actions Opened/Closed Audits Scheduled/Completed
		Accumulated Milestone Completion	Milestone Dates Schedule Compression Ratio
		Accumulated Critical Path Performance	Slack Time
		Accumulated Work Progress	Action Items Opened/Closed Change Requests Opened/Closed Problem Reports Opened/Closed Audits Scheduled/Completed Requirements Coverage Requirements Verified Architecture Views Completed Architecture Components Designed Unit Designed/Coded/Tested/Integrated Test Cases Attempted/Passed
		Accumulated Incremental Capability	Components Integrated Functionality Integrated
	Product Quality	Functional Correctness	Defects Age of Defects Estimating Accuracy
		Maintainability	Complexity
		Accumulated Functional Correctness	Defects Age of Defects Technical Performance Level Requirements Traceability Estimating Accuracy

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Table 7 - Contractor Environment (Part 3)

Factor	Sub-Factor	Influence (Issue)	Metric
Contractor Environment	Constraints	Cost	Must Cost to Will Cost Ratio Productivity Goals Volatility
		Schedule	Fixed Milestone Dates Volatility
		System Performance	Throughput Resource Utilization Growth Capacity Processing Speed Size Weight Power Mean Time to Restore Mean Time Between Failure Volatility
		Process Performance	CMM/CMMI Goals Process Volatility
		Product Assurance Level	Safety Security Quality IV&V Volatility
		Technology Effectiveness	Suitability Readiness (TRL) Volatility

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5.0 Product Development Factor

This factor covers the influences of all contractor organizations and functions that are directly involved in the performance of the engineering work on the contract. This includes systems engineering, software development, specialty engineering, test, and configuration management organizations and functions. This factor also covers the technical management (as opposed to program management) of the engineering work on the contract. As such, this factor covers the scope of work that is addressed by the PSM approach and the CMM®/CMMI® (except for quality assurance, which is covered under the Contractor Environment factor).

This factor is replicated for the prime contractor and each team member performing software or systems engineering work on the contract. Examples of team member are subcontractors, subcontractors of subcontractors, intra-corporate organizations and vendors. Team members performing systems engineering are included in the framework since systems engineering strongly influences the success of software development. On the other hand, the influences of hardware development on software development are indirectly included in the framework as software dependencies and constraints. Team members performing solely hardware functions, therefore, are not included in the framework for software acquisition early warning indicators. In addition, any strictly hardware portion of work performed by software or systems engineering team members is not directly included in the framework.

The organizations/functions in this factor are responsible for producing the following types of products:

- Systems Engineering Plans
    - Systems Engineering Management Plan (SEMP)
    - Risk Management Plan
    - Program Configuration Management (CM) Plan
    - Reliability/Maintainability/Availability (RMA) Program Plan
    - System Safety Plan
    - System Security Plan
    - Human Systems Integration Plan
    - Integrated Logistics Support Plan
    - Master Integration and Verification Plan (Master Test Plan)
    - System/segment/element incremental implementation plans
    - Earned Value Management Plans (including descriptions of lower level WBS elements and work packages)
    - System Transition Plans (for transition to operations and support)
    - System Installation and Site Activation Plans
    - Training Plans for systems engineering technical and management personnel
- Systems Engineering Management Products
    - System/segment/element detailed schedules
    - Systems engineering management metrics
    - Technical Performance Measures (TPMs)
    - Monthly Management Review briefing charts
    - Earned Value Management Reports
    - Risk Management Reports

