National Defense Industrial Association
Integrated Program Management Division

Production Working Group White Paper
EVMS Guideline Cross Reference Addendum

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Table of Contents

Introduction

The purpose of this Addendum to the Production Working Group white paper published in 2011 is to add comments related to compliance. The group used the DCMA Cross Reference Checklist that was created in 2012 to evaluate system compliance. It should be noted that with the recent publication of the DoD EVMS Interpretation Guide (EVMSIG) in March 2015 that this checklist will no longer be used. That said, the concepts in the EVMSIG are very similar to previous views on compliance and the use of the checklist should yield the same information.

The working group built upon the prior white paper by reviewing the checklist to determine if compliance in a production environment would be any different across each of the 32 guidelines. Only seven guidelines were determined to require some additional comments and that discussion is provided in this addendum. The checklist items presented below indicate relevant differences between a development and production / manufacturing effort or shipbuilding environment.

Also presented are three associated sections describing additional factors to be considered with the respective guidelines: Production / Manufacturing Considerations, Additional Shipbuilding Considerations, and Typical Production / Manufacturing & Shipbuilding Attributes.

Guideline 1 – Define Work Scope (WBS)

2.1 a) Define the authorized work elements for the program. A work breakdown structure (WBS), tailored for effective internal management control, is commonly used in this process.

DCMA Cross-Reference Checklist Criteria	Relevance within Production / Manufacturing & Shipbuilding
a. Is only one CWBS used for the contract?	Shipbuilders have a unique need to track extremely large products by internal modular construction practices and may have alternative WBS structures
b. Is all contract work included in the CWBS including a complete definition of work scope requirements?	The WBS needs to be comprehensive in its coverage of work, regardless of which WBS structure is referenced
c. Are the following items included in the CWBS:	
(1) Contract line items and end items (if in consonance with MIL-STD-881 latest edition)?	Normal production should be the same, but shipbuilding may be based on the modular assembly process incorporating milestones
(2) All CWBS elements specified for external reporting?	Normal production should be the same, but shipbuilding may have a different WBS used for internal purposes, and this WBS must be mapped to the externally reported WBS
(3) CWBS elements to be subcontracted, with identification of subcontractors?	Should be the same
(4) Control account levels?	In typical manufacturing operations, the person with responsibility, authorization and accountability over the effort is higher up in the organization than would be in R&D. Due to this, the Control Accounts are rather broad and may not be created at the lowest level of the WBS. For shipbuilding, the control accounts would be based on the internal WBS structure focused on the modular construction process

Production / Manufacturing Considerations

The production phase WBS normally follows a physical parts breakdown rather than the subsystem breakdown typically used in the design or development phase. It may be impractical therefore to use the same lower levels of the CWBS in the production phase as were used during the design / development phase. Extension of production WBS requirements should be reviewed by the contractor to verify compatibility with the product manufacturing breakdown and should be limited to those levels absolutely essential.

Additional Shipbuilding Considerations

Current shipbuilding construction practices typically plan and execute based on a modular or milestone approach in which given modules/milestones would include system elements from across the Expanded Ship WBS (ESWBS). An internal WBS framework for planning and executing work that is consistent with the current module-based construction practices is valuable in that it provides the shipbuilder and the Navy accurate management information aligned with actual construction processes.

For shipbuilding programs, compatible work breakdown structures may be used, a production WBS that feeds the WBS used for the program IMS. Internally, contractors may use an internal WBS that is consistent with the shipbuilders' construction processes (modular-based construction practices) which reflects the planning and execution of work. For external reporting, the contractor shall report using the ESWBS which supports integration of contract cost data and cost modeling in a common framework. To satisfy both, the contractor will need to establish a mapping of the internally managed WBS to the externally reported one.

Typical Production / Manufacturing & Shipbuilding Attributes

- The WBS identifies all WBS elements specified for external reporting.
- The WBS is extended at a minimum to the level(s) at which control accounts are established
- The WBS may evolve as the project requirements change.
- It contains all project work, including revisions for authorized changes and modifications
- The WBS should identify in house versus subcontracted effort
- Must hierarchically summarize to the contract
- The CWBS aligns with the Program WBS

Guideline 6 – Schedule with Network Logic

2.2 a) Schedule the authorized work in a manner which describes the sequence of work and identifies significant task interdependencies required to meet the requirements of the program.

