Cover

Program Management Guide

With Emphasis on Managing High Technology Engineering Development Programs

By S. A. Siegel

About the author Stuart A. Siegel:

Stuart is a retired electrical engineer and former defense industry executive spanning a career of over thirty years helping to protect those who protect us. He has a Bachelors of Science Degree in Electrical Engineering (BSEE) from the Polytechnic Institute of New York and a Masters of Science Degree in Electrical Engineering (MSEE) from the University of Pennsylvania's Moore School of Engineering. He has written several non-fiction texts for engineers, engineering managers, and program managers providing in depth guides for managing high technology programs, for managing high technology proposals where businesses are in a competitive environment, and for learning program management basics applicable for engineering and business management majors alike.

He was born and raised in Queens New York and currently lives on Long Island New York with his wife. They have three grown children and six grand children. He enjoys skiing, sailing, and golf and in his spare time he writes. Having mostly written non-fiction educational material he is currently experimenting with writing fictional accounts of money, sex and power, within the defense industrial complex.

Program Management Guide - With Emphasis on Managing High Tech Development Programs

by S. A. Siegel

Author's Note

There are many textbooks, papers and the like that address Program Management. Often Program Management is treated as a subset of Management Science and can be very comprehensive as part of a college course in the subject. The focus of the material contained herein is on the management of technical programs. Oftentimes the material discussed elsewhere is analytical inclusive of linear programming and from my perspective is treated in detail that is more than is needed to actually manage most technical projects encountered in the real world.

What is beneficial to manage a technical project is experience and education in a technical discipline – preferably in one of the technologies that comprise a measurable portion of the project being executed. Beyond this, what is needed by a Program Manager is an understanding of what constitutes a project, how to break it down into manageable segments, and an understanding of basic tools to be employed to help in facilitating the execution of the project.

In my view there are a few but important key traits that a PM in charge of a technical project should embody to be successful:

> Experience and education in technology preferably in one of the technologies that comprise a measurable portion of the project being managed – Avoids complete dependency on technical personnel for assessing and guidance on steps to take in understanding issues.
>
> Knowing what questions to be asking and assessing the answers to regarding issues in-process during each stage of a project.
>
> Tenacity and the avoidance of intellectual laziness – knowing what is needed to be done, no matter how intrusive to the status quo, and initiating the action to do it.
>
> Knowing it is their role to make a decision particularly in the midst of conflicting opinions.

My motive in producing what follows is to offer a relatively brief but useful synopsis of the topics that a PM will be exposed to and to include checklists that will help enable the PM to focus on the issues at hand at each stage of the project.

Introduction

Although much of what follows is generic to what constitutes program management in general, the overarching purpose of the material contained herein pertains to what constitutes program management of technological development projects.

To understand what Program Management entails, it is key to understand the role of a Program Manager (PM). The Program Manager of a project is the single point authority responsible for the successful execution of the project inclusive of cost, schedule, performance, work statement commitments, and terms and conditions in accordance with a contract. An insightful way to see this is to view a project as a business unto itself with a customer and a contract that articulates the project requirements in detail. In this context, the Program Manager is essentially the 'president' of that project / business with full authority for its conduct. It is the responsibility of the Program Manager to 'Manage' the execution of the contract. The PM plans the activities needed to meet contractual cost, schedule, performance, and delivery commitments. It is the responsibility of the PM to obtain the needed manpower resources from the functional groups within the company (e.g. engineering, finance, etc.) thereby standing-up the program team that will do the work. Thereafter, the PM leads the team, assigns budgets, initiates work, conducts essential periodic reviews to manage the progress of the project, and makes important decisions as variances from plan arise as they always do. Moreover, the PM is the face of the company to the customer as well as the face of the project to senior company management.

Note: An appendix to this document includes an overview of an alternative Program Management approach whereby the Program Manager does not lead the team; the team leads itself. The approach called "Scrum" is adapted from a lean software management process.

There are key practices to be followed in the planning and execution of a project and they include:

1. Breaking down the scope of the work to be performed into manageable tasks or work packages producing the Work Breakdown Structure (WBS) of the program.
2. Developing and tracking an Integrated Master Schedule (IMS) that is inclusive of both a 'Waterfall' / Gantt view (developed by Henry Gantt in 1910) that time phases and resource loads the tasks to be performed on the project and provides insight to the critical path(s) of the project; and a Network Flow Diagram / PERT (Program Evaluation and Review Technique) view that is ideal for visualizing the Work Flow and the Interactions & Interdependencies on the project. Microsoft Project is an ideal tool for this.
3. Evaluating Cost and Schedule performance and variances to plan utilizing the Earned Value Management System (EVMS) technique.
4. Implementing a Risk and Opportunity management system for the project that identifies key risks and associated risk mitigation initiatives to help preclude the occurrence of negative impacts to the

project as well as identifying and establishing opportunity realization initiatives to improve upon project success criteria.

These 4 processes will be illustrated later in this document using a simplistic example of a project.

There is a 5th important process that will be explained later as well, namely:

5. Implementing a structured approach referred to a the ‘5-Why?’ approach to identify the Root Cause(s) and Corrective Action(s) associated with those failures that are deemed so serious and impactful when they occur that if they are repeated the cost, schedule, and/or performance impacts could be disastrous.

As stated, these practices will be discussed at a later point in this document, however it is first important to understand more of what constitutes a technological development program. This insight is highly pre-requisite for a program manager to possess to be successful in managing developmental programs.

Phases of a Development Program

A project’s life cycle is its phased activity from its birth as a new business opportunity through its maturity from concept development to production, deployment, and support. Understanding these phases and the critical elements of each phase is pivotal to successful program management. The material that follows describes the salient activities in each phase and is augmented further with checklists for each phase to serve as a tool to aid in keeping abreast of the key issues to be managed during the execution of an engineering intensive developmental project.

The total life cycle phases of a project can be broken down as stated below, however, this discussion of program management is concerned with the management of projects through their developmental phases up to the transition-to-production.

1. Pre-proposal
2. Proposal
3. Contract Award
4. System Design
5. Preliminary Design
6. Final Design
7. Buy, Build, & Low Level Test
8. Assembly
9. Integration & Test, Qualification, Verification, & Validation
10. Transition-to-Production
11. Production, Maintenance, & Field Support

The pre-proposal and proposal discussions are so important that they are treated in a separate document that is totally devoted just to Proposal Management. What follows is a narrative of the typical steps from a technical perspective from contract award to transition-to-production. The presumption is that the proposal was the basis for contract award and that the technical baseline inclusive of architecture selection was established at that time.

Contract Review, Planning, & Start of Work

Following contract award, program documents (i.e. specifications, statement of work, etc.) are reviewed and updated to reflect any negotiated changes. Once updates are agreed to, the program manager plans the project by breaking down the tasks into manageable activities, time phases and resource loads them, stands up the team that is tasked to do the work, distributes budgets, and authorizes work. The technical activity is the essential activity in a development program and typically is in sync with the following:

System Design

Having been baselined during the proposal phase, the system architecture is revisited to assure its selection is still optimum and the system is then definitized in detail. System concepts are established relative to system architecture, safety, human factors, commonality, built-in test, design for manufacturability, etc., and design guidelines are set forth. Risk areas are clearly identified and special activities to resolve potential problems at an early stage are set into motion. This includes analyses, selective prototyping, unique mockups, and any special tests deemed necessary to mitigate risk. System documentation e.g. block diagrams, interface control documents (ICDs), system partitioning and a family tree, and lower level specifications are generated so that the detailed design activity can be initiated. Major subcontract specifications are updated so that associated supplier activity is started. Technical work is broken down and parceled out in a logical fashion to bring the final product together as a system.

Detailed Design (Preliminary Design & Final Design)

Family trees and the contract work breakdown structure and the Integrated Master Schedule (IMS) define the equipment and the activities that must be performed to provide all deliverables in accordance with end item performance specifications and the contractual statement of work. The design activities are broken down to the lowest practical level of control namely the subassembly or printed circuit card level. Work packages are established such that each engineer covering analog, digital, software, mechanical, reliability, maintainability, safety, etc. have well-defined tasks to accomplish within a defined timeframe, a defined budget and defined completion criteria as well as a clear understanding of the interdependencies of who needs what from whom and when.

An important output of the detailed design phase is a complete set of documentation that defines the hardware for production so that the end product meets performance specifications within budgetary constraints. With this in mind, the design proceeds to address all of the detailed concerns of the engineering functional and environmental performance requirements. This includes concurrent engineering inputs regarding reliability, maintainability, safety, human factors, producibility, testability, supportability, affordability i.e. designing to a target unit production cost (DTUPC), etc. Often, the pacing of activity is event driven by scheduled documentation requirements. Plans, specifications, procedures, analyses, test reports, and other data items are prepared as required, updated as necessary, and managed in accordance with a data management plan. Detailed electrical and mechanical drawings including schematics, parts lists, assembly drawings, and detailed layouts are prepared by the design and drafting group with support from engineering.

The detailed design activity is a 2-step process: a preliminary design phase followed by a final design phase where each phase culminates in both internal and customer design reviews. During the design activity depending on design maturity, the design packages are released in various stages for purchasing, fabrication, and assembly. At the conclusion of the final design phase and its critical design review (CDR), the designs come under configuration control. Beyond this point in the program, design activity is affected by changes, which are instituted via formal engineering change control. Typically changes are brought about by problems with drawings and / or design deficiencies uncovered during manufacturing and integration and test of the hardware & software. However, design improvements and change proposals brought about by value engineering or design performance enhancements also can be initiated and controlled by the formal change process.

As the program matures, and in conjunction with the program test needs, greater insight is gained into defining characteristics and required quantities of the in-house tools, test fixtures, and test equipment to support the engineering development, manufacturing, and test requirements of the program. The design of tools, fixtures, and test equipment, which include environmental test sets, system testers, and subassembly testers, proceeds as a parallel design activity with all inherent controls and procedures described previously for the prime item equipment development.

