System Development Performance Measurement: Validation of the Effectiveness of an Initial Indicator Set and Addressing Additional Information Needs

(14938)

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Special Thanks

- Institute for Defense Analyses (IDA), which implemented the survey on the web
- Office of the Deputy Assistant Secretary of Defense for Systems Engineering (ODASD(SE)) which funded the IDA work
- INCOSE, PSM, and NDIA for their willingness to use their mailing lists to solicit participation in the survey
- And especially those who responded to the survey, particularly those providing textual comments

A Top Systems Engineering Issue

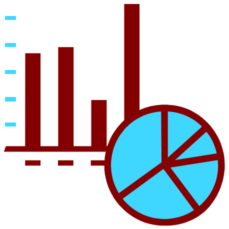
Technical decision makers do not have the right information & insight at the right time to support informed & proactive decision making or may not act on all the technical information available to ensure effective & efficient program planning, management & execution.

[NDIA Top Systems Engineering (SE) Issues (2010)]

In September 2010, the NDIA Systems Engineering Effectiveness Committee chartered a working group to identify a small set of key leading indicators that would help address this issue.

Working Group Goal

Identify potential high value



- measures,
- indicators, and
- methods

for managing programs, particularly in support of

- making better technical decisions and
- providing better insight into technical risk

at key program milestones during

- Technology Development and
- Engineering and Manufacturing Development

for both the acquirer and supplier

System Development Performance Measurement Project

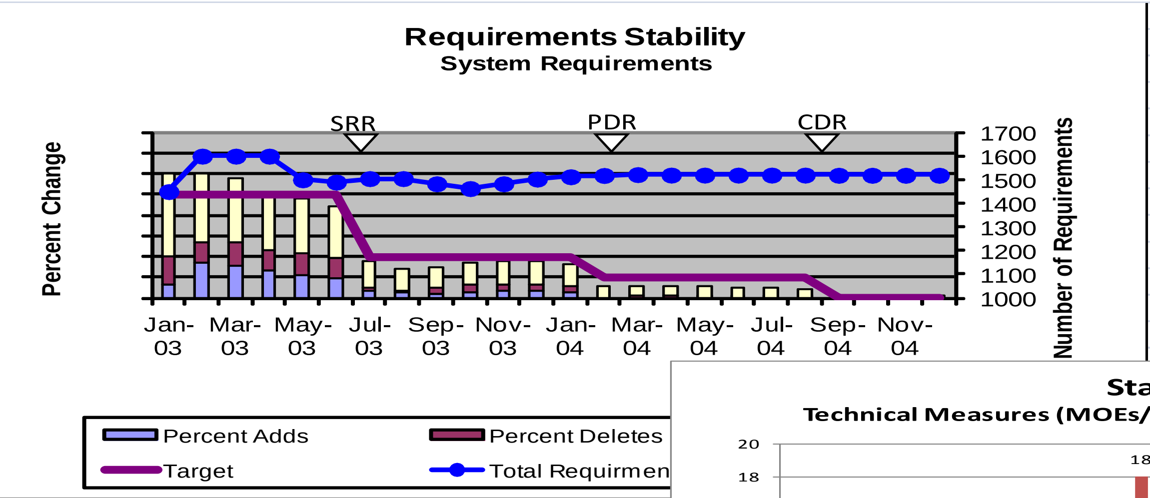
- Phase 1 Report:
  - http://www.ndia.org/Divisions/Divisions/SystemsEngineering/Documents/Studies/NDIA%20System%20Develpopment%20Performance%20Measurement%20Report.pdf
- Phase 2 Direction (2012)
  - Validate initial indicator set via survey and/or pilots
  - Determine leading indicators that address the other important information needs identified by the working group
    - Architecture
    - Affordability
    - Testability
    - Requirements Verification and Validation
    - Defects and Errors
  - Recommendations on Benchmarking
  - Harmonize contractor reporting and government requirements