DCMA Cross-Reference Checklist Criteria	Relevance within Production / Manufacturing & Shipbuilding
a. Does the scheduling system contain (Prepare exhibit showing traceability from contract task level to work package schedules.)--	
(1) A master program schedule?	Can the contractor demonstrate how the MRP system (or the combination of MRP and an IMS) provides useful schedule information in a compliant manner? Does the contractor's system description address the relationship of production work orders to the EV work packages?
(2) Intermediate schedules, as required, which provide a logical sequence from the master schedule to the control account level?	
(3) Detailed schedules which support control account and work package start and completion dates/events?	
b. Are significant decision points, constraints, and interfaces identified as key milestones?	Is the IMS a single integrated network that contains significant external interfaces, Government furnished equipment / information / property and relationship dependencies for the entire contractual effort?
c. Does the scheduling system provide for the identification of work progress against technical and other milestones, and also provide for forecasts of completion dates of scheduled work?	Is Travelled Work forecast against the original plan? Does the original CAM forecast against the Plan and the "Travelled to" CAM forecast impact?
d. Does the schedule support the development of a critical path?	If Critical Path is at a higher level than MRP, is a process in place to regularly reconcile changes made in the IMS back to the MRP system?

Production / Manufacturing Considerations

The NDIA IPMD recognizes and identifies distinct differences between scheduling in development and production environments:

> "Government development programs or significant development efforts typically schedule the discrete authorized work through the use of a network schedule. Production programs typically schedule using a Manufacturing Resource Planning

(MRP) or Enterprise Resource Planning (ERP) tool employing a line of balance schedule that supports the project objectives."[1]

Further, the NDIA IPMD identifies the Planning and Scheduling Excellence Guide (PASEG) as a primary resource for identifying "knowledge, awareness, and processes that enable the user to achieve reasonable consistency and a standardized approach to project planning, scheduling and analysis."

Section 13.2 of PASEG provides guidance for scheduling in a production environment. It states, "Most production-schedule architecture discussions and decisions focus on the relationship and integration of Manufacturing Resource Planning (MRP II) data with an Integrated Master Schedule (IMS). The goal should be to balance the value added summarization of MRP tasks in the IMS as representations of the detailed manufacturing activities for managerial visibility and assessing meaningful critical path impacts."[2]

Additional Shipbuilding Considerations

Shipbuilders schedule authorized work in a manner which describes the sequence of work and identifies significant task interdependencies. The IMS aggregates the production orders/work bills maintained within the MRP system as work packages (or lower level) to ensure visibility of task interdependencies and network logic. The aggregate MRP production orders/work bills integrates into the IMS with the appropriate interdependencies and sequencing to preserve accurate network logic that supports the generation of a valid program-level critical path. In the event that all work cannot be detail planned to the work package level, planning packages are used to represent efforts that cannot be planned to the same level of fidelity.

Typical Production / Manufacturing & Shipbuilding Attributes

- The IMS baseline is maintained
- The IMS is vertically traceable to the Integrated Master Plan (IMP) (if applicable), the Contract Work Breakdown Structure (CWBS), and the Statement of Work (SOW)
- Critical Path has vertical and horizontal traceability
- IMS review addresses MRP tracking / planning and potential parallel activities that could drive multiple critical paths
- The IMS contains an aggregate representation of the MRP content (labor and material) that will allow for visibility of the critical path through the manufacturing / material content, but not necessarily down to the part number or touch labor level
- Some Full Rate Production programs might not utilize an IMS at all
- If the MRP work packages or summaries of work packages are identified in the master schedule, the critical path can be calculated to that level of fidelity
- Line of Balance shows the process, status, background, timing and phasing of project activities

[1] *NDIA IPMD EIA-748-B Intent Guide,* August 2012, page 9.
[2] NDIA *Earned Value in a Production Environment* White Paper, October 2011, page. 9.