Procurement and Fabrication

Usually during the proposal stage major make-or-buy decisions are made. These decisions are established based on practical considerations of availability of in-house expertise, risk, schedule constraints, competitive pricing, and historical experience. The result is that major subcontracts are let at the outset of the program under the auspices of a subcontracts administration group. Subcontract specifications, statements of work, and in progress monitoring criteria such as performance, schedule, cost, and data reporting form the basis of subcontract control. Additionally, other long lead items are identified early and action initiated and commitments monitored.

Apart from these special activities, the basic material acquisition process stems from the detailed parts list generated during the design process. During the design process part selection is evaluated with respect to specification and quality requirements, standardization, and multiple sourcing considerations. Specification and source control drawings are prepared. Nonstandard parts are identified, and formal request procedures are followed. Having established acceptable parts lists, composite bills of material are prepared. Individual quantities are increased to reflect anticipated shrinkage due to the build and test cycles as well as increases based on any negotiated spares needs. Purchase requisitions are then prepared and purchase orders are placed with the most cost competitive and schedule acceptable qualified vendors. Internal shop orders are released for items that are being made in-house.

As material is received, it is inspected and / or tested for acceptance and stocked in kit packages for assembly. Defective material is reviewed for disposition and is either rejected as beyond repair, returned to vendor, or repaired in-house. Material expediting is utilized to track scheduled material requirements as they pertain to assembly schedules. Potential problems such as kit shortages are identified early and corrective action taken.

Assembly

The build cycle is initiated by a design release for manufacturing and the prototype products undergo full quality assurance (QA) inspections prior to issuance to engineering for integration and test. The assembly activity for the program is inclusive of building breadboards, mockups, brassboards, engineering development models, prototypes, pre-production units, and ultimately production units. This applies to the prime hardware as well as to tools, test fixtures, test equipment, and spares.

Brassboards and the 1st prototype equipments are typically built under engineering control by engineering prototype technician personnel who can work directly from engineering drawings and do not require detailed methodization. Engineering maintains control over the first systems to prove out the basic design, make changes, and update drawings. Manufacturing engages to build the next lot of deliverables or pre-production systems to a cleaner drawing package and to improve upon planned manufacturing procedures in preparation for full-scale production. This approach helps have a smooth transition to production.

Integration and Test

Major assembly and system tests of the initial equipments are typically performed utilizing the overall subsystem and interconnect cabling as a ‘hot bench test-bed” in conjunction with special purpose system testers that are developed to support assembly test, system acceptance tests, environmental test, reliability demonstration test, etc. Note: Testing of the testers also forms a part of the integration and test phase of the program.

The test program is an integrated activity covering all aspects of engineering evaluations as well as in-process subassembly, assembly, and system level test. Test equipment requirements, capital requirements such as test chambers and the use of outside testing laboratories, are all planned into the program. Engineering evaluations are conducted on mockups, breadboards replicating special areas of concern, as well as installation checks. Safety tests, human factors tests, environmental tests, electromagnetic interference tests, functional and physical configuration audits (FCA/PCA), field tests all form an integral part of the test program. These activities are scheduled to permit changes that result from them to be introduced into the system and revalidated in a timely manner to meet the overall schedule.

Successful completion of verifying that the system meets its contractual performance requirements concludes the developmental cycle of a technical developmental program.

Developmental Phase Specific Check Lists

As an aid in helping a program manager manage this activity, the following phase specific checklists are included for completeness. They are phrased as questions that need answering in each phase. It is key that a PM knows what questions to ask of the team and thereby invoke actions to assure positive outcomes.

Note: Although as stated earlier that the Proposal Management process is treated in a separate document, the check lists for the pre-proposal and proposal phases are included below in this walk through of successive phases. Including them helps see the maturing of key issues that were established in the technical baseline during the front-end-of-the-business phases and that transitioned to the post contract award developmental phases.

Pre-Proposal Phase: Focus items when pursuing an opportunity from inception to a bid/no-bid decision

1. **Are requirements sufficient including a mission understanding and system concept of operations (CONOPS)?**
2. **Is the architecture developed? Does it meet the requirements & CONOPS? Were needed trade studies and simulations performed inclusive of cost-as-an-independent-variable (CAIV), to confirm the approach?**
3. **Are margin analyses & error budget allocations to lower level items complete and are spare/growth capacities defined to reflect high rate/high yield producibility & test needs?**
4. **Is the approach aligned with testability, producibility, maintainability, reliability, supportability, logistics and design-to-cost (DTC) goals?**

5. **Is the work share and interdependencies with the customer and any associate contractors (and subcontractors) defined, including methods of proving compliance?**
6. **Are the cost & schedule estimates realistic and predicated on a sound 'similar-to' basis?**
7. **Have commercial-off-the-shelf (COTS) and Re-Use maturity assumptions in the bid baseline been vetted to be realistic? Realism factors:**
    a. **Cost**
    b. **Schedule**
    c. **Risks**
    d. **COTS noncompliance**
    e. **Reuse maturity**
    f. **Reuse availability**
    g. **Legacy program design deficiencies**
    h. **Dependent program being late or cancelled**
    i. **Allocation & availability of key personnel**
    j. **Spare development and test assets**
    k. **Comprehensive test environment**
    l. **Planning for problems - Does integration and test (I&T) planning include contingency plans for problems and not just plan for success**
    m. **Complexity of requirements, changes, and interfaces not estimated well due to lack of experience, lack of learning and over simplification of similar-to basis**
8. **Has a Risk/Opportunity register been developed to capture technical and programmatic risks and opportunities?**
9. **Is a spiral/incremental development approach being leveraged to minimize I&T complexity?**
10. **Is early prototype testing being considered in the I&T approach?**
11. **Is the Make / Buy process being followed with full stakeholder involvement and vetting of selected suppliers not just for its technical capability?**

Note: **Bold items are new related to the current phase** while un-bolded items still carry-over as important from the prior phase.

Proposal Phase: Focus items from the decision to bid to the submission of the proposal and acceptance of the contract

1. Is the architecture based on firm requirements and system Con-Ops, supported by trade studies/simulations inclusive of CAIV to confirm the veracity of the approach?
2. Has the design margin analysis been performed and error budgets defined and allocation to lower level items including spare/ growth capacities?
3. Has the system architecture approach encompassed testability, producibility, maintainability, reliability, supportability, logistics and DTC goals and requirements?

4. Is the work share and interdependencies with the customer and any associate contractors/subcontractors well defined with exact definition of measures to prove compliance?
5. **Are the bid estimates based on an achievable foundation (e.g.: similar–to, previous actuals, standard metrics)?**
6. **Have planned re-use components been checked to ensure that they actually exist and will meet the allocated requirements and needed maturity / reliability level?**
7. **Are the bid assumptions realistic and assigned to ensure they will be met?**
8. **Have a complete set of bid risks and opportunities been identified including mitigation and enabler plans? Are the major supplier's risks known and do they have mitigation plans?**
9. **Has a realistic staffing plan been defined including key technical skills/staff identified?**
10. **Has a realistic schedule been defined (including schedule reserve) in sufficient detail to ensure the completion date can be met?**
11. **Are challenging requirements identified with associated risks & mitigation plans defined?**
12. **Are there sufficient resources planned for Hardware/Software/Firmware (HW/SW/FW) Tools, Test Equipment, Test Assets, and Simulation capabilities, as needed?**
13. **Do simulators (as planned for) realistically portray the target environment; is there overdependence on simulation without adequate justification?**
14. **Does the development plan consider early component prototyping to find defects early with emphasis on high risk development areas?**
15. Does the development plan consider spiral or incremental development approach to reduce risk and minimize complexity of I&T?
16. **Does the integration and test plan include real dynamic environment testing?**
17. Is the Make/Buy process being followed with full stakeholder involvement and vetting of selected qualified suppliers?
18. **Are the requirements of major suppliers and subcontractors defined and agreed to with no meaningful 'To-Be-Determineds' (TBDs)?**
19. **Have the planned COTS/Gov't-off-the-shelf (GOTS) products been shown to be mature and reliable, and realistically meet the required functionality?**
20. **Has an adequate subcontractor management plan been defined to ensure adequate supplier management?**
21. **Have several technical solutions been vetted to select the most cost-effective solution that meets the proposed requirements?**
22. **Is the final 80/20 bid estimate/technical baseline and priced bid estimate/technical baseline captured in configuration management (CM) for use later at project startup?**

<u>System Design Phase:</u> Focus items from award to a final system design

1. Is there an excellent understanding with the Customer on the mission, system Con-Ops & requirements? **Are they mutually understood, agreed, documented, reviewed and approved?**
2. Is the architecture based on firm requirements & Con-Ops, supported by trade studies/simulations inclusive of CAIV to confirm the approach? **Are interfaces clear for complexity & function?**
3. Are margins & error budgets defined & allocated to low level items with spare/growth capacities?
4. **Do the requirements just meet the customer's requirements and are not "gold-plated"?**
5. **Do the development plans include well-defined entrance and exit criteria?**
6. **Have requirements been vetted with the team to remove ambiguity & no meaningful TBDs?**
7. **Have the requirements been allocated and partitioned into lower level requirements including non-deliverable Test Equipment (TE) requirements and agreed to with the leads?**
8. **Are the lower level item functional requirements (e.g. SW, FW, HW,) complete?**
9. **Are ' ility' requirements flowed down/partitioned/allocated: Built in Test (BIT), mean time between failures (MTBF), mean time to repair (MTTR), size, weight, power, environmental, design for manufacturability (DFM)/producibility, logistics, product support, design to unit production cost (DTUPC), security?**
10. **Has the I&T/verification & validation (V&V) approach to verify each requirement to the Customer been defined?**
11. **Has the development environment been defined and established to support the required tasks, including: design and implementation tools in place; training conducted; etc.?**
12. **Has an integration & test lab been planned for including target assets, test equipment, security, build environment, & CM change control?**
13. **Have technical performance measures (TPMs) / key performance parameters (KPPs) been reviewed, established and a measure plan defined?**
14. **Is concurrent engineering engaged: design for testability, producibility (DTC goals), follow factory design guides, reliability & maintainability (R&M), supportability and integrated logistics support (ILS)? Does the design address ease of test, access, repair (e.g. BIT / other Fault isolation approaches) & DFM and DTC?**
15. **Have untested, novel special materials, hardware and/or processes been minimized?**
16. **Have design reviews, peer reviews and problem tracking system been established?**
17. **For spiral/incremental development, is each build capability defined & put in the IMS?**
18. **Are challenged requirements & assumptions tracked weekly as risks with mitigation plans?**
19. **Have planned re-use components been obtained and baselined in the project's CM system? Is obsolescence an issue with resolution actions in place?**
20. **Are the major suppliers' requirements defined & agreed to via face-to-face reviews to eliminate ambiguity with no meaningful TBDs and to assess their system requirements review (SRR)/system design review (SDR) readiness?**