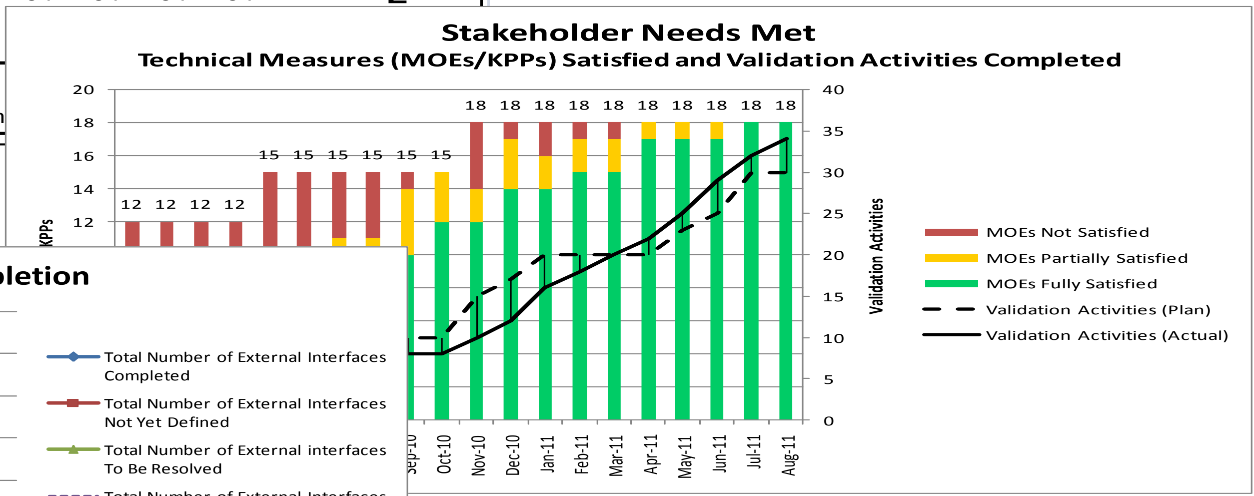
Recommended Leading Indicators

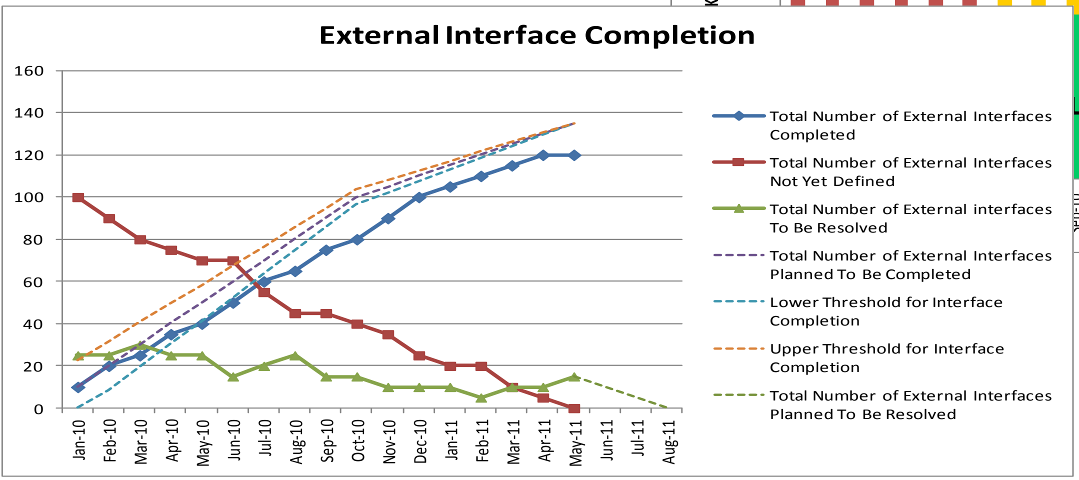
Information Need	Specific Leading Indicator
Requirements	Requirements Stability
Requirements	Stakeholder Needs Met
Interfaces	Interface Trends
Staffing and Skills	Staffing and Skills Trends
Risk Management	Risk Burndown
Technical Performance	TPM Trend (specific TPM)
Technical Performance	TPM Summary (all TPMs)
Technical Maturity	Technology Readiness Level
Manufacturability	Manufacturing Readiness Level

