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# Engineering and Implementing Raytheon Missile Systems Engineering Design to Cost Metric


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# Areas to be Covered

1. Background
2. Design to Cost and Cost As an Independent Variable
3. The DTC Process
4. The DTC Metric
5. Lessons Learned
6. Going Forward

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# Background

- The Engineering Effectiveness Metrics initiative grew out of RMS's desire to reduce the costs and cycle times necessary to design, develop and build products that work right the first time.
- To support these goals, an Engineering Effectiveness Metrics Team developed three primary metrics:
  - On-Time Delivery Performance
  - First-Presentation Yield
  - Design To Cost (DTC)
- Today's focus is on the creation of the DTC Metric, its purpose and use at RMS.
- The DTC metric is designed to allow business unit management to quickly review program(s) progress and status towards meeting their affordability commitments.

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# Background:
# DTC & CAIV at Raytheon Missile Systems

- DTC and CAIV are blended into Business Development under the heading of Affordability.
- Within the process at RMS:
  - Defined cost targets are assigned to each IPT
  - Focus is on identified cost drivers
  - Cost vs performance tradeoffs are conducted that lead to best value solutions
  - Metrics are determined and reported accordingly
- Each design choice is evaluated simultaneously for both cost and benefit
- CAIV begins before Concept Exploration and remains, with DTC, vigorous throughout product development

CAIV – Cost As an Independent Variable

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# DTC as a Management Control System

# DTC - A Management Control System

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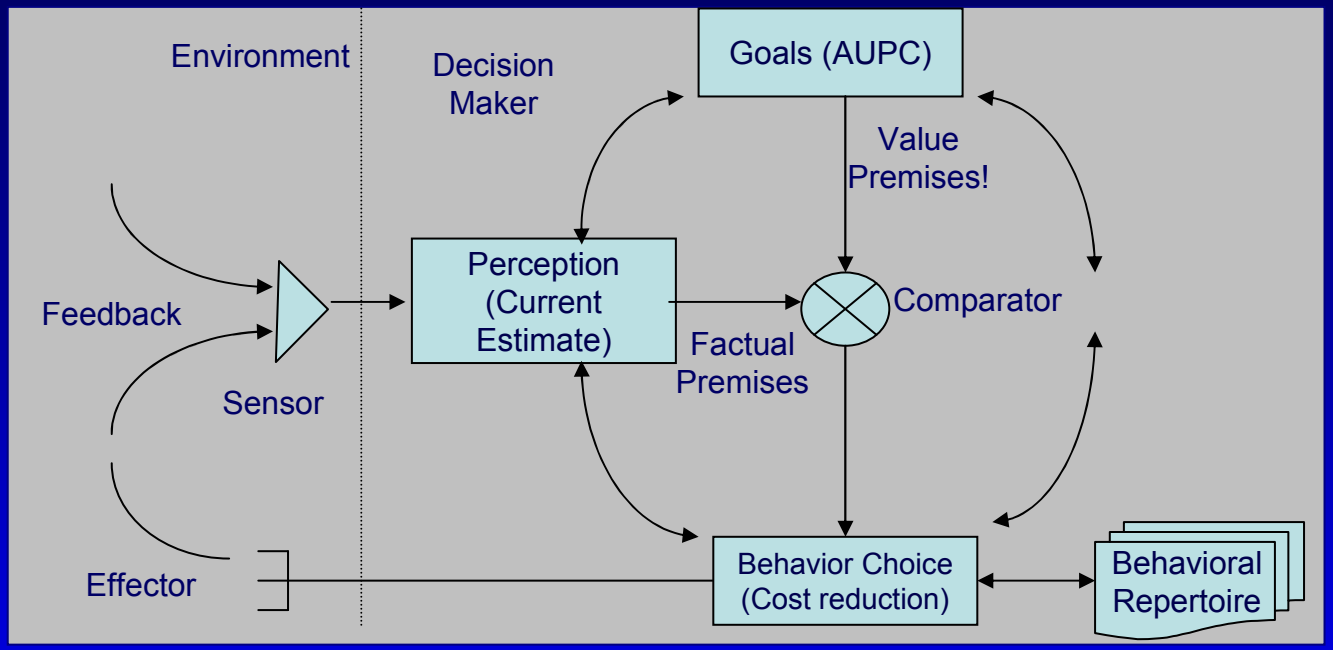