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    - CM reports and audit results
- Systems Engineering and Integration Products
    - Requirements allocations
    - Requirements traceability data
    - Specification tree
    - System/segment/element requirements specifications
    - Interface Requirements Specification (IRSs) and Interface Control Documents (ICDs)
    - System/segment/element architecture descriptions
    - DoD architecture framework views
    - System/segment/element operations concept descriptions
    - Engineering analyses (e.g., system safety analyses, system security analyses, reliability/maintainability/ availability (RMA) analyses, human systems integration (HSI) analyses, performance analyses)
    - Engineering trade studies (e.g., architecture trade studies)
    - System/segment/element test plans, cases, procedures, reports
    - System/Segment/Element requirements and design reviews (briefing charts and data packages)
    - System/segment/element database contents for testing, rehearsals, operations (e.g., onboard calibration constants database, telemetry data formats, command formats)
    - Operations and maintenance manuals and tech orders
    - Launch rehearsal procedures
    - Operations work instructions (e.g., Orbital Handbooks, operations procedures)
    - Operations training materials
- Software Engineering Plans
    - Software Development Plan (SDP)
    - Software Build Plan
    - Software Risk Management Plan
    - Software Configuration Management (SCM) Plan
    - Software Metrics Plan
    - Software Reliability Plan
    - Software Safety Plan
    - Software Earned Value Management Plans (including descriptions of lower level software WBS elements and work packages)
    - Software Transition Plans (for transition to operations and maintenance)
    - Training Plans for software technical and management personnle
- Software Engineering Management Products
    - Software technical and management metrics
    - Software detailed schedules
    - Software Earned Value Management Reports
    - Software Monthly Management Review briefing charts
    - Software Risk Management Reports
    - SCM reports and audit results
- Software Engineering Products
    - Software Requirements Specifications (SRSs)
    - Interface Requirements Specifications (IRSs) for software-to-software and software-to-hardware interfaces
    - Software architecture descriptions (including views)

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- Software designs
- Interface designs
- Database designs
- Human-Computer Interface (HCI) designs (including screen designs)
- Software code and other implementation data
- Build scripts
- Software test plans, cases, procedures and reports for all levels of software testing (unit testing, unit integration and testing, software qualification testing, hardware/software integration and testing)
- Software test data and test databases
- Engineering analyses for software (e.g., software reliability analyses, computer resource utilization analyses, performance analyses, software safety analyses, information assurance analyses, HCI analyses, root cause analyses)
- Engineering trade studies for software (e.g., software architecture trade studies, COTS software product evaluation and selection trade studies)
- Procured COTS software packages and COTS configuration data

The subfactors in the Product Development factor are shown in Figure 8. There are five subfactors that address resources and cost, process performance, size and stability, schedule and progress, and product quality. Each subfactor contains influences shown in Figure 8 and Tables 8 and 9. Each influence is characterized by metrics, as shown in Tables 8 and 9. The subfactors, influences and metrics for the Product Development factor are closely (but not identically) aligned with PSM's information categories, measurable concepts, and measures. The influences and metrics are described in more detail in the text below.

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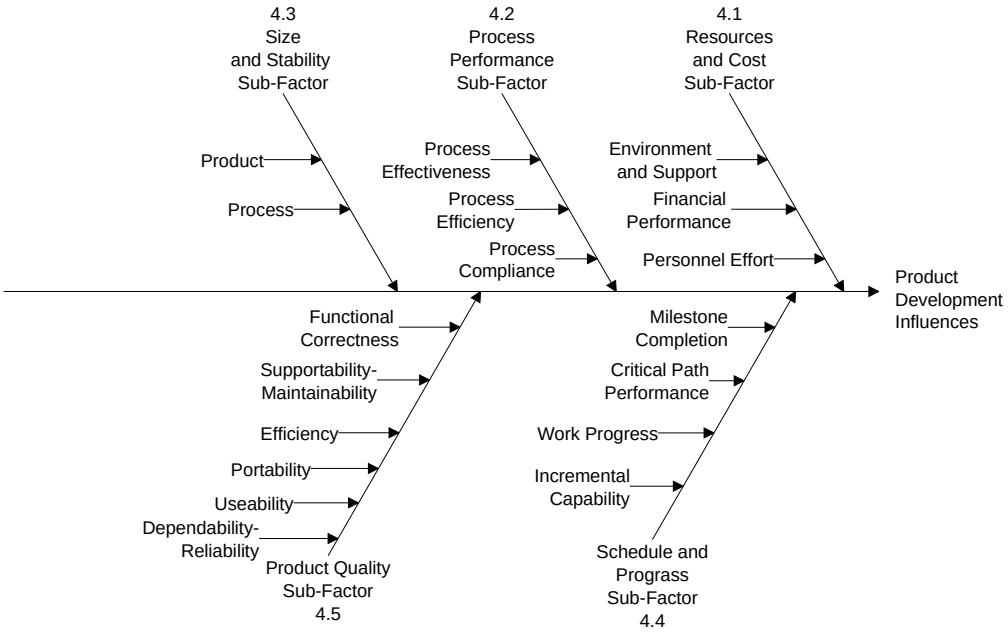