No recommendations for Affordability and Architecture

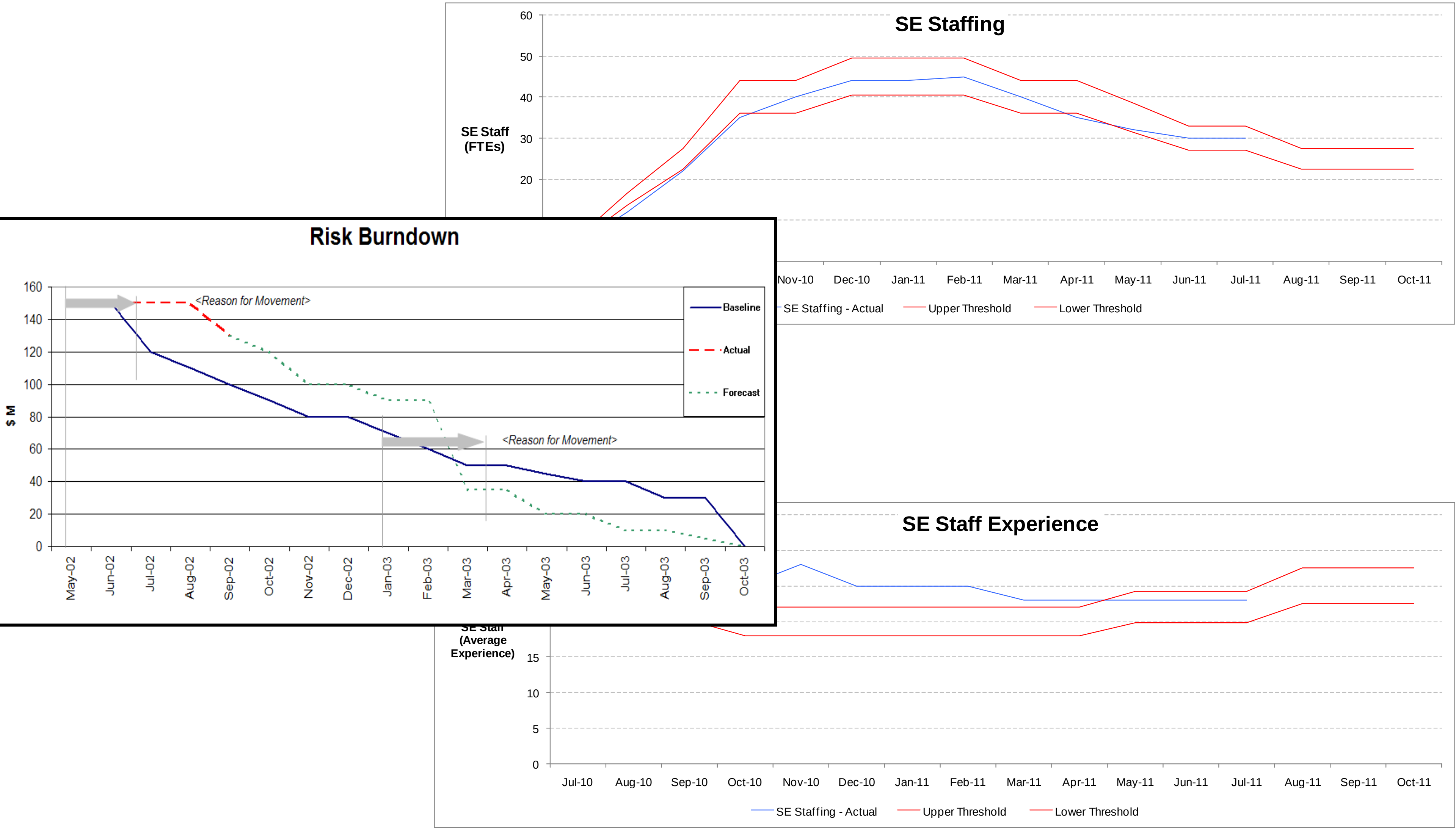
Requirements & Interfaces







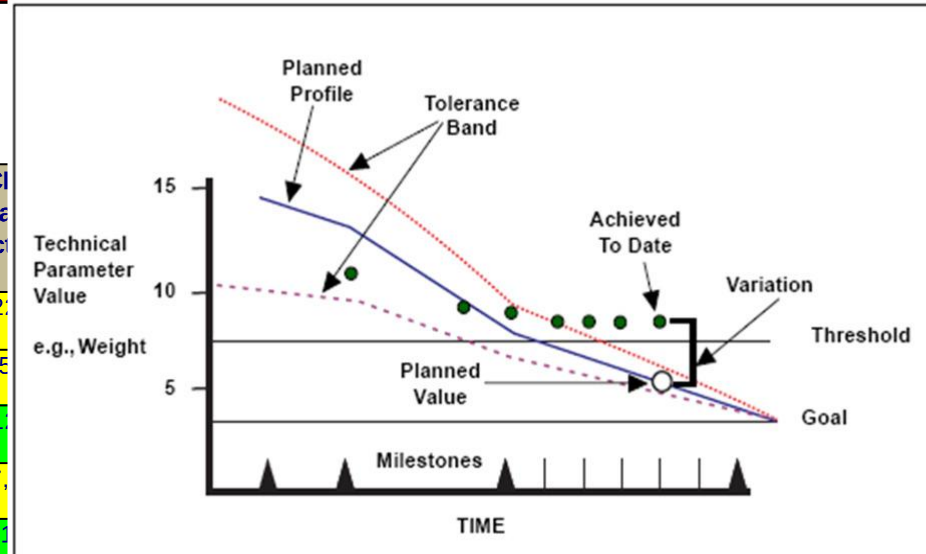
Staffing & Risk



Technical Performance and Maturity Manufacturability

Name	Responsible Position /IPT	KPP or KSA	Performance Spec.	PDR Status Actual	MS B Status Actual	CI Sta Act
Aerodynamic Drag (count)	SE IPT		<222	225	223	2
Thermal Utilization (kW)	SE IPT		<60	56	59	5
Electrical Power Usage (kW)	SE IPT		<201	150	185	1
Operating Weight (lb)	SE IPT		<99,000	97,001	101,001	97,
Range (nm)	SE IPT		>1,000	1,111	1,101	1,1
Average Flyaway Unit Cost (number)	SE IPT					

*Note: Margin is 10%



System Milestone / Technical Review	TRL (Plan)	TRL (Actual)	MRL (Plan)	MRL (Actual)	Comments / Risk Action Plan
ITR	TRL 2	TRL 3	MRL 2	MRL 2	Analysis model based on ABC study
ASR	TRL 3	TRL 3	MRL 3	MRL 3	Lab validation of ASIC mfg concept
MS A	TRL 4	TRL 3	MRL 4	MRL 3	Study funding delayed 30 d. TRA completed.
SRR	TRL 5	TRL 4	MRL 5	MRL 3	Mechanical packaging ICD validation issues. Supplier facility contention elevated.
SFR	TRL 6	TRL 5	MRL 6	MRL 5	Prototyped XYZ subsystem w/ test bed I/F. Investigating low yield on lot 6 wafer fab.
PDR / MS B	TRL 6	TRL 6	MRL 6	MRL 6	Dwgs on plan. Tin whisker fab issue ok. Producibility plan approved.
CDR	TRL 7		MRL 7		Evaluating alternative µW feeds (risk #23).
TRR	TRL 7		MRL 8		
SVR (FCA PRR)	TRL 7		MRL 8		
MS C	TRL 8		MRL 9		
FRP Decision Review	TRL 9		MRL 10		