21. **Do the subcontract management plans/contracts define mechanisms to monitor and ensure adequate performance with penalties & corrective actions for poor performance?**
22. **Have supplier qualification plans/methods been identified to ensure product testing meets requirements and functionality, including producibility, testability and repair concerns?**
23. **Has the team been organized to prevent functional stovepipe problems?**
24. **Is a robust CM system in place to configure the deliverable System, SW & HW work products plus non-deliverable items e.g.: test software, design analyzes, documents, etc?**
25. **Is a mechanism established to identify, track, elevate and adjudicate scope growth issues?**
26. **Is there sufficient, experienced, skilled staff to do all work on time within budget? Is the schedule & budget realistic to do the job right the first time, with enough cost/schedule reserve to address risk realism? Is the schedule granular enough to track real progress?**
27. **Have the major suppliers been assessed in a similar fashion to all of the above?**

Preliminary Design Phase: Focus items from system design to a preliminary design

1. **Are the requirements and interfaces e.g. specs, interface control documents (ICDs), defined and reviewed for all the lower level deliverable items and non=recurring engineering (NRE) test equipment (TE) items. Do the receiving groups accept these requirements/interfaces?**
2. **Are the designs defined & reviewed for all the low level deliverable items & NRE TE items, including re-use items, interfaces, SW-HW-FW partitioning and error budgets?**
3. **Did the reviews follow the respective discipline's design practice to ensure a complete and adequate review (e.g. de-rating; spare thru-put, pin-outs, memory; system reliability, ease of test; ease of making SW/FW changes; no 'gold plating', etc.?**
4. **Has one 'owner' been defined and agreed to for each design deliverable item? Does he/she agree with the final design?**
5. **Are both internal and external scope growth items being managed, identify, track, resolve?**
6. **Is concurrent engineering engaged: design for testability, producibility (DTC goals), Factory Design Guides, R&M, supportability & ILS, and were these flowed to the subs?**
7. Is there a sufficient BIT/Fault isolation design in place to support integration and test efforts?
8. Have untested, novel special materials, hardware and/or processes been minimized?
9. **Are all cables specified & designed inclusive of system integration lab (SIL) & TE needs?**
10. **Is the 'Power-Up' sequence specified and designed? Are grounding schemes sound?**
11. **Have the high risk/'really-hard-to-meet' requirements been identified along with mitigation and work-around plans; are they in the integrated master schedule (IMS)? Are mitigation plans in place for high risk dependencies e.g.: subcontract/vendor deliveries; GFE hand-ins; long lead procurements?**
12. **Have the lower level risks been identified, understood and are mitigation plans in place?**
13. **Have simulations been identified & performed to confirm the veracity of the designs?**

14. Is the parts selection process being adhered to? Are long lead items identified?
15. Has the 'family tree' been matured to identify all required drawings inclusive of TE?
16. Is there a plan to identify, track, and resolve defects found throughout the lifecycle?
17. Is the I&T / V&V plan at a high degree of maturity?
   - **a. Is there a detailed PERT of the planned IV&V flow? For each sub-element in the structured build up of the end item, is the required level of HW, FW, & SW at each stage defined & addressed?**
   - **b. Have all the lower level dynamic (not static) design verification tests (DVT) tests been identified in the plan?**
   - **c. Were TE design requirements established and the approach to calibrate, sell-off, and prove the TE's readiness developed?**
   - **d. Have all system & development 'Dependencies' been addressed: Capital, G/CFE, reuse, other?**
   - **e. Have 'Security' and related clearance & handling concerns been addressed?**
   - **f. Does the plan address spares and adequate test assets to support testing?**
   - **g. Are regular team communication sessions being held beginning with a stakeholder (with major Suppliers) requirements walk-down to eliminate ambiguity of requirements?**
   - **h. Is there a test matrix mapping each prime item, allocated and partitioned requirement to a specific test, analysis or other direct or indirect method to prove compliance?**
   - **i. Is the test plan developed? Does it address the system test procedure scope, need date, etc, including required TE, cables, G/CFE, etc.?**
   - **j. Is the I&T/V&V schedule and assumptions (e.g. Tools, TE, Test Assets, Key personnel availability) realistic and have risks been identified and quantified realistically?**

18. Have the major suppliers been assessed in a similar fashion to all of the above?

Final Design Phase: Focus items from a preliminary design to a final design

1. **Are all Spec & ICD flow-down documents complete with no TBDs for the prime items & TE?**
2. **Are all designs complete & reviewed for all the low level deliverable items & NRE TE items, including re-use items, interfaces, SW-HW-FW partitioning and error budgets?**
3. Did the reviews follow the respective discipline's design practice to ensure a complete and adequate review (e.g. de-rating; spare thru-put, pin-outs, memory; system reliability, ease of test; ease of making SW/FW changes; no 'gold plating', etc.?
4. **Does the defined 'owner' for each design deliverable item agree with the final design?**
5. Are both internal and external scope growth items being managed, identify, track, resolve?
6. Is concurrent engineering engaged: design for testability, producibility (DTC goals), Factory Design Guides, R&M, supportability & ILS, and were these flowed to the subs?
7. Is there a sufficient BIT/Fault isolation design in place to support integration and test efforts?
8. Have untested, novel special materials, hardware and/or processes been minimized?

9. **Are all Prime and TE drawings identified and being produced and released per plan?**
10. Are all cables specified & designed inclusive of SIL & Test Equipment (TE) needs?
11. Is the 'Power-Up' sequence specified and designed? Are grounding schemes sound?
12. **Are all requirements stable? Have simulations verified the design approach?**
13. **Have all required analyses been identified and are completed, per schedule?**
14. **Are all risk mitigation efforts / design assurance testing of high risk areas underway? Do the results verify the design? Are any additional work-arounds developed? Are mitigation plans in place for high risk dependencies e.g.: subcontract/vendor deliveries; government furnished equipment (GFE) etc.?**
15. **Are all assemblies and parts lists (P/Ls) defined and is the bill of material (BOM) under configuration control?**
16. **Have long lead items been defined, released, and purchase orders (Pos) & Work Orders placed?**
17. **Are defects being identified, tracked, and resolved?**
18. **Is the I&T/V&V plan at a very high maturity level & aligned with the I&T/V&V Check List?**
    a. Is there a detailed PERT of the planned IV&V flow? For each sub-element in the structured build up of the end item, is the required level of HW, FW, & SW at each stage defined & addressed?
    b. Have all the lower level dynamic (not static) DVT tests been identified in the plan?
    c. Were TE design requirements established and the approaches to calibrate, sell-off, and prove the TE's readiness developed?
    d. Have all system & development 'Dependencies' been addressed: Capital, G/CFE, reuse, other?
    e. 'Security' and related clearance & handling concerns been addressed?
    f. Does the plan address spares and adequate test assets to support testing?
    g. Are regular team communication sessions being held? Are hand-ins/outs & dependencies understood?
    h. Is there a test matrix mapping each prime item, allocated and partitioned requirement to a specific test, analysis or other direct or indirect method to prove compliance?
    i. Do test procedures for each test exist inclusive of all required STE, cables, G/CFE, etc.?
    j. Is the I&T/V&V schedule and assumptions (e.g. Tools, TE, Test Assets, Key personnel availability) realistic and have risks been identified and quantified realistically?
19. **Do the designs meet the margins & error budgets for high manufacturing & test yields?**
20. **Are the TE designs complete with a build & test plan that supports the product test needs?**
21. **Are all analyses (e.g. producibility, testability, R&M) and 'ility' engineering design trades & design inputs defined, conducted, & do the results support the system needs?**
22. **Are the major suppliers being tracked IAW the above to assure their progress & readiness?**

Buy, Build, Low Level Test Phase: Focus items to assure all assets are being made ready for I&T

1. **Are all Parts-Lists complete and under configuration control subsequent to their respective design reviews?**
2. **Is there a composite BOM for prime hardware and for TE?**
3. **Is material being tracked to the lowest level of assembly (e.g. PCB level)?**
4. **Are all Requisitions prepared? Do quantities reflect shrinkage and spare asset and test asset needs?**
5. **Are all PO's placed?**
6. **Are all need dates defined?**
7. **Are all promise dates defined and are they being tracked? Any work-arounds needed/in place?**
8. **Is the build plan (lot sizes, inspection points, etc.) defined?**
9. **Are all kits defined and are they being tracked?**
10. **Are assemblies being produced per plan?**
11. **Is a prototype build and test plan in place and being assessed relative to improvements for transitioning to a high rate high yield production and test environment?**
12. **Are manufacturing and test personnel assigned to the development phase?**
13. **Is a pilot production run planned to work out the XTP kinks and improve cost and yield?**
14. **Are lower level test set-ups in place**
15. **Are all work products under control?**
16. **Is the SW & FW complete enough to support initial low level HW testing of the prime items and Test equipment?**
17. **Are low level functional tests occurring and are the prime items & Test Equipment being produced per plan, including major suppliers?**
18. **Do the hardware and software simulators used in unit testing/sub-integration realistically represent the target environment?**
19. **Are the major suppliers being tracked and assessed on the same above items to assure their readiness and ability to deliver their products: on schedule, cost and functional operability?**

Integration Phase: Focus items during integration phase to assure system functional operability – Pre V&V/Qual

1. **Is there sufficient, reliable, calibrated commercial and/or developed Test Equipment that realistically represents the target environment & system interfaces?**
2. **Is the developed Test equipment meeting the required schedule, budget and functional operability?**