Guideline 10 – Create Work Packages, Planning Packages

2.2 e) To the extent it is practicable to identify the authorized work in discrete work packages, establish budgets for this work in terms of dollars, hours, or other measurable units. Where the entire control account is not subdivided into work packages, identify the far term effort in larger planning packages for budget and scheduling purposes.

DCMA Cross-Reference Checklist Criteria	Relevance within Production / Manufacturing & Shipbuilding
a. Do work packages reflect the actual way in which the work will be done and are they meaningful products or management-oriented subdivisions of a higher level element of work? (Provide representative sample.)	
b. Are detailed work packages planned as far in advance as practicable?	In MRP systems, work scope is scheduled from delivery date backwards to accommodate shop flow time and material lead time. Consequently, the MRP system drives the advance timeframe.
c. Is work progressively subdivided into detailed work packages as requirements are defined?	
d. Is future work which cannot be planned in detail subdivided to the extent practicable for budgeting and scheduling purposes? (Provide sample.)	
e. Are work packages reasonably short in time duration or do they have adequate objective indicators/milestones to minimize subjectivity of the in process work evaluation?	Because production data is reflected at the part number or operation level, WPs become the aggregate of all this detail. As such, WPs may be longer but the EV measurement is taking place in an objective manner. The length of WPs tends to be longer for production and utilizes MRP status for short term status update. Manufacturing and Material work packages are typically longer, sometime much longer, than in development efforts. Work packages can be created at the operation level up through a "lot release"; while still providing enough detail to substantiate the performance generated.
f. Do work packages consist of discrete tasks which are adequately described? (Provide representative sample.)	Discrete tasks may only be detailed in the MRP system and then aggregated into the IMS. This allows for all work to be reflected in the IMS, but the detailed description of

DCMA Cross-Reference Checklist Criteria	Relevance within Production / Manufacturing & Shipbuilding
	discrete tasks may be present in the MRP system.
g. Can the supplier substantiate work package and planning package budgets?	
h. Are budgets or values assigned to work packages and planning packages in terms of dollars, hours, or other measurable units?	Resources for the scope of the Control Account are assigned by elements of cost as required. Values are assigned as necessary to determine performance evaluation.
i. Are work packages assigned to performing organizations	A Manufacturing or Material CAM may have various support function work scope within work packages that are not in their organizational chain.
j. Where engineering standards or other internal work measurement systems are used, is there a formal relationship between these values and work package budgets? (Provide samples showing relationships.)	Clarification: Realizations and/or production factors are typically used to derive budgeted hours from labor standards.
k. Where "learning" is used in developing underlying budgets is there a direct relationship between anticipated learning and time phased budgets?	Clarification: Most Production activities use a form of Learning Curve analysis (Andelohr, unit theory, cumulative average or equivalent) to plan budgets.

Production / Manufacturing Considerations

Work packages in a manufacturing environment are typically more detailed than in the design or development phases. The assembly of components into higher level assemblies in a production environment is accompanied by process paper work or travelers that document and capture production status. Work packages are the control points where work is scheduled (planned) monitored for completion and performance is calculated. Actuals at the work package level may be available, through an MRP system, to allow for variance analysis of an errant work packages.

Additional Shipbuilding Considerations

- The work package structure and organization must directly relate to the products built and the manner/methodology/operation in which they are built. This then enables the management of processes and products. The work packages are then assigned to performing organizations in the manner of the shipyard organization structure.
- The shipbuilding operation generally involves a fairly lengthy design period which typically overlaps the construction. As such, it is normal that the detail work scope not be fully know at the time when the Baseline is set. Therefore work scope is contained in Planning Packages until such time that it can be broken down into discrete work packages.

- The work package size and duration is typically in a manner that enables the management of the operation. The work package should be represent a meaningful duration of the start and stop schedule timeframe of the task /job and be of a timespan that is in line with the management needs and organization policies that provide insight to the compliant and efficient execution of the scope.
- The IMS Activities have discrete tasks that may not define the shop floor activities when work effort is further defined in “Production Work Instruction Packages”.
- The budget development and distribution associated with the scope is allocated to responsible departments in accordance with the System Description and Disclosure Statement of the contractor.
- Budgets are typically assigned to work packages by element of cost, labor, material and other direct costs. Each type only has either labor or material dollars, they are not intermixed.