Figure 8 - Product Development Influences

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5.1 Resources and Cost Subfactor

This subfactor contains the influences of the resources and costs associated with the organizations and functions included in the Product Development factor. Included in this subfactor are the resources and costs for both the engineering and the technical management work being performed by this contractor (i.e., the prime contractor or a subordinate systems engineering or software team member).

a. Personnel Effort
   This influence covers the personnel effort for the people performing the functions in the Product Development factor.
   - Staff Level (Number and sufficiency of assigned personnel)
   - Effort (Planned and actual effort)
   - Experience Level (Experience/qualifications of assigned personnel)
   - Staff Turnover (Stability of assigned personnel)
   - Overload (Percent of time available/needed, percent overloaded, paid/unpaid overtime)
   - Unplanned Tasking (Number, amount of effort, number of tasks per person)

b. Financial Performance
   This influence addresses the financial performance of the work being performed by this contractor under the Product Development factor.
   - Earned Value (BCWS, BCWP, ACWP)
   - Budget
   - Cost

c. Environment and Support
   This influence addresses the sufficiency of the infrastructure and support facilities being provided by this contractor's engineering organizations under this contract. This covers infrastructure and support facilities within the contractor's engineering organizations that are not corporate resources shared among multiple programs or program resources shared among multiple contractor or engineering organizations within the program. Thus, this influence covers infrastructure and support facilities not covered under the Contractor Environment factor.
   - Quantity Needed/Available (how many and when)
   - Fidelity and Quality of Resources (e.g., fidelity of simulation or test bed capability needed/available, suitability of facility resources)
   - Time Needed/Available (how much and when)
   - Time Used

5.2 Process Performance Subfactor

This subfactor contains influences of the processes used by the organizations and functions in the Product Development factor to perform the work and produce the products for which they are responsible.

a. Process Compliance
   This influence relates to the degree to which the organizations and functions in the Product Development factor comply with their processes, based on appraisals or audits of use of those processes.
   - CMM®/CMMI® Maturity Profile (for this contractor on this program)
   - Process Audit Findings

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b. Process Efficiency
This influence relates to the efficiency of the processes used by the organizations and functions in the Product Development factor to do their work.
- Productivity
- Cycle Time

c. Process Effectiveness
This influence relates to the effectiveness of the processes for producing the products developed by the organizations and functions in the Product Development factor.
- Defects Contained
- Defects Escaped
- Rework Effort
- Rework Components (Number of work components undergoing rework)

5.3 Size and Stability Subfactor

This subfactor addresses the size and stability of the processes used and of the products produced by the organizations and functions in the Product Development factor. The processes included here are those defined within a particular engineering organization that are unique to that organization. Thus, this influence covers process that are not covered under the Contractor Environment factor, which includes processes defined by the corporate or program SEPGs or EPGs.

a. Process
This influence addresses the size and stability of the processes used by the organizations and functions in the Product Development factor.
- Processes (Number of processes, size of processes (e.g., number of pages, number of steps))
- Process Changes (Number added, number deleted, number changed across time)

b. Product
This influence addresses the size and stability of the products produced by the organizations and functions in the Product Development factor.
- Products (Number of products, size of products (e.g., numbers of: pages, requirements, architecture/design components, software units, test cases/procedures/steps, source lines of code (newly developed, unmodified reuse, modified reuse), Graphical User Interface (GUI) screens, database tables, data items, interfaces, Commercial Off-the-Shelf (COTS) products)
- Product Changes (Number of additions, number of deletions, number of modifications to products across time (e.g., additions/deletions/modifications to requirements, architecture/design components, units, test plans/cases/procedures/reports), changes to numbers of sources lines of code (newly developed, unmodified reuse, modified reuse), changes to numbers of COTS products to be integrated, changes to requirements allocated to each build, changes to units to be integrated in each build)
- Baseline Changes