3. **Has the availability of the platform (e.g.: aircraft, ship) been coordinated and scheduled to support integration and test efforts? Travel activities planned?**
4. **Have the SW & HW hand-ins completed their unit testing/sub-integration, are they mature/reliable products, and shown to meet their allocated requirements and operational functionality that can be shown at this point?**
5. **Are the Integration Plans and Procedures completed and approved? Do they cover testing the system over the operational environment versus "just meeting the requirements"? Are "4-corners" of the box being exercised?**
6. Were all 'Dependencies' addressed: Capital, G/CFE, other and in place per plan?
7. Were 'Security' and related clearance & handling concerns addressed and implemented?
8. Does the plan address spares and adequate test assets to support testing and are they in place?
9. **Has any Continental US/Outside Continental US (CONUS/OCONUS) transmission/reception authorizations been coordinated and approvals received?**
10. **Is there a plan to improve system reliability that can impact integration and test progress? Is the plan working?**
11. **Are integration tests being executed per plan with 'requirements passing' being tracked & reviewed per plan?**
12. **Is there sufficient support planned from the development teams to conduct integration efficiently and effectively? Does the core I&T team have the needed skills and experience to be successful IAW the schedule & budget plan?**
13. Has a plan to identify track and resolve defects where ever they are found throughout the program been developed and is it being followed?
14. **Is there a comprehensive PERT of the planned IV&V flow and is it being followed?**
15. For each sub-element to be integrated, tested, verified and validated in the structured build up of the end item, is the required level of HW, FW, & SW at each stage defined and addressed and being met per needs?
16. **Have the integration procedures been executed many times to ensure reliable operational system functionality?**
17. **Are the major suppliers being tracked and assessed on the same above items to assure their readiness and ability to deliver their products: on schedule, cost and functional operability?**

Verification, Validation, & Qualification Phase: Focus items during compliance verification, qualification and validation to assure requirements compliance overall and production readiness

1. Have all the lower level DVT tests been identified in the plan and is dynamic (not static) DVT planned and occurring?
2. Are the V&V Plans and Procedures completed and approved, including with Customer? Do they include the required STE, cables, G/CFE, etc?

3. Have integration procedures been successfully executed front-to-back before beginning the respective test efforts?
4. Are regular team communication sessions being held including major suppliers?
5. Has a kickoff review been held to cover: review of integration testing results, open problems, CM baseline of work products, requirements compliance and coverage, defects planned, etc?
6. Is there a specific, detailed test matrix that maps each prime item requirement (as well as allocated, partitioned lower level requirements) to a specific test or analysis or other direct or indirect method of proving compliance and is it being followed and tracked?
7. Have the high risk, difficult requirements been identified along with mitigation and work-around plans?
8. Is the qualification schedule and assumptions (e.g. Tools, TE, Test Assets, Key personnel availability) realistic and have risks been adequately identified/ quantified and being periodically reviewed?
9. **Are the major suppliers being tracked and assessed on the same above items to assure their readiness and ability to deliver their products: on schedule, cost and functional operability?**

Transition-to-Production Phase: Focus items to assure a smooth transition to production

1. **Is Qualification testing complete? Are all updates to the system been accounted for?**
2. **Is there a detailed buy, build, test, inspect, and sell-off flow for each lower level item as well as final assemblies to be formally sold off for acceptance?**
3. **Is a Production ramp up plan in place? Has a pilot run been planned?**
4. **Have long lead procurement items defined? Have any economical lot sizes been defined?**
5. **Are all facilities, tools, test equipment, test assets inclusive of 'golden units', test cables, key personnel and other special dependencies such as GFE/CFE and capital defined and in place?**
6. **Are contention issues with other concurrent programs being dealt with for production facilities?**
7. **Are all Production security concerns addressed?**
8. **Have the engineering designs been assessed for all of the "ility" needs to be successful in a high rate, high yield, highly automated production environment?**
9. **Have Operations personnel been mentored by Engineering in the development and initial unit build and test phase?**
10. **Has producibility been assessed via a Pilot run in a production environment using production personnel and equipment and processes and procedures?**
11. **Is a configuration control process in place?**
12. **Has an internal FCA / PCA been completed?**
13. **Is a process to incorporate Continuous Improvement suggestions in place?**

14. **Is there a process in place to assess yield and cost goals?**
    a. **Is there a 1st pass yield tracking and improvement process in place?**
    b. **Is there a DTUPC tracking and improvement process in place?**
15. **Are the risks and opportunities identified and are mitigation and realization plans funded and embedded in the IMS, including suppliers?**
16. **Has a realistic plan been developed to introduce products improvements while production is ongoing?**
17. **Have Production test stands been developed and verified reliably operational from many practice runs?**
18. **Is there a streamlined problem tracking/ECO process and toolset in place with Operations and Engineering?**
19. **Have all critical manufacturing processes, test stand and equipment been shown to be operational in a factory environment?**
20. **Is there enough test assets and "Golden Units' to support manufacturing?**
21. **Have the major suppliers been assessed similar to the above?**

Key processes mentioned at the outset of this discussion now follow and include:

- Risk and Opportunity Management
- A simplistic example of 'Re-Modeling a Bathroom" will illustrate the following important practices:
    - Breaking down the scope of the work to be performed into manageable tasks producing the Work Breakdown Structure of the program (WBS).
    - Developing and tracking an Integrated Master Schedule (IMS) that is inclusive of both a 'Waterfall' / Gantt view that time phases and resource loads the tasks to be performed on the project and provides insight to the critical path(s) of the project; and a Network Flow Diagram / PERT view that is key to visualize the Work Flow and the Interactions & Interdependencies on the project.
    - Evaluating Cost and Schedule performance and variances to plan utilizing the Earned Value Management System (EVMS) technique.
    - Applying Risk Management to quantify and Mitigate risks associated with a project.
- Performing Causal Analyses using the '5-Why' approach.

Also presented in an appendix is a rudimentary familiarization overview of an alternative Program Management approach called 'Scrum'.

Risk & Opportunity (R&O) Management

A Program Manager is responsible to meet all contractual obligations on a project. The customer expects that all performance specifications will be met and that all deliveries as stated in the contract will be met on time. The company's management expects that this will be accomplished within the agreed to cost quoted to the customer. It is reasonable to expect that there are going to be some risks associated with the development of technology. Risks translate to the possibility that some of the specifications may not be met and that some of the delivery milestones my not be met unless some actions are taken to identify and mitigates these risks and / or to have contingency plans if some of the risks materialize. Therefore, during the cost estimating phase of the project, before a quote is submitted, the risks to the project have to be identified and quantified so that a reasonable contingency fund is included in the estimate that covers the mitigation activities and that also covers the cost associated with a reasonable amount of risks that will materialize and their contingency plans so that overall contractual commitments are still met.

There may be opportunities as well that if realized will help offset the risks and these also require identification and quantification even though typically the risks tend to out weigh the opportunities. The reason we do not estimate conservatively to cover all conceivable risks and have many opportunities on a project is usually due to competition, customer budget constraints, and the fact that new technical development is inherently risky.

It is interesting to understand that sometimes the same item can be either a risk or an opportunity. It depends on what was assumed in the baseline. If a $100,000 package of money that is in the middle of a highly trafficked highway is part of the estimate to complete the project then getting the money is a risk. If the cost to complete the project did not depend on this money then it represents an opportunity albeit the opportunity is risky and the realization cost may not be worth the effort.

The process to identify and quantify risks and opportunities encompasses an assessment of the likelihood of occurrence of each risk and opportunity identified and an assessment of the associated impact to the program for each risk and opportunity should they occur. A matrix is established for each R&O that categorizes each as one of the following:

- It's going to happen and is impactful so put the full value (100%) of the impact into the baseline including the cost of any contingency plan
- It is highly likely although not a certainty that it will happen and is impactful so put a factored amount (75%) into the baseline and budget the cost to mitigate the risk / realize the opportunity
- It may happen and is somewhat impactful so put a reduced factored amount (50%) of the impact into the baseline and budget the cost to mitigate / realize the R/O
- It probably won't happen and is not very impactful but just in case put some minimal factored amount (25%) of the impact into the baseline and keep an eye on it

Typically the reserve included in the baseline estimate is the sum of the factored risks minus the sum of the factored opportunities. The baseline also includes all mitigation and realization costs.

The methodology to conduct the likelihood of occurrence and impact analyses for each R&O is presented in the ensuing tables where the following notation applies: Very High=VH, High=H, Medium=M, Low=L, Very Low=VL, Risk=R, and Opportunity=O:

Risk / Opportunity Likelihood of Occurrence Analysis

Likelihood / Probability of Occurrence

What is the likelihood that the Risk (R) / Opportunity (O) will happen?		
Level	**Likelihood**	**Planned Approach**
VH	Near Certainty	**R**: May not be able to mitigate this type of risk fully **O**: The opportunity will occur with minimal effort
H	Highly Likely	**R**: May not be able to mitigate this type of risk fully but a different approach might **O**: Can be achieved with a defined plan of implementation
M	Likely	**R**: May mitigate this risk / workarounds will be required **O**: Achievable with concerted effort and follow-up
L	Low Likelihood	**R**: Mitigated this type of risk with minimal effort in past **O**: Significant effort required with many obstacles
VL	Not Likely	**R**: Will avoid or mitigate using standard practices **O**: Too many obstacles to overcome