Typical Production / Manufacturing & Shipbuilding Attributes

- Work packages released for execution will be more detailed in scope description due to process step verification and potential inspection steps
- Mandatory Government Inspections (MGI) may be include at specific points
- Earned value can be driven by the use of standard hours to track and measure performance on the shop floor.
- The use of supplemental schedules the provide status to the program master schedule. The manufacturing Production Schedule (MPS) may be used to substantiate the quantifiable backup data for an IMS percent compete work package.
- The time frame for a manufacturing work package may be longer than a development work package due to cure times, scheduling of inspections, environmental testing, etc.
- If an IPT is involved, Manufacturing or Production personnel may be the CAM rather than an Engineering organization

Guideline 11 – Sum Detail Budgets to Control Account

2.2 f)	Provide that the sum of all work package budgets plus planning package budgets within a control account equals the control account budget.

DCMA Cross-Reference Checklist Criteria	Relevance within Production / Manufacturing & Shipbuilding
a. Does the sum of all work package budgets plus planning packages within control accounts equal the budgets assigned to those control accounts?	This is math and should not be any different between development and production, manufacturing, and naval construction. Current EV software systems calculate the value of the control account from the sum of the work packages and planning packages.

Production / Manufacturing Considerations

Production environments often employ engineering standards based on historical actual or parametrics for comparison purposes and to manage "shop-floor" productivity. For example, shipbuilders often use measurements such as man-hours per ton of steel erected, or man-hours per installed pipe spool. These metrics are important management tools to measure and manage workforce productivity, but often do not equal the authorized budget.

Depending on the specific contract and its associated bid structure, the level of detail required to build a bid based on these measurements is often not available when establishing the baseline. As such, production environments often encounter situations where the available budget is misaligned with the volume of resources that engineering standards would indicate is required to complete the associated work. This scenario should be addressed in a contractor's System Description. Shop floor targets should not be confused with the performance budget values established by the program performance baseline. Manufacturing floor targets may be the sum of manufacturing orders, travelers, etc. and are typically additional challenges presented to shop supervision. However, the sum of the target values should be less than the budget values established for the comparable control account in the program baseline.

Additional Shipbuilding Considerations

Shipbuilding is by nature a very low volume production environment with a considerable amount of uncertainty involved in planning work, and detailed scope definition is typically not available when bidding a contract or when decomposing planning packages. As such, the use of engineering standards to manage "shop-floor" productivity will often result in situations where the sum of these estimates varies significantly from established budgets for a given scope of work.

The effective use of rolling wave planning will help align engineering standards and control account budgets, because work will not be detail planned (and budgeted) until sufficient technical information is available. This will not alleviate situations where, at the control account level, work has been either over or under-budgeted. As such, CAMs will often reference a lack of detailed engineering information at the time of budget distribution when writing variance explanations. While this is not an acceptable explanation from a purist EVMS perspective, the CAMs reasonably assess that they have not been allocated an appropriate budget. Failure to acknowledge this inconsistency can lead to EVMS lacking credibility as a valuable management tool in the shipyard. The inclination of most CAMs is to take credit for positive variances by

claiming remarkably high productivity, and to rely on engineering standards to explain negative variances. As such, shipbuilders who use engineering standards as a means to manage productivity and inform variance explanations must ensure there are controls in place for the adjustment of these standards and have a consistent and unbiased approach for comparison of engineering standards to established budgets. This approach ensures asymmetrical application of engineering standards to explain positive, as well as negative, variances.

Typical Production / Manufacturing & Shipbuilding Attributes

- Ships are often designed and built in parallel, with design work often leading production by weeks or days. As such, work scope is often budgeted before full technical details are available and the budgets are notoriously unreliable.
- Engineering standards based on parametrics are developed at the production order level and used by the Manufacturing organization to manage “shop-floor” productivity on a day-to-day basis.
- Changes to engineering standards are controlled and based on sound facts, with quantifiable backup data.
- Engineering standards for all production orders within a control account do not necessarily sum to control account budget.
- Sum of work package budgets and planning package budgets equals the control account budget.