5.4 Schedule and Progress Subfactor

This subfactor addresses the schedule and progress of the work performed by the organizations and functions in the Product Development factor.

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a. Milestone Completion
   This influence addresses the milestone completion for the work performed by the organizations and functions in the Product Development factor.
   - Milestone Dates (Planned and actual; number of days slipped)
   - Schedule Compression Ratio

b. Critical Path Performance
   This influence addresses the critical path performance for the work performed by the organizations and functions in the Product Development factor. Note that multiple critical paths are possible.
   - Slack Time

c. Work Progress
   This influence addresses the work progress for work performed by the organizations and functions in the Product Development factor.
   - Action Items Opened/Closed ("Action items" here is a broad term including all types of issues and actions.)
   - Change Requests Opened/Closed
   - Problem Reports Opened/Closed
   - Audits Scheduled/Completed
   - Requirements Coverage (e.g., Allocated/Implemented, planned versus actual)
   - Requirements Verified (Planned versus actual)
   - Architecture Views Completed (Planned versus actual)
   - Architecture Components Designed (Planned versus actual)
   - Units Designed/Coded/Tested/Integrated (Planned versus actual)
   - Test Cases Attempted/Passed (Planned versus actual for integration and qualification test cases)

d. Incremental Capability
   This influence addresses the incremental capability for work performed the organizations and functions in the Product Development factor.
   - Components Integrated
   - Functionality Integrated

5.5 Product Quality Subfactor

This subfactor addresses the quality of the products produced by the organizations and functions in the Product Development factor

a. Functional Correctness
   This influence addresses defects in the products produced by the organizations and functions in the Product Development factor. The defects include defects identified by any organization (e.g., contractor/subcontractor engineering, contractor/subcontractor management, program office (Government, Aerospace, other FFRDC, SETA) personnel). Defects can be identified using a variety of different mechanisms, such as action items, discrepancy/problem reports, and written comments.
   - Defects (Discovered/Resolved, for each product or class of products)
   - Age of Defects (For each product or class of products)
   - Technical Performance Level (e.g., Actual versus required performance for each TPM)

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- Requirements Traceability (e.g., Number traced/untraced, number traced incorrectly, ratios of traced to untraced and correctly traced to incorrectly traced)
- Estimating Accuracy (e.g., for cost, schedule)

b. Supportability-Maintainability
This influence addresses the ease with which the products produced by the organizations and functions in the Product Development factor can be maintained.
- Mean Time to Restore (MTTR)
- Mean Time to Repair (MTR)
- Complexity (e.g., Cyclomatic)

c. Efficiency
This influence addresses the efficiency of the products produced by the organizations and functions in the Product Development factor in terms of their use of computer resources. The measures of this influence are frequently managed as TPMs.
- Utilization (e.g., processors, memory, storage, networks/busses/channels)
- Throughput
- Response Time

d. Portability
This influence addresses the portability of the products produced by the organizations and functions in the Product Development factor.
- Standards Compliance

e. Usability
This influence addresses the usability of the products produced by the organizations and functions in the Product Development factor.
- Operator Errors

f. Dependability-Reliability
This influence addresses the dependability and reliability of the products produced by the organizations and functions in the Product Development factor.
- Mean Time to Failure
- Mean Time Between Failure (MTBF)
- Number of Defects Remaining (e.g., Via a reliability growth model)

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Table 8 - Product Development (Part 1)