**Management Control Systems are put in place to direct targeted activity toward achievement of the desired results.**

| Management Control Process | DTC Process |
|---|---|
| Set goals and performance measures | Sets AUPC Goal as part of DTC Plan |
| Measures achievement | Prepares current cost estimate |
| Compares achievement with goals | Current estimate vs. DTC goal |
| Computes the variances as the result of the preceding comparison | Estimates system and subsystem variances |
| Reports variances | Reports $ Data |
| Determines the cause(s) of the variances | Cost Drivers, spec. risk, etc. |
| Takes action to eliminate variances | Action plan: changes |
| Follow-up to ensure that goals are met | Repeats at interval per plan |

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# Our DTC Process

# Requirements Flowchart

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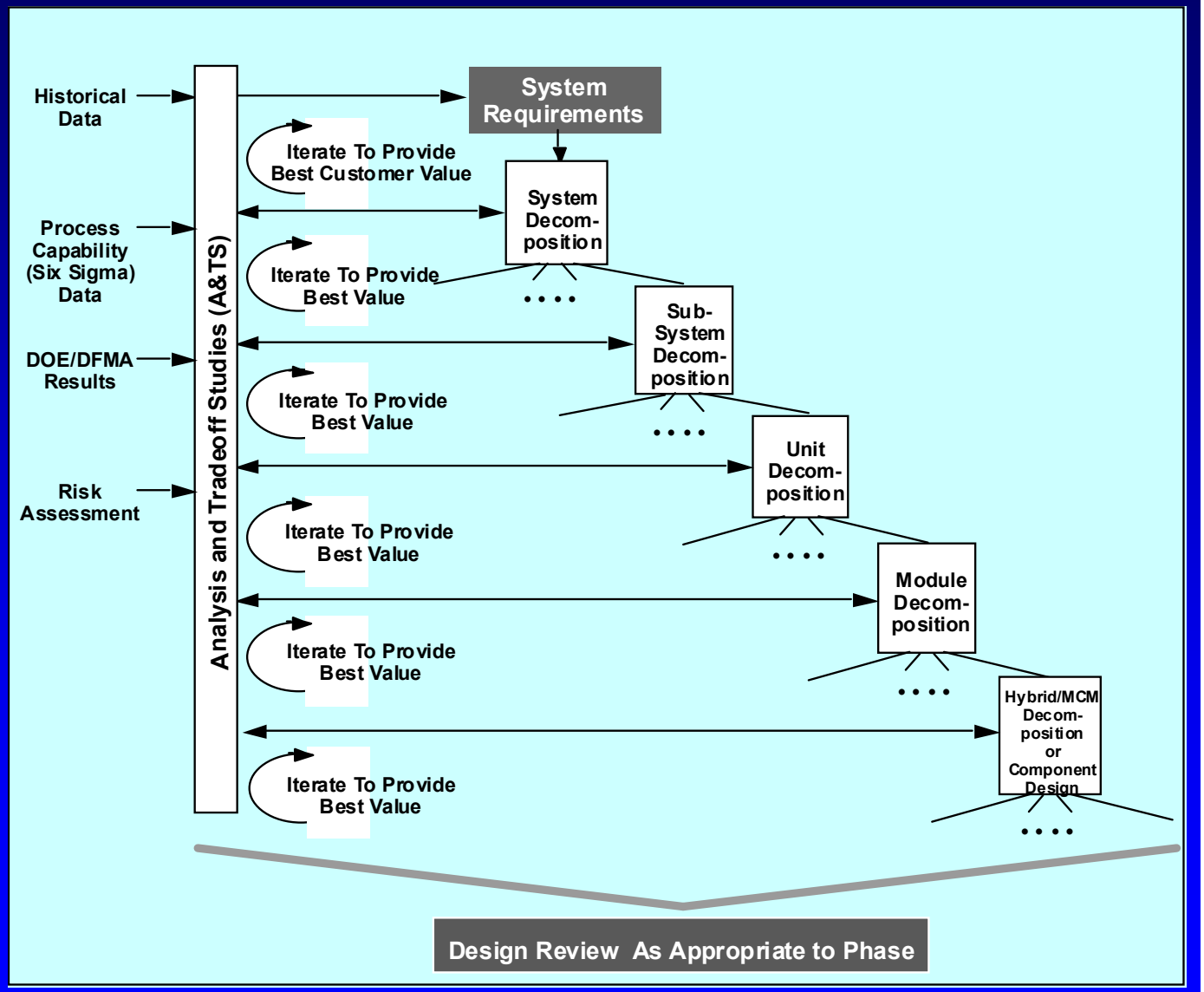
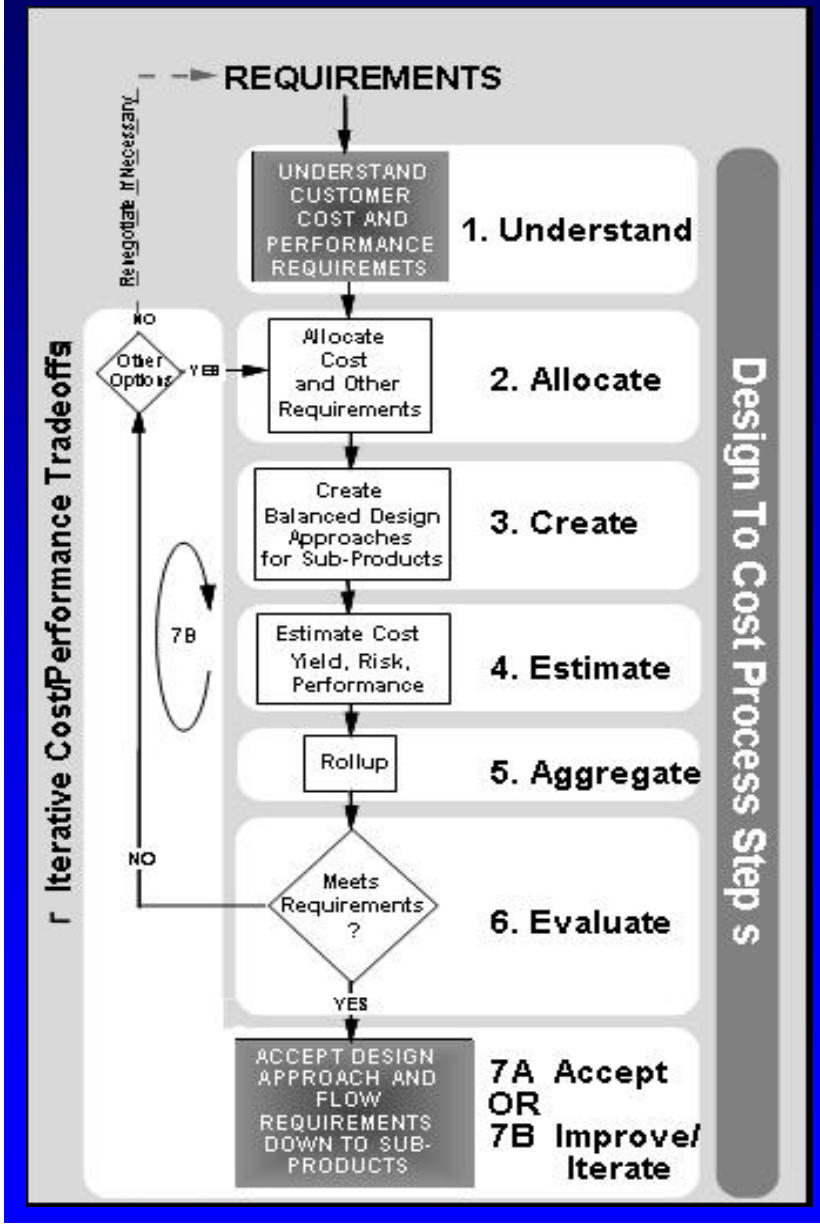
**Design to Cost is a continuous iterative process that begins at the top level with a product requirement that includes cost as a major priority and then seeks to optimize the entire product while allocating requirements down to all levels**



# Seven Steps to an Affordable Design




**The engineer must use the following 7 steps to execute DTC:**

1. **Understand requirements**
2. **Analyze functions**
3. **Identify physical alternatives / allocate requirements / plan task**
4. **Design synthesis**
5. **Cost Modeling – Estimation & Rollup**
6. **Evaluate – Meet or changes requirements?**
7. **Select/Formalize Design**