Initial Indicator Set Validation

- A survey instrument was used for validation and to solicit information for the additional information needs
- Institute for Defense Analyses (IDA) acted as the "honest broker" for implementing a web based mechanism and managing the mechanics of the survey.
- The results briefed today will be published in an end of year report

Survey Targets

- Broadcast request for participation to:
  - NDIA Systems Engineering Division
  - International Council on Systems Engineering (INCOSE)
  - Practical Software and Systems Measurement (PSM)
  - System Development Performance Measurement Working Group
  - DoD Systems Engineering Forum

General Information

- Survey was anonymous
- 252 accessed the survey page, 165 started, 77 completed. Seven of the surveys not completed were deemed to have sufficient information to be utilized
- Primary target was senior decision makers on a program: lead systems engineer, chief engineer, deputy program manager, and program manager. However, anyone who was solicited could choose to take the survey.
- Due to the manner of solicitation, the sample is certainly not representative

Program Manager/Deputy PM	9
Chief Engineer	9
Lead Systems Engineer	32
Other Leaders	13
Individual Contributors	21
Total	84

Examples of other leaders

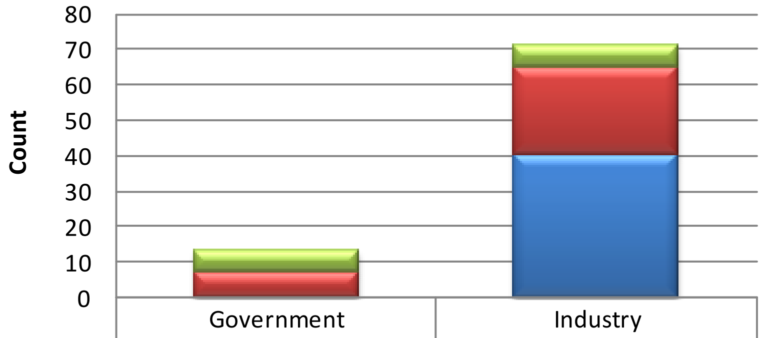
- Systems Integration Lead
- Systems Engineering Functional Manager
- Software Senior Manager
- Quality Management