Factor	Sub-Factor	Influence (Issue)	Metric
Product Development	Resources & Cost	Personnel Effort	Staff Level Effort Experience Level Staff Turnover Overload Unplanned Tasking
		Financial Performance	BCWS, BCWP, ACWP Budget Cost
		Environment and Support	Quantity Needed/Available Fidelity & Quality of Resources Time Needed/Available Time Used
	Process Performance	Process Compliance	CMM/CMMI Maturity Profile Process Audit Findings
		Process Efficiency	Productivity Cycle Time
		Process Effectiveness	Defects Contained Defects Escaped Rework Effort Rework Components
	Size & Stability	Processes	Processes Process Changes
		Product	Products Product Changes Baseline Changes

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Table 9 - Product Development (Part 2)

Factor	Sub-Factor	Influence (Issue)	Metric
Product Development	Schedule & Progress	Milestone Completion	Milestone Dates Schedule Compression Ratio
		Critical Path Performance	Slack Time
		Work Progress	Action Items Opened/Closed Change Requests Opened/Closed Problem Reports Opened/Closed Audits Scheduled/Completed Requirements Coverage Requirements Verified Architecture Views Completed Architecture Components Designed Unit Designed/Coded/Tested/Integrated Test Cases Attempted/Passed
		Incremental Capability	Components Integrated Functionality Integrated
	Product Quality	Functional Correctness	Defects Age of Defects Technical Performance Level Requirements Traceability Estimating Accuracy
		Supportability-Maintainability	Mean Time to Repstore Mean Time to Repair Complexity
		Efficiency	Utilization Throughput Response Time
		Portability	Standards Compliance
		Usability	Operator Errors
		Dependability-Reliability	Mean Time to Failure Mean Time Between Failure Number of Defects Remaining

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6.0 Unification Factor

The Unification factor covers common interrelationship issues both within and among the other factors. Included in the Unification factor are the influences that cross the boundaries of the other four factors. This factor addresses issues involving the various types of interrelationships among the organizations and functions in the other four factors, including interrelationships among people, processes, organizations, and resources. Also included in this factor are interrelationship issues that occur within each of the other factors. These issues are centralized in the Unification factor to reduce duplication. The Unification factor contains no organizations or functions itself and produces no products.

On the surface there are only six pairs of interrelationships among the factors, as follows:

- Acquisition Environment and Acquisition Program Office
- Acquisition Environment and Contractor Environment
- Acquisition Environment and Product Development
- Acquisition Program Office and Contractor Environment
- Acquisition Program Office and Product Development
- Contractor Environment and Product Development.

However, there are a great many additional interrelationships among these factors when the multiple organizations and functions in each of these factors are considered.

These multiple organizations include the prime contractor and all other systems engineering and software team members on the contractor team, which result in multiple instantiations of the Contractor Environment and Product Development factors. Each of these other factors also contains numerous organizations and functions that interrelate differently with other organizations. For example, in the acquisition environment, there are acquisition management, user/operator, interfacing systems, and certification organizations; in the acquisition program office, there are Government, FFRDC, and SETA organizations; in the contractor environment, there are program management, corporate management, contracts, scheduling, quality assurance and process improvement organizations; and in product development, there are systems engineering, software development, specialty engineering, test and configuration management functional organizations as well as multiple Integrated Product Teams. In addition, the interrelationships among these organizations are not simply one-to-one relationships among the organizations and functions in the other four factors. Frequently the interrelationships that must be considered are many-to-many relationships among these organizations and functions.

The subfactors in the Unification factor are shown in Figure 9. There are seven subfactors that address customer satisfaction, motivation, communication mechanisms, disconnect resolution, arrangements across boundaries, process performance, and organization. Each subfactor contains influences shown in Figure 9 and Tables 10 and 11. Each influence is characterized by metrics, as shown in Tables 10 and 11. The influences and metrics are described in more detail in the text below.