Guideline 21 – Track and Report Material Costs and Quantities

2.3 f)	For EVMS, the material accounting system will provide for:
1)	Accurate cost accumulation and assignment of costs to control accounts in a manner consistent with the budgets using recognized, acceptable, costing techniques.
2)	Cost recorded for accomplishing work performed in the same period that earned value is measured and at the point in time most suitable for the category of material involved, but no earlier than the time of actual receipt of material.
3)	Full accountability of all material purchased for the project including the residual inventory.

DCMA Cross-Reference Checklist Criteria	Relevance within Production / Manufacturing & Shipbuilding
a. Does the supplier's system provide for accurate cost accumulation and assignment to control accounts in a manner consistent with the budgets using recognized acceptable costing techniques?	Careful consideration should be made and documentation should be required when developing the systemic approach to how material transfers, rework, and scrap are handled to ensure appropriate handling and timing of actual costs and earning performance. There is the potential for significant current month negative ACWP and BCWP based on large material purchases and potential transfer issues.
b. Are material costs reported within the same period as that in which BCWP is earned for that material?	Use of estimated actuals may be required to account for billing lags. **Reconciliation would occur in a future period once the final invoice is available.** Use of estimated actuals should be documented in the company's processes. "De-earning" or "un-earning" of performance (and potentially actuals as appropriate) may be required for part transfers, rework, or scrap.
c. Does the supplier's system provide for determination of price variance by comparing planned versus actual commitments?	Same as Development.
d. Is cost performance measurement at the point in time most suitable for the category of material involved, but no earlier than the time of actual receipt of material?	Contractor EVM Process Descriptions should specify categories of material. For example nuts and bolts verses large components. The performance measurement is dependent on the type of material category.

DCMA Cross-Reference Checklist Criteria	Relevance within Production / Manufacturing & Shipbuilding
	Use of PERT (or "EAC-based") calculations for material performance may be used on low-dollar/less critical material. Same as Development.
e. Does the supplier's system provide for the determination of cost variances attributable to the excess usage of material?	Same as Development.
f. Does the supplier's system provide unit or lot costs when applicable?	Same as Development
g. Are records maintained to show full accountability for all material purchased for the contract, including the residual inventory?	Same as Development

Production / Manufacturing Considerations

The NDIA IPMD recognizes and identifies differences between material management and material performance measurement in development and production environments.

Government Production programs typically have Parts Movement and Scrap and Rework considerations that support the project objectives.

Additional Shipbuilding Considerations

Compliance Requirement: "Material shall be claimed by objective measures in the manner in which it is planned." Objective methods may include: time when the material is applied to or installed on the deliverable item; at inventory release; based on receipt, inspection and acceptance; or apportioned. The contractor's system description shall identify different material categories (hatchable, non-hatchable, high value/low value, critical, etc. - other examples are commodity type, purchased equipment vs. subcontracted items, etc.) and the appropriate methodologies for each type. BCWP and ACWP must be claimed in the same period and based on the same methodology. PERT may be used on low dollar or less critical material.

Typical Production / Manufacturing & Shipbuilding Attributes

- The contractor's Material Management Accounting System (MMAS) will have the capability to collect and accurately assign material costs to the control accounts where material budgets (i.e. BCWS) have been planned and where earned value (i.e. BCWP) is claimed. The MMAS will also account for all material purchased for the program including the acquisition, disbursement, return of unused material, scrap quantity and disposition, and residual inventory. Ensuring material actuals are recorded consistent with the control accounts budgets will provide the program manager with accurate analysis and variance reporting.
- Shipbuilding often has developmental material lasting for years prior to the actual delivery or consumption of said material. During this time, vendors invoice the shipbuilder after they have met objective measures and the shipbuilder accrues actuals and performance as a result.