**Plus, an often overlooked 8th step to:**

8. **Document and report progress towards meeting the cost goal.**

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# The Design is Complete IF

**The design is complete when the customer/contractor team has accomplished the following:**

- **Performed detailed cost, performance, supportability, and risk assessments that indicate that all final requirements will be met with levels of cost, schedule and technical risk acceptable to both the customer and the company.**
- **Allocated all requirements to non NDI items or specific custom designed components.**
- **Completed the detailed design of all custom components.**
- **Successfully modeled/prototyped custom components and assemblies that can drive cost, performance, or schedule.**
- **Completed a thorough manufacturing plan defining the approach to the fabrication or procurement of all components and the assembly, integration, and test of the product and each significant sub-product.**
- **Complied with all customer and company requirements for ILS, support, review, documentation, verification, scheduling, warranty, and the like.**

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# The DTC Metric

# Metrics and System Engineering

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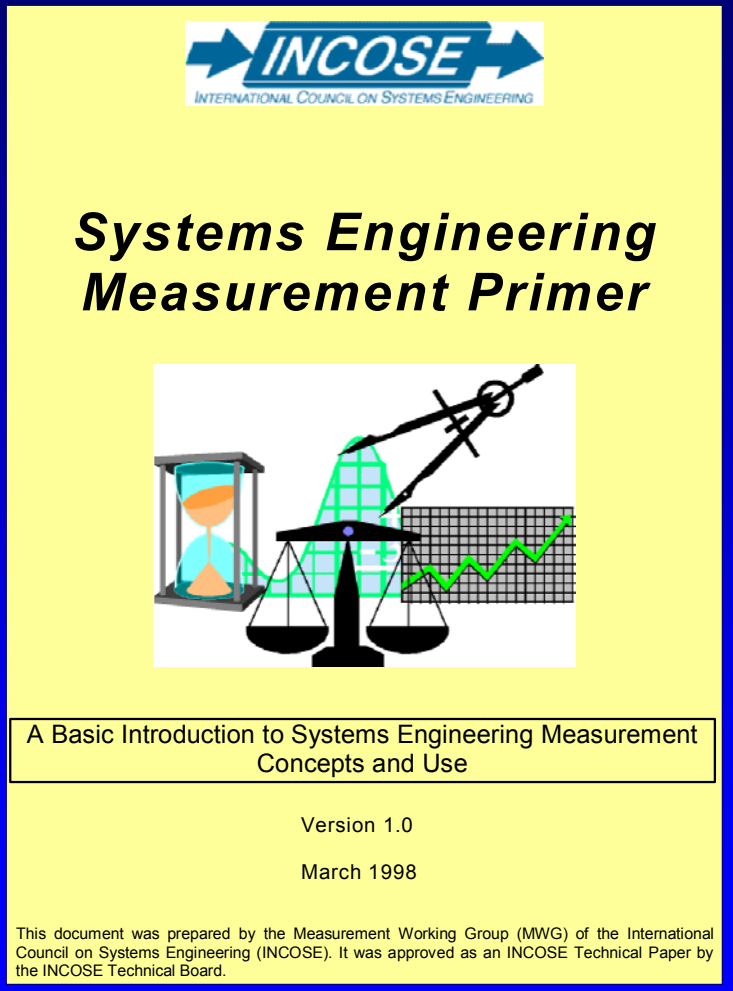
An often asked question deals within what role do metrics have within the System Engineering Community.



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# Metrics

**The purpose of any metric is to drive proper behavior.**

- Proper behavior is achieved by setting, striving for, and ultimately reaching goals. A DTC metric is therefore one that keeps cost and cost reduction in the forefront.
- The proper metric for DTC is one that establishes a system cost goal for the design and that requires attainment of estimated production costs at specified points along a program timeline starting pre-SDD and going through production.
- By establishing cost goals for a program (and its subsystems) that are time phased, and constantly decreasing, a program is able to measure its cost reduction effort toward the ultimate program cost goal.
- The DTC metric is measured as cost variance to the required time-phased goals. Any variance to a cost goal should precipitate IPT action to eliminate the discrepancy.
- Variances are measured and reported at design team meetings and program reviews. Efforts to eliminate cost variances (the proper behavior) become part of the IPT design effort when tradeoffs are made between cost, risk, performance, and cycle time.