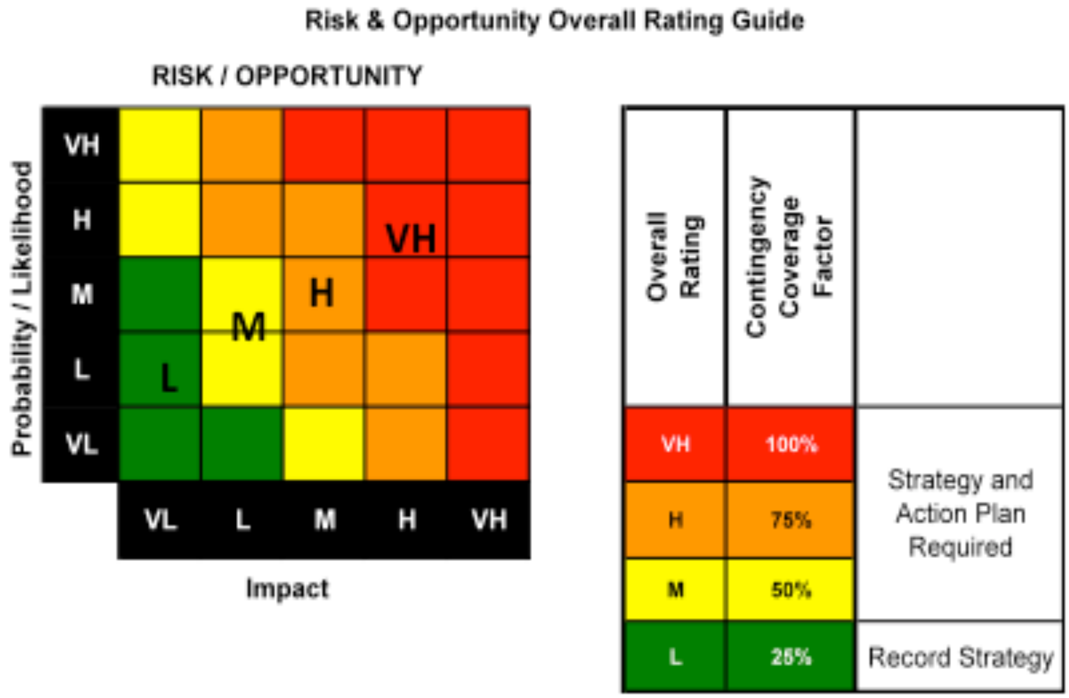
Risk / Opportunity Impact of Occurrence Analysis

Consequence / Impact

What is the impact if the Risk (R) / Opportunity (O) happens?			
Level	**Technical / Performance**	**Schedule**	**Cost**
VH	**R**: Serious non-compliance **O**: Big improvement; will achieve both desired and required goals	**R**: Cannot meet program milestones **O**: Will complete ahead of schedule	**R**: Serious cost overrun **O**: Very big under run
H	**R**: Degraded performance; workarounds available **O**: Improved performance; many desired goals met	**R**: Loss of slack in critical path and key milestones **O**: Improved slack in critical path and key milestones	**R**: Significant cost overrun **O**: Big under run
M	**R**: Some shortfall not negotiable **O**: Moderate improvement	**R**: Minor slip requiring re-planning of the critical path **O**: Moderate improvement to critical path	**R**: Moderate budget overrun **O**: Moderate cost improvement
L	**R**: Minor shortfalls but negotiable **O**: Minor improvement	**R**: Minor shortfalls but negotiable **O**: Minor improvement	**R**: Minor increase **O**: Minor decrease
VL	**R / O**: Little or no impact	**R / O**: Little or no impact	**R / O**: Little impact

Using the previous assessments, the Matrix that establishes the factored amount follows:

Risk / Opportunity Quantitative Rating & Percentage Factor Chart



NOTES:

Risk mitigation drives toward the lower left corner of the matrix. {Red is unfavorable}

Opportunity realization drives toward the upper right corner of the matrix. {Red is favorable}

Risk Mitigation & Opportunity Realization

Enacting a plan to Mitigate or 'Burn-down' the major risks on a program is essential to reducing the likelihood and impact of their occurrences and it is important to enact a realization plan as well to make opportunities happen. Both activities form an integral part of the overall program plan to offset and reduce risk and thereby meet contractual and budget commitments.

The following seven example activities are listed as an aid to stimulate thought in developing mitigation and realization plans. Typically if implemented they generally reduce risk and/or lead to opportunities:

Analyses, Requirements review with customers, Multiple Sourcing Vendors, Early Testing, Selective Prototyping, Modeling / Simulation, Formulating a 'Tiger Team' to focus on key areas of concern.

Each Mitigation / Realization (M/R) task in a M/R plan is intended to improve upon the situation. The expected improvement in risk or opportunity factor (an improvement of 5%, 19% etc.) is a judgment without the need for formal likelihood vs. impact quantification. By definition, if the interim event is successful it is assumed that the actual improvement has been achieved. For example, if an analysis is performed relative to a performance risk with favorable results the improvement may be judged to be a few percent reduction in the risk factor; if modeling or simulation is then performed on the risk area and the outcome is judged to be successful the risk is reduced further by a percentage deemed appropriate based on experience; and if selective prototyping is then performed on the risk area and its outcome is successful the risk is burned-down even further possibly mitigating it completely. A similar argument can me made for assessing the success when enacting opportunity realization plans.

Note: Mitigation is not the only way to handle risks. Transferring the risk is an option. For example, if meeting a requirement via a hardware design is risky, performing the task in software may not be risky. Moreover, if the cost benefit trade to mitigate a risk is not sound, i.e. spending $50,000 to mitigate a $60,000 risk would not be sound, then absorbing the risk may be the best strategy.

The following tables are provided as an aid to assess areas of potential risks / opportunities in key functional developmental domains of Software, Hardware, Systems, and Program Management:

Software
R&O Areas to Consider / Checklists

Risk Areas	Opportunity Areas
Defect Detection	Can Program be accelerated?
Requirements	Ability to under run estimate or budget due to additional efficiencies or learning
Acceptance Criteria	
Cost Evaluation	
Productivity	
COTS	
Re-Use	
Co-Development	
Asset Availability	
Design Tools	
Technology	
Design	
Commonality	

Hardware
R&O Areas to Consider / Checklists

Risk Areas	Opportunity Areas
Sole Source Parts Component Lead Time Manufacturability Manufacturers' Change in Product Design Tools Component Life Cycle Subcontracts Unique/Exotic Parts & Materials Experience & Expertise Requirements Asset Availability Design Validation Size, Weight, and Power Re-Design/Rework DTUPC	Can Program be accelerated? Ability to under run estimate or budget due to additional efficiencies or learning Ability to under run cost budget due to lower than planned defect rate, rework percentage or higher than planned test yields Manufacturing capability or application of new Manufacturing/ Test technology Use of existing stock parts or sub-assemblies Potential safety margin

Systems
R&O Areas to Consider / Checklists

Risk Areas	Opportunity Areas
Requirements Experience & Expertise Re-Use System Design Design Validation Asset Availability Plan System Trades Metrics System Design & Development Life Cycle Risk Guidelines	Program can be accelerated Potential safety margin Additional requirements create added scope & hence added fee Customer acceptance of Qualification by Similarity

Program Management
R&O Areas to Consider / Checklists

Risk Areas	Opportunity Areas
Requirements	Program can be accelerated
Plan	Customer Milestones are less aggressive or schedule is elongated from standard or typical lead times
Baseline	Ability to increase through-put or monthly delivery rate
Technology	Improvement on cost due to program acceleration versus established support budgets & duration
Dependencies	Subcontractor/Vendor may improve cost/schedule/delivery
Re-use	
Special Issues	
Design Validation	
Re-Design/Rework	
Assets	

Program Planning, Tracking, and Control

The following example of ‘Re-Modeling a Bathroom’ will illustrate key program planning, tracking, and control processes inclusive of: Developing a Work Breakdown Structure (WBS) of program activities and resource loading them; Time phasing the tasks to produce an Integrated Master Schedule (IMS) using both Gantt and PERT views; Using the Earned Value Management System (EVMS) for cost and schedule assessments; and an applied example of Risk Assessment is included for completeness. This material is presented in power point format for simplicity and compactness of narration.

Program Management Overview (Introductory Level)