- Scrap and rework are typical, non-value outputs of production operations. Scrap may be defined as unusable material (e.g., waste material) for production need as a result of production process yields
- Grouping, Pegging and Distribution (GPD) - enterprise level systems that gather requirements from multiple sources (multiple contracts) to group them together and allow for movement of parts between contracts and/or control accounts to ensure part availability for the worker is maximized. The letters GPD stand for:
    - Requirements **G**rouping
    - Replenishments **P**egging
    - Cost **D**istribution
- Depending on the frequency of contract awards and delivery date requirements, it is conceivable that a part could move multiple times thus changing the performance status on multiple contracts each time the movement occurs. Some companies have not implemented the GPD functionality and still use the traditional part movement processes of loans (borrow/payback) and transfers.
- Documentation should be required when developing the systemic approach to how material transfers, rework, and scrap are handled to ensure appropriate handling and timing of actual costs and earning performance.
- Use of Estimated Actuals to account for Billing lags
- Contractor EVM Process Descriptions should specify classes of material. For example nuts a bolts verses large components. The performance measurement may be dependent on the type of material class.
- Optimize the efficiency of producing the parts and final product. One way to achieve this is to combine the purchase or build of the same part or like parts so that larger quantity efficiencies occur.

For more discussion of parts movement occurring in a production environment, reference the NDIA Earned Value in a Production Environment White Paper, October 2011, pages 17-20.

Guideline 22 – Calculate Schedule Variance and Cost Variance

2.4 a)	At least on a monthly basis, generate the following information at the control account and other levels as necessary for management control using actual cost data from, or reconcilable with, the accounting system:
1)	Comparison of the amount of planned budget and the amount of budget earned for work accomplished. This comparison provides the schedule variance.
2)	Comparison of the amount of the budget earned and the actual (applied where appropriate) direct costs for the same work. This comparison provides the cost variance.

DCMA Cross-Reference Checklist Criteria	Relevance within Production / Manufacturing & Shipbuilding
a. Does the supplier's system include procedures for measuring performance of the lowest level organization responsible for the control account?	No difference from a development program.
b. Does the supplier's system include procedures for measuring the performance of critical subcontractors?	No difference from a development program.
c. Is cost and schedule performance measurement done in a consistent, systematic manner?	Production efforts typically use standards to calculate performance for labor scope and receipt/consumption of the BOM for material.
d. Are the actual costs used for variance analysis reconcilable with data from the accounting system?	No difference from a development program.
e. Is budgeted cost for work performed calculated in a manner consistent with the way work is planned? (For example, if work is planned on a measured basis, is budgeted cost for work performed calculated on a measured basis using the same rates and values?)	Clarification: Issues can arise in Production with Out of Station (OOS) or Traveled Work, but the intent of the guideline must still be met. It should not be permissible to earn performance in an account where it is not planned.
f. Does the scheduling system identify in a timely manner the status of work?	No difference from a development program.
g. Does the supplier use objective results, design reviews, and tests to trace schedule?	No difference from a development program.

Production / Manufacturing Considerations

While developing BCWS, BCWP and ACWP information and calculating the schedule and cost variances is no different in a Production/Manufacturing environment, the details in which performance is measured and tracked and the standard work flow can be different from a

development environment. Specifically, in terms of "cost and schedule performance is being done consistently" it can be viewed that manufacturing labor or even material costs are not comparable with how development program items are measured. In production, manufacturing labor performance is often tracked by the completion of standards.

Standards are developed in many ways from detailed time measurement studies that track operating performance to minute or second increments and then calculate the optimum time at peak efficiency to more subjective ways of developing what a specific operation should take to complete. Regardless of how the standard was developed, companies will often develop their budget profile and measure completion based on standards. Simplistically, a series of operations and therefore standards will be gathered together for a work package. A realization factor, the delta between optimal efficiency and expected efficiency will be applied to the standard to create the budget. When work commences, standards completed will be measured to track schedule performance and actual realization will be tracked to measure cost performance. These key performance indicators (KPI's) should additionally be utilized to support Risk and Opportunity Assessments.

For material, the receipt of hardware to build or assemble the product may often be treated differently from a supplier doing engineering effort to develop their item or the use of test articles in development. For Production/Manufacturing, performance is often taken upon receipt or consumption of the material. It should be noted that these methods to track progress and cost at lower levels of detail and are the most objective methods for assessing earned value/BCWP. So in reality, the objectives for guideline 22 are met to a greater degree than development programs, when utilizing MRP Systems.