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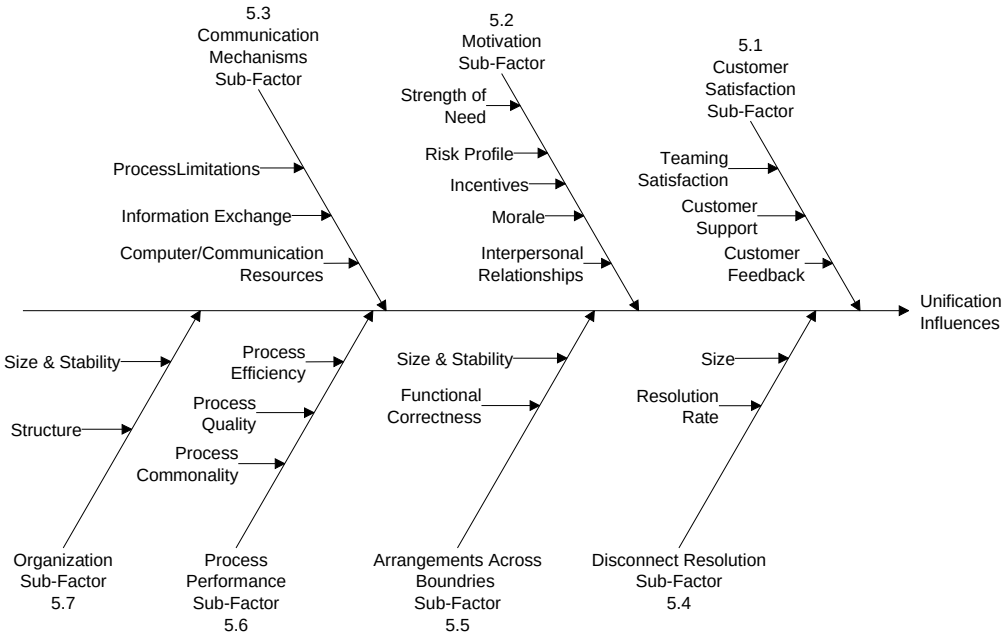

Figure 9 Unification Influences

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6.1 Customer Satisfaction

This subfactor covers the influence of customer satisfaction among the organizations in the other four factors in this model. Customers, here, should be interpreted in the broadest sense. Examples include: (1) the prime contractor's program management organization is a customer of a subcontractor's product development work; (2) the Government acquisition program office is a customer of the FFRDC organizations, and (3) a contractor's systems engineering organization is a customer of the same contractor's software development organization.

a. Customer Feedback

This influence covers various types of feedback from customer organizations.

- Satisfaction Rating (e.g., Via evaluation and other types of feedback forms, interviews, surveys)
- Award Fee (Acquisition program office to prime contractor, prime contractor to subcontractors)

b. Customer Support

This influence covers the adequacy of support provided to customers from organizations and functions responsible for providing customer support.

- Requests for Support (Requested versus delivered, time between requested and delivered support)
- Support Time (Planned versus actual)

c. Teaming Satisfaction

This influence covers the satisfaction of contractor personnel with their teaming partners. It also covers the satisfaction of the acquisition program office and acquisition environment personnel with the contractor team.

- Satisfaction Rating

6.2 Motivation

This subfactor covers the influence of motivation of the personnel in the various organizations and functions of the other four factors. Motivation is very important to successful communication and cooperation among people. Many aspects of motivation can only be evaluated subjectively.

a. Interpersonal Relationships

This influence addresses personality characteristics that can affect the ability of people to perform their work and to work well with others. It covers personnel in the various organizations and functions in all of the other four factors.

- Work Style Profile (Measured by various work style instruments)

b. Morale

This influence addresses the morale of the people in the various organizations and functions in the other four factors. Morale is a strong contributor to the ability of people to get the job done.

- Morale Rating (e.g., Via surveys, interviews, the SEI Taxonomy-Based Questionnaire[3] as part of a risk identification process)

c. Incentives

[3] See Carr, Marvin, et al. *Taxonomy-Based Risk Identification* (CMU/SEI-93-TR-6). Pittsburgh, Pa.: Software Engineering Institute, Carnegie Mellon University, 1993.

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This influence addresses the incentives that are motivating the people in the various organizations and functions in the other four factors. It includes both positive and negative incentives.