Examples of individual contributors

- Systems Engineer
- Quality Engineer
- Senior Software Engineer
- University professor

Respondent Background

In your role, you represent:



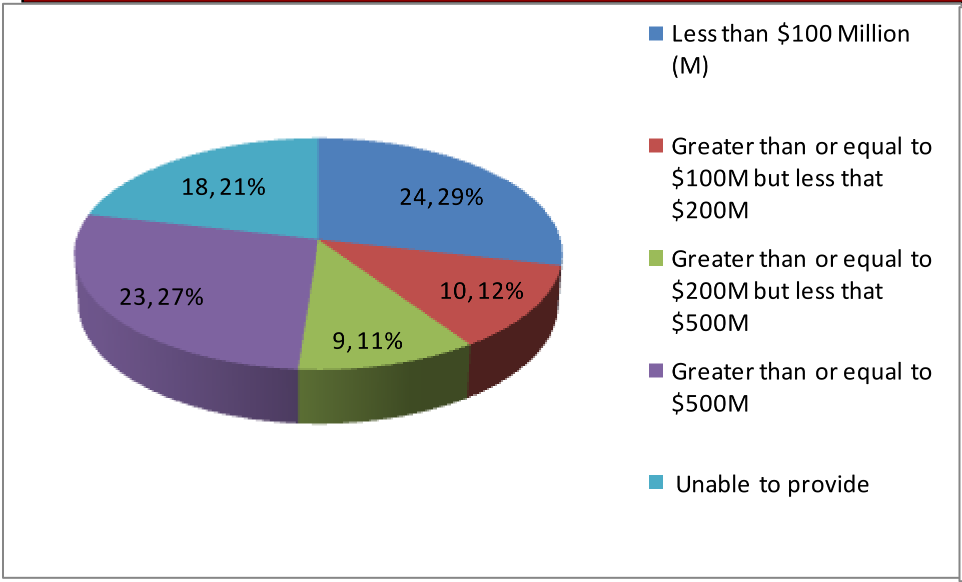
	Government	Industry
Other Government	6	6
Military	7	25
Commercial	0	40

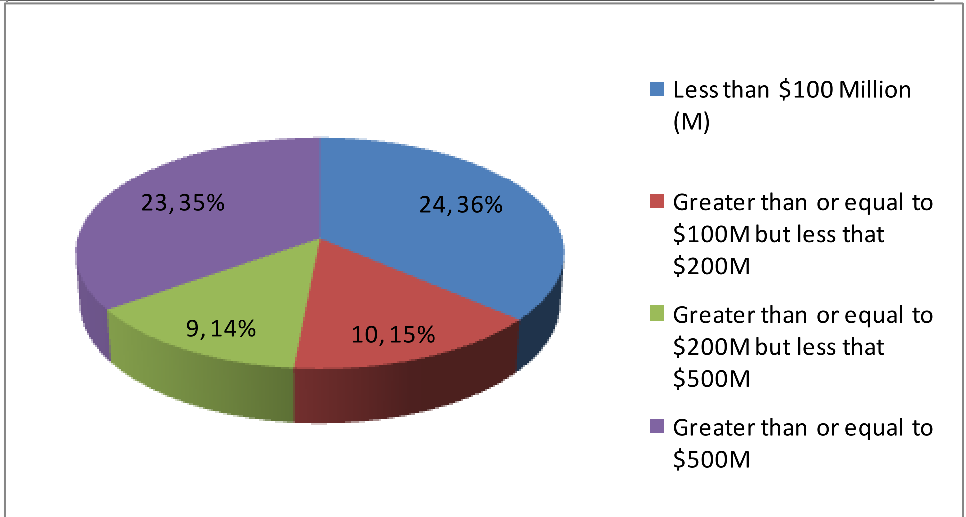
- Reasonable government participation
- Strong commercial participation

To be evaluated in the future

- Does the primary targeted group have different opinions than the non targeted group?
- Do government respondents have different opinions that industry respondents?
- Do commercial respondents have different opinions than government respondents?

Cost





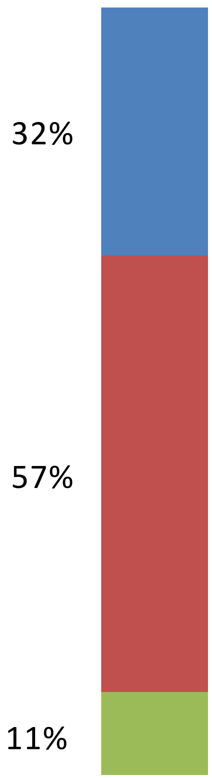
Does not include “Unable to Provide”

- Reflects a very decent spread as a basis for further analysis
- 14 ACAT I, 2 ACAT 1A and 2 ACAT III programs represented

To be evaluated in the future:

- Does the cost of the program influence responses?