Another detail that can often be an interpretation issue is the discussion around whether work is being performed as planned. In most assembly operations, there is a specific sequence in which a product is put together. Each "station" along the assembly line will have a parts list intended for that station. Normally this is viewed as the optimal build sequence. A station may have a hundred or even thousands of parts that are intended to be completed at that point in the assembly line. In some cases, a small subset of parts may be late from a supplier or from fabrication feeder plants, and decision needs to be made whether to hold the product in place on the assembly line or move it to the next station. By definition, the product would only move if moving to the next station still allowed the product to be assembled properly. However in Lean Manufacturing Processes, it may be not be permissible to interrupt the build process but instead allow the unit to continue with the build cycle, whereby the small subset of parts are at a later point in the cycle assembled while meeting the delivery date with a quasi retrofit. In a purist EVM environment, CPI will continue to be negatively impacted as Material Actuals are incurred, but performance not taken until consumed, unless material is earned at receipt. However if not networked to the appropriate manufacturing task would not show in large scale that potentially critical manufacturing activities are delayed because of the volume of the material offsetting negligible manufacturing activity impacting SPI.

This movement before all the parts are completed in the station originally planned is called travelled work. Companies have policies in place to ensure when work travels the proper work packages are charged and that performance is measured to the plan properly. This method is used to ensure that product flows to meet delivery schedules, so that factory floor personnel are being used optimally and to not stop the assembly line just because a rivet or decal is missing that can be installed at the next station. Travelled work does not in any way compromise the ability to track and report schedule or cost variances.

Additional Shipbuilding Considerations

Shipbuilding practices do not vary considerably from other Production/Manufacturing processes and utilize the same principles noted above.

Typical Production / Manufacturing & Shipbuilding Attributes

- MRP development of time phased standards and material delivery dates (receipts)
- Measurement of work accomplished via a standards earned system
- Detailed tracking of part receipt or consumption (issuance to the manufacturing floor)
- Measurement of realization factors (variance to standard)
- Measurement of learning curves (improvement in labor hour performance as more units are built)
- Integration of MRP information within the IMS but not the details found with the MRP system

Guideline 23 – Identify Significant Variances for Analysis

2.5 b) Identify, at least monthly, the significant differences between both planned and actual schedule performance and planned and actual cost performance, and provide the reasons for the variances in the detail needed by program management.

DCMA Cross-Reference Checklist Criteria	Relevance within Production / Manufacturing & Shipbuilding
a. Does the supplier have variance analysis procedures and a demonstrated capability for identifying (at the control account and other appropriate levels) cost and schedule variances resulting from the system (provide examples) which:	
(1) Identify and isolate causes of favorable and unfavorable cost and schedule variances?	Schedule variances are more finitely measured since production / manufacturing work packages are typically more controlled through an MRP system than development activities. Cost and schedule variances may also be more readily identified by the "wanding" at the start and completion of each operation in the process paperwork associated with production work packages. These time increments can be compared to the standards used to establish the work package budgets at the time of baseline. Department efficiency calculations can also be utilized to determine under or over performing efforts. Production departments are typically more attuned to the efficiency of the work force and the subsequent accomplishment of work compared to the time charged.
(2) Evaluate the performance of operating organizations?	Working Group Concurrence
(3) Identify potential or actual overruns and underruns?	Working Group Concurrence
b. Identify potential or actual budget-based and time-based schedule variances?	Working Group Concurrence
c. Evaluate the impact of schedule changes, work around, etc.?	Schedule impact and change analysis can occur in either the program IMS or the MRP system. When an IMS is utilized, Critical Path analysis becomes available. Detailed impacts to the production floor environment are typically evaluated through MRP

DCMA Cross-Reference Checklist Criteria	Relevance within Production / Manufacturing & Shipbuilding
	systems. Either system can provide the required variance analysis capability.
(1) Does the scheduling system identify in a timely manner the status of work? (Provide representative examples.)	Production Reporting may occur more often utilizing MRP but, reporting to the cost and schedule EV Engines occurs at least monthly. An MRP type system manages or "schedules" the shop floor in a manner that accommodates the most productive use of resources. When the program baseline schedule changes, adjustments to work flow are typically more involved than during a development effort.
(2) Does the supplier use objective results, design reviews and tests to trace schedule performance? (Provide examples.)	The criteria for determining objective results may be different but both development and production do use objective results. Quantifiable Backup Data (QBD) that is objective must exist in some form for either scenario if using a percent complete earned value method. Manufacturing environments utilize standard hours to monitor and determine shop floor efficiencies. This metric can be used to provide the QBD for claimed BCWP.