- Dollars (Number, amount (dollars), type (e.g., merit raises, bonuses, reductions in pay due to demotions or reassignments))
- Promotions/Demotions (Number, amount (dollars), ratio of number of promotions/demotions to number of engineering staff, time in grade (Air Force (AF) personnel), time in position (AF personnel), expected time to next grade (AF personnel))
- Awards (Number, amount (dollars), type)
- Downsizing (Number laid off, by total and type of personnel affected; number reassigned due to lay offs)

d. Risk Profile

This influence addresses how comfortable the personnel in the organizations and functions in the other four factors are with degrees of risk. Mismatches in risk comfort can strongly affect the ability of people to perform on the program (e.g., a risk adverse person will not be able to function well in a high risk environment).

- Risk Profile Rating

e. Strength of Need

This influence addresses the motivation of the perceived strength of need for the system under development that is held by the people in the various organizations and functions in the other four factors. For example, a strong strength of need for the system by the acquisition environment and acquisition program office can carry a troubled program through to completion, while a weak strength of need in a similar situation may lead to program cancellation. As another example, the perceived strength of need can affect management's priorities for work performed by their subordinates. A program for which management perceives a weak strength of need may be assigned less experienced or less capable personnel by matrix management. Mismatches that can adversely affect the program can occur when the entire organization is not aligned to the same strength of need.

- Strength of Need Rating

6.3 Communication Mechanisms

This subfactor covers the influence of the communication mechanisms among the people in the organizations and functions in the other four factors. Included are influences of processes, procedures and regulations governing communication, as well as the hardware and software resources used.

a. Computer/Communication Resources

This influence addresses the adequacy of the computer and communication resources (hardware and software) used for communications. Examples of communication systems are telephones, video and audio teleconferencing capability, and high speed data lines. Examples of computer systems include classified and unclassified hardware and software used for e-mail and electronic access.

- Quantity Needed/Available
- Time Needed/Available
- Fidelity and Quality of Resources
- Response Time
- Time Used

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b. Process Limitations

This influence addresses the limitations that process requirements impose upon people attempting to make use of the communication mechanisms. Examples include procedures for establishing accounts and for obtaining access to classified resources. Mismatches in terminology across organizations can cause difficulty in understanding procedures and thus can cause communication delays.

- Time to Perform Process (total time, delay times between process steps)

c. Information Exchange

This influence addresses the ease with which information exchange occurs. Delays and other difficulties with exchanging information can be caused by such influences as the lack of common tools, difficulty in moving information from one environment to another, and notification delays. In addition, restrictions on travel can affect the ease with which information exchange occurs, as can the lack of availability of personnel due to too many travel commitments.

- Number of Common Tools (Across organizations)
- Information Exchange Delays

6.4 Disconnect Resolution

This subfactor addresses the influences of disconnects across organizational boundaries within and across the other four factors as to product and process quality issues. Examples of such disagreements are review comments provided by acquisition program office or user personnel on contractor technical products that the contractor disagrees with. Other examples of these disagreements are quality assurance non-compliance reports that the product development organization is not addressing. Sources of disconnects also include action items and unresolved issues that cross organizational boundaries.

a. Size

This influence addresses the size of the disconnects across organizational boundaries as to product and process quality.

- Number of Disconnects (e.g., Number of unresolved action items, review comments, non-compliance reports)
- Number of Generated Actions (i.e., Actions generated in order to resolve the disconnects)
- Number of Organizations Involved (i.e., Number of organizations involved in order to resolve the disconnects)

b. Resolution Rate

This influence addresses the speed with which the product and process quality disconnects are resolved.