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# Establishing a DTC Metric at RMS

- RMS Announced the formation of the Engineering Effectiveness Metrics Council in early 2003.
- The Engineering Effectiveness Metrics (EEM) team supports its goals with three primary metrics:
  - On-Time Delivery Performance
  - First-Presentation Yield
  - Design To Cost
- The DTC Metric is designed to allow business unit management to quickly review the progress and ability of their programs.
- DTC Metric implementation has a phased approach
  - SDD Programs
  - SDD and Production Programs
  - CAIV Metrics

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# Implementation

- Potential programs taken from the EEM "Deployment Matrix," which are programs that are reporting other EEM metrics (First Time Presentation Yield and On-time Delivery Performance).
- Initial meetings with PLCE to identify candidate programs.
- E-mails or phone calls to program manager.
- "Getting Started" packets mailed to candidates:
  - Product Cost Control Survey
  - DTC Start-Up Instructions
  - DTC Points of Contact
  - DTC Guidelines
  - DTC Process
  - Sample DTC Plan Table of Contents
  - CAIV/DTC Training Schedules plus "Program-Specific" CAIV/DTC offered

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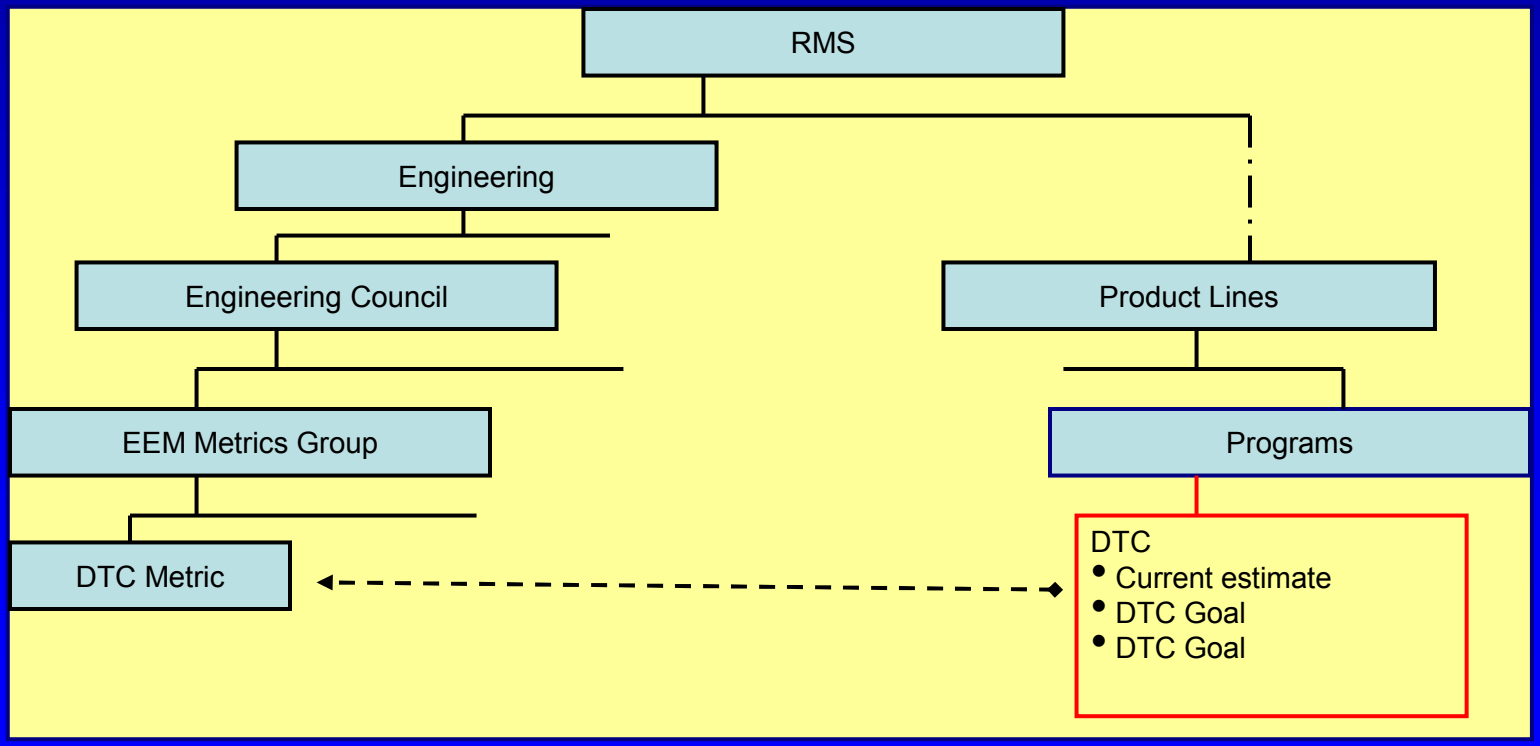
# Report Structure for the DTC Metric at RMS