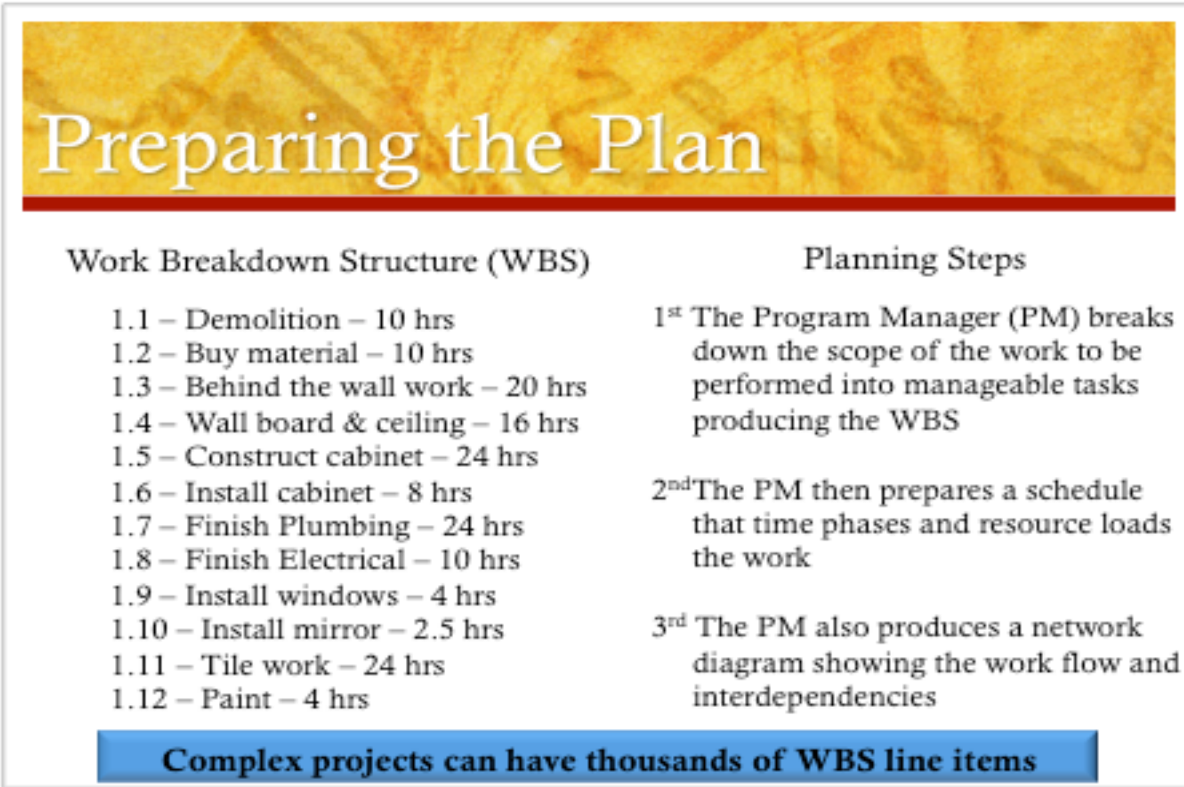
Project Example: Remodeling a Bathroom

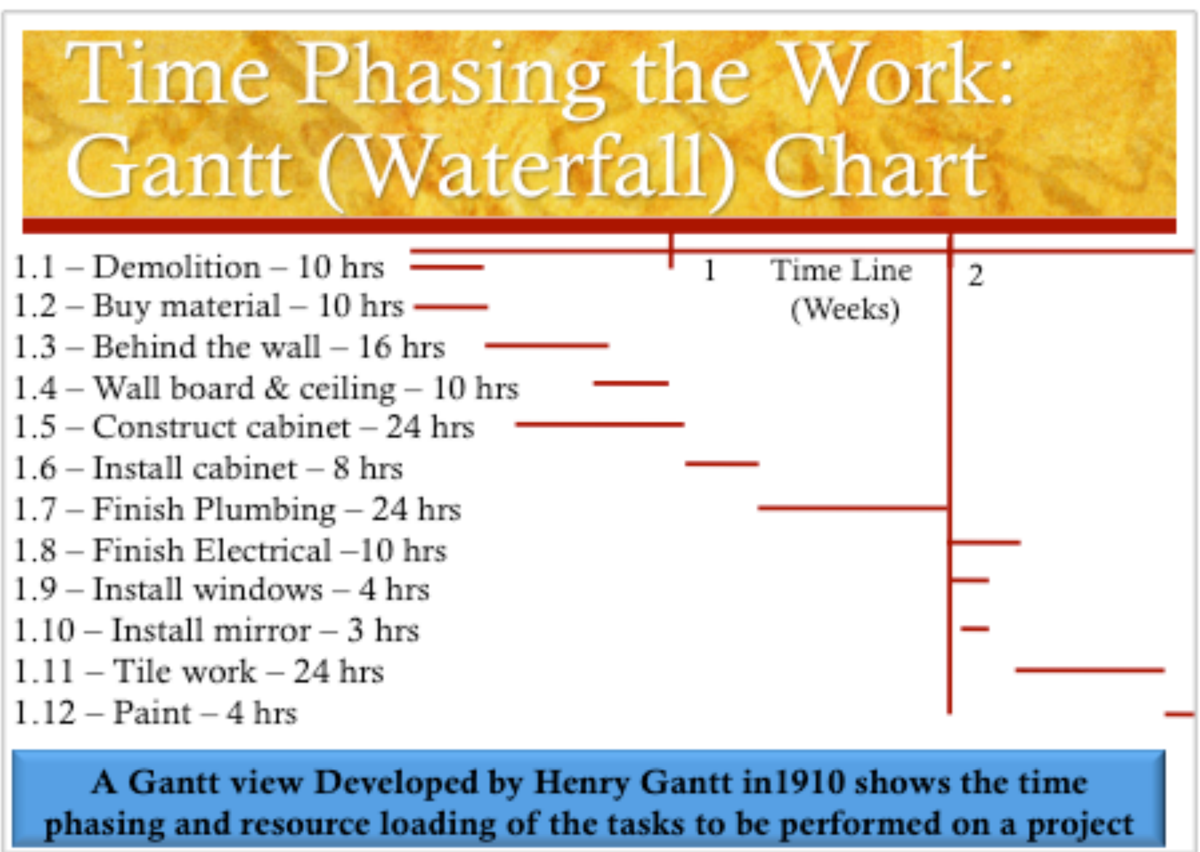
Program Management (PM) Contents of Key PM Topics

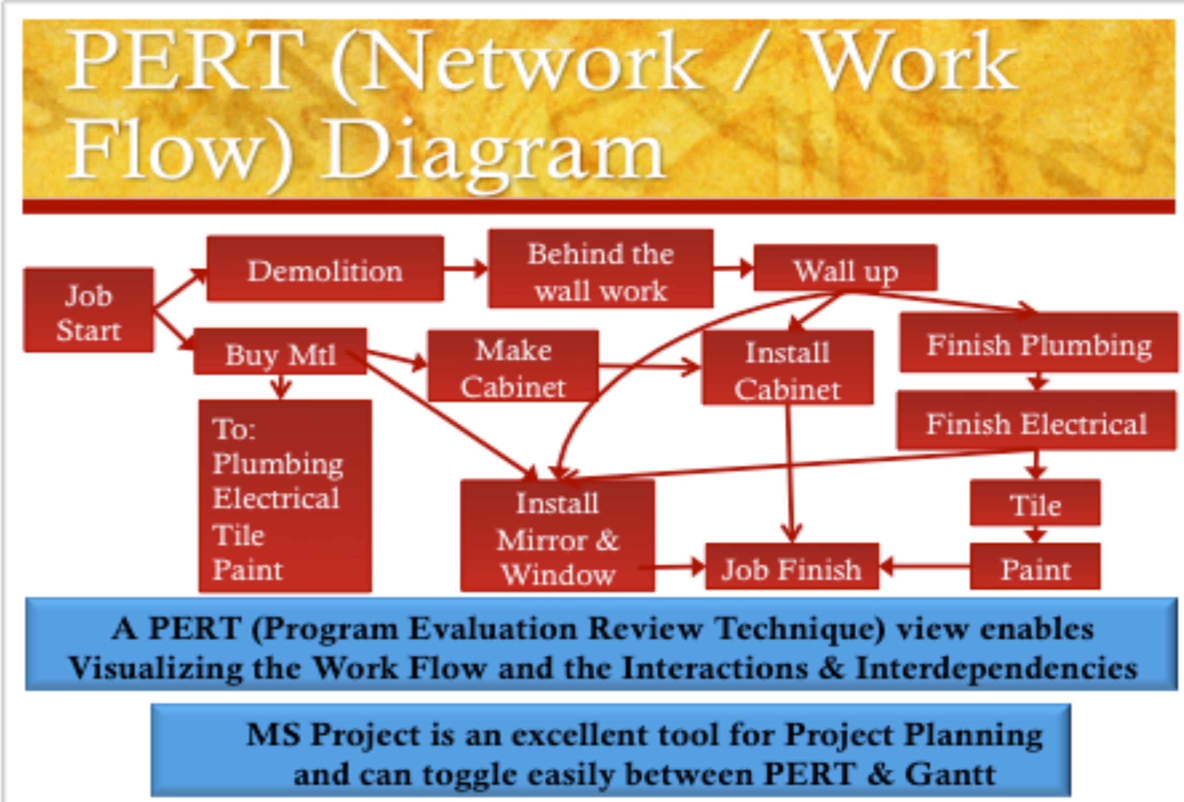
- PROGRAM PLANNING & FINANCIAL MANAGEMENT
  - Project Work Breakdown Structure
  - Project Plan Views
  - Project Execution / Cost & Schedule Assessment
  - Earned Value Management System (EVMS)
  - Variance Analysis & Recovery Planning
- RISK MANAGEMENT
  - Example Risks and Risk Mitigation
  - Schedule Risk Assessment
  - Risk Quantification

The Principles discussed herein are Scalable

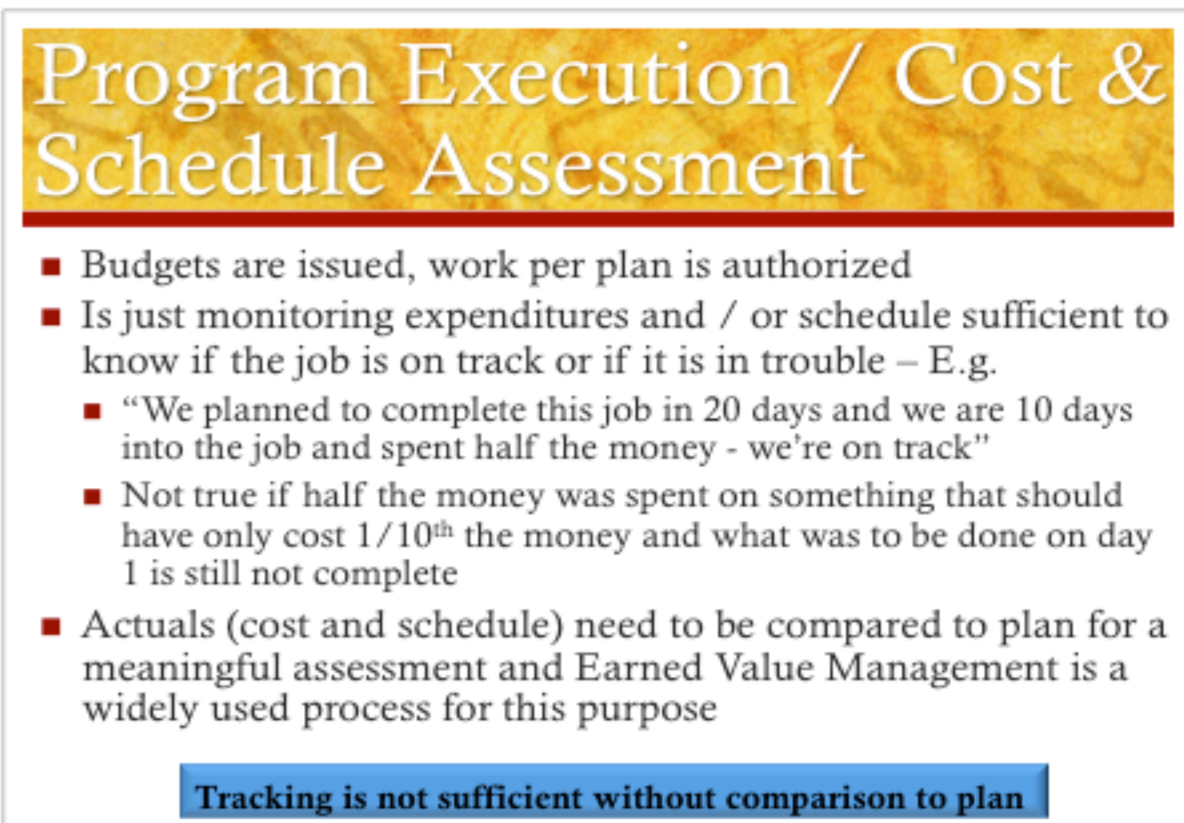
Developing the Program Plan (Note: Plumbing = all sinks, tubs, etc; Electrical = all lights, outlets, etc.)