- Elapsed Time to Close

6.5 Arrangements Across Boundaries

This subfactor addresses the influences of the adequacy of the arrangements across organizational boundaries. Such arrangements include contracts and other types of formal agreements across the organizational boundaries. Examples include the contract that the SPO has with the prime contractor; subcontracts between the prime contractor and its subcontractors or between a subcontractor and its subcontractors. Other examples are agreements between two separate organizations within one contractor company or within one subcontractor company (e.g., between the division of a corporation that has the contract and another division that is performing a

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specific portion of the contract work). Such agreements are often documented in Work Authorization Documents. Another example of other agreements is an agreement between the SPO and an operational site as to the schedule for and amount of time allocated to installation and testing of new capabilities. Such agreements are often documented in a Memorandum of Agreement (MOA) or Memorandum of Understanding (MOU).

a. Size and Stability
   This influence covers the size and stability of the arrangements across the organizational boundaries.
   - Number of Arrangements
   - Volatility (e.g., Number added, deleted, modified; number of undefinitized contract/agreement actions; ration of undefinitized actions to definitized actions; amount of time actions have remained undefinitized)

b. Functional Correctness
   This influence covers the functional correctness (i.e., the quality) of the arrangements across the organizational boundaries.
   - Complexity
   - Completeness (e.g., Number of TBDs)

6.6 Process Performance

This subfactor addresses the influences of the processes that cross the boundaries of organizations and functions in the other four factors.

a. Process Efficiency
   This influence relates to the efficiency of the processes that cross the boundaries of organizations and functions in the other four factors.
   - Productivity
   - Cycle Time

b. Process Quality
   This influence relates to the quality of the processes that cross the boundaries of organizations and functions in the other four factors.
   - Adequacy

c. Process Commonality
   This influence addresses the commonality of processes and how well processes are integrated across the boundaries of organizations and functions in the other four factors.
   - Number of Process per Organization
   - Number of Common Processes
   - Number of Integrating Processes

6.7 Organization

This subfactor covers the structure of the organizational arrangements within and across the organizational boundaries in the other four factors. This subfactor addresses influences of organizational size, stability and complexity. It also addresses influences involving the degree of cohesion within organizational elements and the degree of coupling among the organizational elements. This subfactor includes all types of organizational structures within the other four factors, including functional structure, Integrated Product Team structure, and structure defined by contractual relationships or relationships defined by other types of formal agreements. Most programs have multiple types of overlaying organizational

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structures. This subfactor also covers the influences among these overlaying organizational structures.

a. Size and Stability

This influence covers the size and stability of the various organizational structures.

- Physical Nodes
- Logical Interfaces
- Organizational Volatility

b. Structure

This influence covers the structural aspects of the organizations and their interrelationships.

- Complexity
- Cohesion
- Coupling
- Dispersion

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Table 10 - Unification (Part 1)

Factor	Sub-Factor	Influence (Issue)	Metric
Unification	Customer Satisfaction	Customer Feedback	Satisfaction Rating Award Fee
		Customer Support	Requests for Support Support Time
		Teaming Satisfaction	Satisfaction Rating
	Motivation	Interpersonnal Relationships	Work Style Profile
		Morale	Morale Rating
		Incentives	Dollars Promotions/Demotions Awards Downsizing
		Risk Profile	Risk Profile Rating
		Strength of Need	Strength of Need Rating
	Communication Mechanisms	Computer/Communication Resources	Quantity Needed/Available Time Needed/Available Fidelity & Quality of Resources Response Time Time Used
		Process Limitations	Time to Perform Process
		Information Exchange	Number of Common Tools Information Exchange Delays

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Table 11 - Unification (Part 2)

Factor	Sub-Factor	Influence (Issue)	Metric
Unification	Disconnect Resolution	Size	Number of Disconnects Number of Generated Actions Number of Organizations Involved
		Resolution Rate	Elapsed Time to Close
	Arrangements Across Boundries	Size & Stability	Number of Arrangements Volatility
		Functional Correctness	Complexity Completeness
	Process Performance	Process Efficiency	Productivity Cycle Time
		Process Quality	Adequacy
		Process Commonality	Number of Processes per Organization Number of Common Processes Number of Integrating Processes
	Organization	Size & Stability	Physical Node Logical Interfaces Organizational Volatility
		Structure	Complexity Cohesion Coupling Dispersion

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