- The EEM reporting organizational structure below is used to facilitate executive level portfolio management of RMS programs.
- RMS' Engineering council reports its metrics monthly at the Engineering level process reviews.



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# Process

- Programs provide their initial cost goal and current estimate.
- Programs provide an initial basis of estimate.
- Programs are contacted monthly for their prior month's current estimate (trailing indicator)
- Current estimate is divided by the cost goal for a DTC metric. This is reported in a percentage format; i.e., Program A's DTC metric is 1.04, which is 4% over their cost goal.

| | |
|---|---|
| | DTC Goal <100% to no >4.99% over goal |
| | Over DTC Goal >4.99% to 9.99% |
| | Over DTC Goal >10% |

- Latency or how often the cost information is reviewed and updated is also reported.

| | |
|---|---|
| | Latency - 1-2 months |
| | Latency - 2-3 months |
| | Latency - 5 months + |

- For programs in "yellow" and "red" categories, "Root Causes and Corrective Actions reports are required.

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# DTC Metric Definition and Reporting Levels

| Program | Phase | Gate | Metric | Latency | Accuracy | Comment |
|---|---|---|---|---|---|---|
| One A | SDD | 6 | 1.12 | 1 | +15 -10 | High Subcontractor cost for motor assembly |
| Two B | SDD | 7 | 1.50 | 7 | +25 -15 | Program undergoing major corrections and rebaselining |
| Three C | SDD | 5 | 1.04 | 4 | +10 -5 | Lower FPA Cost |

- **Phase/Gate:** The program's current position in its life-cycle
- **DTC Metric:** Current Cost Estimate / DTC Target
  - Green: < 1.05; Yellow: between 1.05 & 1.1; Red: > 1.1
- **Latency:** Months since completion of last Current Cost Estimate.
  - Green: < 3 months; Yellow: between 3 & 5 months; Red: > 5 months
- **Accuracy:** Represents the relative possible cost risk associated with current cost estimate expressed as a plus and minus percent. Accuracy is not currently being reported.

# DTC Metric Reporting Frequency and Initial Results

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**RMS's Engineering Council reports its metrics monthly at the Engineering Process Review Meeting. All engineering metrics are distilled into a series of color-coded stoplight charts that show current status in relation to goals for the year.**

**Variances are measured and reported at design team meetings and program reviews. Efforts to eliminate cost variances (the proper behavior) become part of the IPT design effort when tradeoffs are made between cost, risk, performance, and cycle time.**

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# Action

- "Five Why's" reports required for programs that remain in the red category without signs of improvement.
- Areas of concern are identified for "yellow" and "red" programs, and Engineering Centers assist in resolving the challenges.
- The Engineering Accountability Review Group reviews monthly the programs that should be reporting DTC Metrics.
- "Programs That Should Be Reporting 'DTC' Metrics" are now being reported to Louise Francesconi at the monthly product line reviews.

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# Lessons Learned

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# Lessons Learned

- Affordability is the primary driver in all architecture design and development activities.
- DTC requires mandatory cost requirements be assigned to all programs down to the lowest levels.
- Programs must track and measure their current design to cost status against their goals at periodic intervals. (Cost Management)
- Cost must be a design requirement with importance equal to or greater than performance.
- DTC focus must begin as early as possible in a program (pre-RFQ) for early cost driver identification.
- Cost estimation can be approximate in early program phases, progressively better during later phases.
- Proper DTC behavior is achieved by setting, striving for, and ultimately reaching goals. A DTC metric is therefore one that keeps cost and cost reduction in the forefront of IPT activity.
- By establishing cost goals for a program (and its subsystems) that are time phased, and constantly decreasing, a program is able to measure its cost reduction effort toward the ultimate program cost goal.