Production / Manufacturing Considerations

The typical manufacturing operation utilizes an MRP type system that drives the procurement of the component parts, delivery of same, schedules the fabrication and testing of the subassemblies and/ or higher level assembly. This process is controlled through an automated system that is updated daily to provide functional management the status of work in their respective department. The level of detail in the production / manufacturing environment is more granular than in development. A "work package" in production contains multiple steps that are typically performed in sequence to take performance for completion. In process inspections may be used as an 'inch stone' to declare completion of efforts within that EV work package. This level of detail is not typically found in the program Integrated Master Schedule (IMS) but may be used as the basis for Quantifiable Backup Data for percent complete earned value work packages. Production tasks for complicated assemblies are typically longer that two accounting periods and would tend to favor that EV technique.

Work is being performed on multiple projects or even programs at the same time, all of which may have some of the same requirements, components and assembly processes. The Goal in manufacturing is overall production efficiency. Processing multiple, similar production items aids in increasing the efficiency and reducing the cost of each item. This consolidation or "Batching" of like work causes problems with the normal project EV because work from one project or deliverable may be held up from its baseline plan, (causing a negative variance), while the similar work from another may be processed way ahead of its baseline, (causing a positive

variance). In reality neither has performed badly unless those components that were held up are affecting the critical path.

Most if not all production operations have “bottle-neck” areas where production can back up when throughput cannot be processed as fast as the preceding production area. Bottle-necks have the effect of slowing down production. Poor or improper planning of consolidated work-loads can cause delays in the production cycle, storage space issues and eventually missed commitments.

Delays in the production cycle can produce unfavorable schedule variances and cost variances.

Production facilities are, many times, limited by space and equipment as much as by people. It doesn’t matter how many people you can get to do the work if there is only one workstation capable of manufacturing the product or you can only house and store one manufactured piece at a time without having to deliver it. By the same token you may have all the equipment and space you need you need but you may not be able to find enough qualified individuals to perform the work.

Additional Shipbuilding Considerations

CDRL requirements customized to meet the Navy Program Office requirements (which may differ from the DID) may be used to dictate the level and detail of Variance Analysis. The customization may include the use of analysis performed to support Quarterly Production Progress Conferences (QPPC), monthly and bi-weekly standard meetings. Typically, in these meetings the Contractor's Program Office describes major issues, production status and forecast of events. Working with the Navy Program Office the appropriate actionable level discussed at Navy/Contractor conferences with input from the CAMs as necessary will be used to define Variance Analysis requirements. The CDRL customization may also dictate the appropriate time frame for Variance Analysis, i.e. current period vs. cumulative (continuous reporting of cumulative variances may be determined to be redundant during the shipbuilding construction cycle).

Individual organizations function according to the circumstances of their organizational structure and execute scope in the environment in which they exist. During the execution of any project, the reporting of the progress against the plan and the expenditure of resources should reflect actuality versus the program baseline. The methodology of the process would be documented in their system description and would be the standard to which they are measured.

Typical Production / Manufacturing & Shipbuilding Attributes

- The WBS identifies all WBS elements specified for external reporting.
- The WBS is extended at a minimum to the level(s) at which control accounts are established
- Critical Path has vertical and horizontal traceability.
- If the MRP work packages or summaries of work packages are identified in the master schedule, the critical path can be calculated to that level of fidelity
- Compliant and approved Business systems, especially Material and Procurement are used to identify the root cause of variances.
- It contains all project work, including revisions for authorized changes and modifications
- Labor situations may arise that foster conflict in the factory with the potential circumstances of collective bargaining situations