Tracking Cost and Schedule using the Earned Value Management System (EVMS)



Earned Value Management System (EVMS)

- Key EVMS Terminology
  - Budgeted Cost for Work Scheduled (BCWS) is the planned dollar amount budgeted to do a task
  - Budgeted Cost for Work Performed (BCWP) is the budgeted BCWS amount credited when the task has actually been performed
  - Actual Cost for Work Performed (ACWP) is the actual cost incurred on a task
  - Cost Performance Index (CPI) is a measure of program cost goodness; >1 is good

    CPI = BCWP ÷ ACWP (budgeted amount for a task ÷ actual amount spent)
  - Schedule Performance Index (SPI) is a measure of schedule goodness; >1 is good

    SPI = BCWP ÷ BCWS (In a given time period, the planned value of work actually performed in that time ÷ value of work that was supposed to be completed in that time period)

CPI & SPI Provide Measures of Project Goodness via Variances to Plan

Example: In-process EVMS Program Assessment

- 80 hrs into the work – how's it going (Should have completed: Demolition, Buy Mtl, Behind the wall, Wall board, Build & Install Cabinet, Finish Plumbing) Note: All labor @ $100/hr
- Demolition: BCWS = $1,000 (10 hrs) – Complete BCWP = $1,000; Actual cost $1,100
- Buy Mtl: BCWS = $1,000 (10 hrs) – Complete BCWP = $1,000; Actual cost $1,100
- Wall work: BCWS = $2,600 (26 hrs) – Complete BCWP = $2,600; Actual cost $2,700
- Cabinet: BCWS = $3,200 (32 hrs) – Complete BCWP = $3,200; Actual cost $3,100
- Plumbing: BCWS = $2,400 (24 hrs) – 50% complete BCWP = $1,200; Actual cost $1,400
- Total BCWS = $10,200
- BCWP = $9,000 (Only 50% credit for plumbing)
- SPI = BCWP ÷ BCWS = .88 (behind plan); Schedule variance BCWP – BCWS = -$1,200
- ACWP = $9,400
- CPI = BCWP ÷ ACWP = .96 (over plan); Cost variance BCWP – ACWP = -$400

Early In-Process CPI & SPI Warning Enables Recovery Planning

Variance Analysis & Recovery Planning

- What is causing the Plumber's schedule delay – possible causes need to be looked into to determine a schedule recovery plan
  - Plumber was ill and out for a day – work overtime to recover
  - Something broke and took unplanned time to fix – challenge the electrician to make up the time difference in his work
- What is causing the Plumber's cost increase – possible causes need to be looked into to determine a cost recovery plan
  - A task was more complicated than originally estimated – make up the difference in another work package
  - Something broke and took unplanned time to fix – release some reserve to cover a realized risk

Recovery Plans Depend on an Analysis of Variances to Plan

Program Planning & Cost Management Summary

- Prepare the project WBS (Work Breakdown Structure) that breaks the job down into manageable tasks that can be resource loaded and time phased
- A Gantt (Waterfall) Chart & PERT (Network / Work Flow) Diagram are two views of a Project Plan to visualize the project's time phasing and work flow
- Track progress to plan for each WBS scheduled work package and budget via the Earned Value Management System (EVMS)
- Use the CPI (BCWP ÷ ACWP) & SPI (BCWP ÷ BCWS) as indicators of project goodness
- Perform a Variance Analysis when Actuals differ from Plan particularly if CPI is <1 or if SPI is <1
- Early warnings of cost and schedule issues enable the development and implementation of 'Get Well' plans to recover

Planning is key and tracking is not sufficient without comparison to plan

RISK MANAGEMENT

- RISK MANAGEMENT
  - Example Risks & Risk Mitigation
  - Schedule Risk Assessment
  - Risk Quantification

What are some possible Risks and Mitigation Plans

- Risk: Something breaks; Mitigation: Develop and follow 'handle with care' procedures
- Risk: Wrong material; Mitigation: Check before install
- Risk: Installation error (e.g. – pattern of tile upside down); Mitigation: Check with customer before install
- Something leaks water after plumbing installation is complete; Mitigation: Test before walling up with tile
- Schedule Risk – (The risk associated with the veracity of our time per task estimates); Mitigation: Perform a Schedule Risk Assessment (Next Chart)

Identify and Quantify key Risks & Plan to Mitigate them

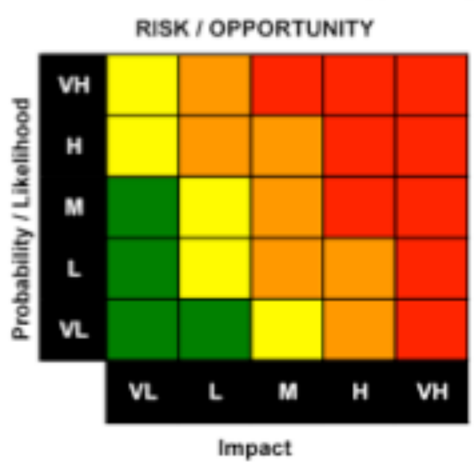
Schedule Risk Assessment

- We've all heard 'Time is Money' so how do we assess the veracity of our estimates of the time it takes to do each task in the plan
- For Complex Projects: 3 point estimating & Monte Carlo simulations are often performed to obtain the overall probabilistic assessment of a completion date
  - Earliest possible optimistic completion
  - Latest pessimistic completion
  - Most likely completion
- Critical Path Assessment (those tasks that determine the time to complete a project that cannot be made shorter unless there is slack in the path – e.g. It takes 9 months to have a baby)
- Slack Determination – how much 'cushion' there is in the time allotted to do a task

Schedule delays are costly - the 'marching army' keeps charging the job

Risk Quantification Process

Risk & Opportunity Overall Rating Guide



Overall Rating	Contingency Coverage Factor	
VH	100%	Strategy and Action Plan Required
H	75%	
M	50%	
L	25%	Record Strategy

Judgment Determines Which Risks are Important to Mitigate

Quantification Example

- Something breaks (Likelihood is medium; Impact is medium $1,000 mtl+labor if it happens – factor is high 75%); Net risk = $750
- Wrong material (Likelihood is very low; Impact is medium $900 Mtl + labor if it happens – factor is medium 50%); Net risk = $450
- Installation error (Likelihood is low; Impact is high $2,000 labor – factor is high 75%); Net risk = $1,500
- Leaks occur after complete plumbing (Likelihood very low; Impact is high $3,000 labor – factor is high 75%); Net risk = $2,250
- Schedule delay due to task complexity (Likelihood very high; Impact medium 4hrs = $400 – factor is very high 100%); Net risk = $400
- Overall Gross Risk = $7,300; Net Risk = $5,350

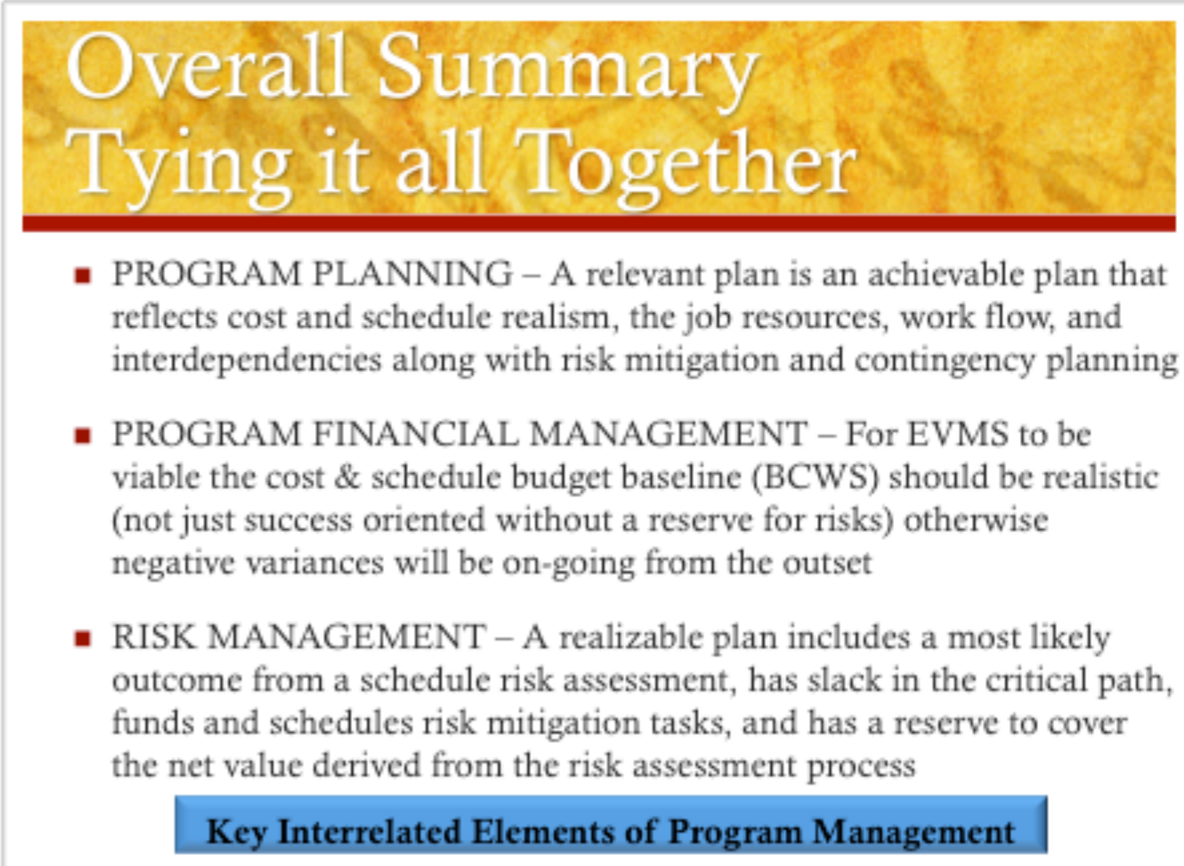
Mitigation Plans are Essential

Risk Management Summary

- Identify potential risks and mitigation plans
- Perform a schedule risk assessment to determine the risk to the schedule
- Quantify the gross financial impact should the risks occur
- Assess the "Net" financial risk by multiplying the gross impact by the Overall Rating and establish a reserve
- Fund and implement each mitigation plan

Note: Although only risks are being discussed, this process applies equally to to Opportunity Realization as well

Identify & Quantify Risks / Perform a Schedule Risk Assessment
Set Aside a Reserve to Cover Risks / Develop & Fund Mitigation Plans



Root Cause and Corrective Action Determination

There are at times unknown unknowns that occur during a high tech development program that impact the program's ability to meet cost, schedule, or performance objectives. Often times early warnings that something is amiss can be discerned from the alerts provided by unacceptable in-process drops in either of the program's CPI or SPI indices. Determining the root cause of the issue causing the CPI/SPI drop in a timely fashion is essential so that corrective / preventive actions can be implemented to preclude further occurrences of the issues and further erosion of these indicators and enable recovery plans to get the program back on track. Failing to get to the real cause or causes and not just the symptoms of the problem is key to assure that the fixes implemented are not just 'band-aids' but are truly adequate to prevent reoccurrences. A very effective and simplistic practice known as the '5-Why?' process that facilitates the ability to get to the real causes of an issue is presented in the discussion that follows:

5-Why Causal Analysis Approach

Why is this practice called the 5-Why approach?