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# Going Forward

To quote Sun Tsu, The Art of War, “the wise general in his deliberations must consider both favourable and unfavourable factors. By taking into account the favourable factors, he makes his plan feasible; by taking into account the unfavourable, he may resolve the difficulties.”

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# Going Forward: Plans for the Future

**A DTC Metric, by itself, is not enough!**

**It is time to consider expanding DTC Metrics into CAIV Metrics:**

- **CAIV Metrics encompass not only cost, but performance, schedule and risk as well. The primary metric to measure specific CAIV project effectiveness is cost. The utilization of this metric requires an established cost baseline in sufficient detail to compare prior and resultant impacts of a CAIV project.**

**The proper metric for CAIV:**

- **Establishes a system cost goal for the design**
- **Requires specific points of estimated development production and operation/support costs**
- **Reflects on program costs and system performance**

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# Going Forward: CAIV Metrics Sample Chart

## DTC Metrics can be enlarged with Cost, Performance, Schedule and a Risk Assessment to form a set of CAIV Metrics.

| CAIV Metric | Threshold | Goal | Current | Current/Goal | Risk Assess | Cost Driver | Latency | Plan of Action |
|---|---|---|---|---|---|---|---|---|
| Cost - System | $ 32,775.00 | $ 31,500.00 | $ 37,790.00 | 1.20 | | | | |
| Sub-System | $ 5,000.00 | $ 4,500.00 | $ 6,200.00 | 1.38 | | | 2 | no |
| Sub-System | $ 1,500.00 | $ 1,500.00 | $ 1,400.00 | 0.93 | | | 4 | no |
| Sub-System | $ 12,275.00 | $ 12,000.00 | $ 17,890.00 | 1.49 | | | 1 | yes |
| Sub-System | $ 8,000.00 | $ 7,500.00 | $ 6,000.00 | 0.80 | | | 3 | yes |
| Sub-System | $ 2,500.00 | $ 2,500.00 | $ 2,700.00 | 1.08 | | | 3 | yes |
| Sub-System | 3500 | 3500 | 3600 | 1.03 | | | 2 | yes |
| Sub-System | | | | | | | | |
| Sub-System | | | | | | | | |

| Performance | Requirement | Goal | Current | Req/Current | Risk Assess | Cost Driver | Latency | Plan of Action |
|---|---|---|---|---|---|---|---|---|
| speed mph | 200 | 220 | 180 | 1.11 | | | 1 | no |
| range nm | 500 | 550 | 525 | 0.95 | | | 1 | yes |
| load lbs | 750 | 750 | 800 | 0.94 | | | 1 | yes |
| KPP-4 | | | | | | | | |

| Schedule | Contract | Goal | Expected | Exp/Con | Risk Assess | Cost Driver | Latency | Plan of Action |
|---|---|---|---|---|---|---|---|---|
| Dates | | | | | | | | |
| Months to Go | 18 | 15 | 15 | 0.83 | | | 2 | no |

| Red Yellow Green Blue Violet | Red Yellow Green | What is/are the major cost driver(s) | Red Yellow Green | Is there a plan of action - yes/no Comment |
|---|---|---|---|---|

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# Going Forward: CAIV Metrics Sample Chart

**CAIV Metrics chart at a glance:**

- Discloses a program's status in the areas of cost, performance and schedule. From the above sample chart one can quickly see:
  - The program is projected to over-run costs by 20%.
    - Two of the sub-systems are in the red; one with a high risk of failing.
    - The PM has no plan of action to fix one of the red areas
    - One sub-system is in the "violet" with low risk of failure so perhaps cost goals ought to be re-allocated.
    - The others are close to goals on one-side or the other
  - Two of the performance areas have superseded requirements while one area, without a plan of action and at high risk of failure is in the red.
  - And, the program is planning on an early delivery.
- The color coding helps management key in on specific areas of concern and make necessary changes.

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# Any Questions?

- Now is a good time to ask.

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