If the question is asked why an issue is occurring or has occurred, usually the 1^{st} answer to why an issue is occurring is generally just a symptom of the issue and not the ‘root cause’. For example: ‘Why is there blood on your shirt?’ ‘I cut my hand’ is a symptom and basing it on a fix such as ‘putting on a ‘band-aid’ will not prevent getting cut again. Asking Why? a 2^{nd} time i.e. asking why the 1^{st} answer is occurring gets closer but is usually a symptom as well. ‘Why did you get cut?’ ‘The tool I used had a sharp edge that cut me’ is also a symptom. Asking Why? 3-5 times more as to why each of the previous answers are occurring gets to the root cause or primary causes with a much higher probability and implementing corrective / preventive actions at this level will tend to fix the systemic issues which are at the core of the problem. So continuing with the example, ‘Why did it cut you?’ ‘I used it for the 1^{st} time and did not get trained yet’. This is clearly a more primary cause. ‘I also forgot to wear gloves.’ is another primary cause and ‘The tool I used wasn’t the correct one for the job.’ is also a primary cause. Fixing these causes will have a meaningful effect on preventing cuts.

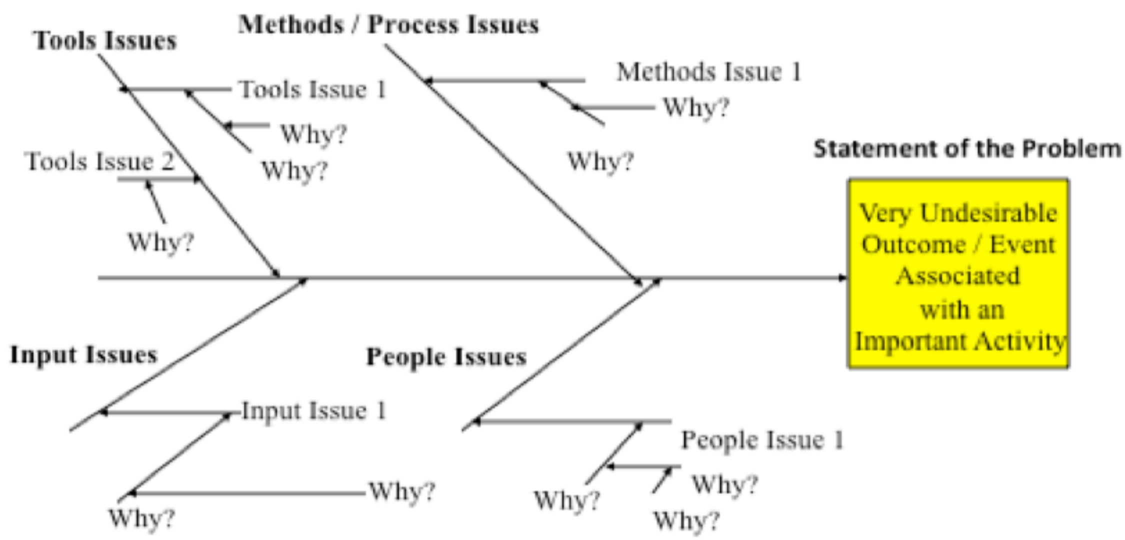
Note: Asking ‘Why?’ too many times can get meaningless results in terms of implementing corrective / preventive actions. For example, ultimately if you ask ‘Why?’ enough times you’ll get the result that the ‘Big Bang’ is the root cause of all the previous answers so asking about 5 times is reasonable.

Categorizing the issues helps the analysis and from the example we see that there are:

- ‘People’ issues (staff may lack the needed training or expertise to do the job)
  - In this case the person doing the job was not experienced or trained
- ‘Tools’ issues (tools may be unreliable, defective, or difficult to use)
  - In this case tools were not marked to assure the correct one was selected
- ‘Input / Requirements’ issues (input or requirements may be incomplete, ambiguous, or incorrect)
  - In this case the job needing a tool did not specify the required tool needed
- ‘Methods / Process’ issues (methods may be incomplete, ambiguous, wrong, or not followed)
  - In this case there were no ‘how-to-use’ procedures in place

Often times diagramming the ‘5-Why?’ causal analysis procedure using a ‘Fishbone / Ishikawa’ diagram as shown below helps visualize the outcomes. (*The diagram looking like a fishbone was developed by Haoru Ishikawa in 1968.*) However, before the causal process can begin a clear and accurate ‘Statement of the Problem’ must be established and data regarding the problem must be obtained and analyzed to determine the systemic issues impacting the problem.

Cause-&-Effect (5-Why) Diagram
(Fishbone / Ishikawa Diagram)



An alternative template is provided below that uses the ‘5- Why?’ method directly for each category without the need to diagram it. Although it is shown for ‘Methods / Process’ issues, the same format is applicable for the other three categories as well.

5 Whys – Why (State Problem) – Methods / Process Issues

- Methods / Process Issues – Why?
  - State Methods Issue 1 and ask Why? is issue 1 occurring
    - State answer to Why issue 1 is occurring and ask Why? this answer is occurring
      - – State answer to Why the previous answer is occurring and ask Why? again
        - » Answer Why and ask Why? again
          - Answer Why (stop asking Why? if an answer seems to be a root cause and further asking would result in a meaningless outcome)
      - – State another answer to Why? at this Indented level and ask Why? for this answer
        - » Answer Why? ...and so on
  - State Methods / Process Issue 2 and ask Why?
    - Answer Why
    - Another answer to Why
  - State Methods / Process Issue 3 and ask Why?
    - Answer Why

In each case ask ‘Why?’ as many times as deemed appropriate to get to a primary / root cause

Summary of Steps in the Process to get to the Primary Causes and Corrective / Preventive Actions

- Develop a Statement of the Problem
- Obtain and analyze data to determine the systemic issues impacting the undesirable outcomes
- Identify the principal cause(s) using a cause-and-effect (Fishbone / Ishikawa) diagram or use the '5- Why?' method directly (using template provided) without the need to diagram it
- Partition the assessment in to 4 principal cause categories:
    1. Methods/Process (methods may be incomplete, ambiguous, wrong, or not followed)
    2. Tools (tools may be unreliable, defective, or difficult to use)
    3. People (staff may lack the needed training or expertise to do the job)
    4. Input/Requirements (input or requirements may be incomplete, ambiguous, or incorrect)

The categorizing and issues drill-down using the "5-Why" approach using the template provided yields several primary causes (the lowest indented answers to each of the "Why's" for each issue). Implementing corrective / preventive actions at this level will tend to resolve the systemic issues which are at the core of the problem to preclude repetition as opposed to just 'band-aiding' the symptoms.

Appendix A

An Introduction to "Scrum"

The following is presented simply to provide the reader with a cursory familiarization of the Scrum process and its terminology because it may be encountered in the workplace. Note: As with all of the topics contained herein, this info is also searchable on the web for more details.

What is "Scrum"?

"Scrum" (also a Rugby term) comes from an 'Agile' software development process that has been seen to be very effective in the software domain and is being applied to project development other than just software. The fundamental basis of the Scrum process is that a 'small' (sometimes called 'lean' or 'agile') Team of cross-functional members who have the skills to do the job, is empowered to lead itself with the responsibility to do the needed work. The work is iteratively accomplished by the Team who commit to take on 'bursts of activity' called 'Sprints' to produce prioritized product increments in ‘small’ periods of time. The overall work is broken down into prioritized activities called ‘Stories’ by the Product Owner (the new role of the Program Manager) who explains the Stories to the Team so that they can estimate the complexity of each Story and thereby determine which Story(s) they can commit to accomplish in a Sprint.

In addition to Stories and Sprints, other terminologies associated with the process are:

1. ‘Product Backlog’ – All the work to complete a project broken down into ‘Stories’ or narrative descriptions of manageable activities, prioritized by what is most important to the customer.
2. ‘Sprint Backlog’ – A pending amount of work (Stories) committed to be done in an agreed to time frame broken down further into tasks.
3. ‘Product Increment’ – The output of each Sprint is a ‘Product Increment’.
4. ‘Burn-down’ – The rate of completion of Sprints is the Burn-down of the effort.
5. ‘Scrummaster’ – An independent person assigned to help remove obstacles and distractions so the Team remains focused on meeting its Sprint goal.
6. ‘Scrum Board’ – Literally a physical board whereby the Team often tracks and coordinates the Sprints on a daily basis by posting the Stories to the board and posting what was completed recently, what is to be completed next, and issues impacting work completion.

Sprint Completion

Ultimately upon Sprint completions there are reviews with Stakeholders to describe, assess, and obtain feedback on what was delivered.

Note: This is a Scalable Process: Large projects can be subdivided into the sum of smaller activities each with small Teams so that the above process can be applied.

See Managementkeyskills.com for more Program Management material including people skills for survival in a harsh management environment and for leadership relationship skills at work and at home.