Complexity



High — Not Low or Medium. Significant need for technical risk mitigation.

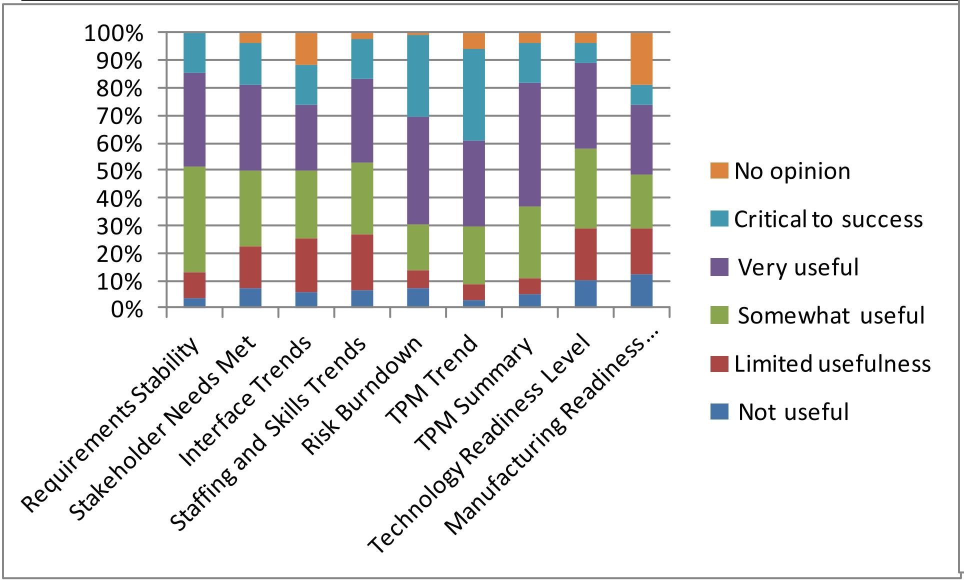
Medium — There are significant technical risks which are typical.

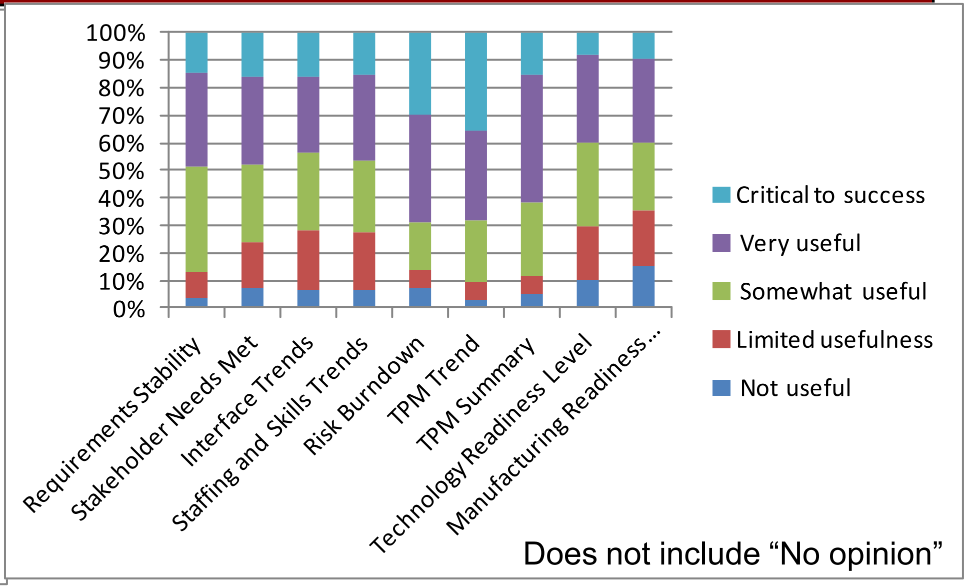
Concerns include: application area understanding, requirements stability, external interface specification, or implementation strategies

Low — The application area is well understood, requirements well defined, external interfaces well understood, and implementation straight forward (technical risk is low)

Future Evaluation - Does complexity affect responses?

Are the recommended indicators any good for their intended purpose?





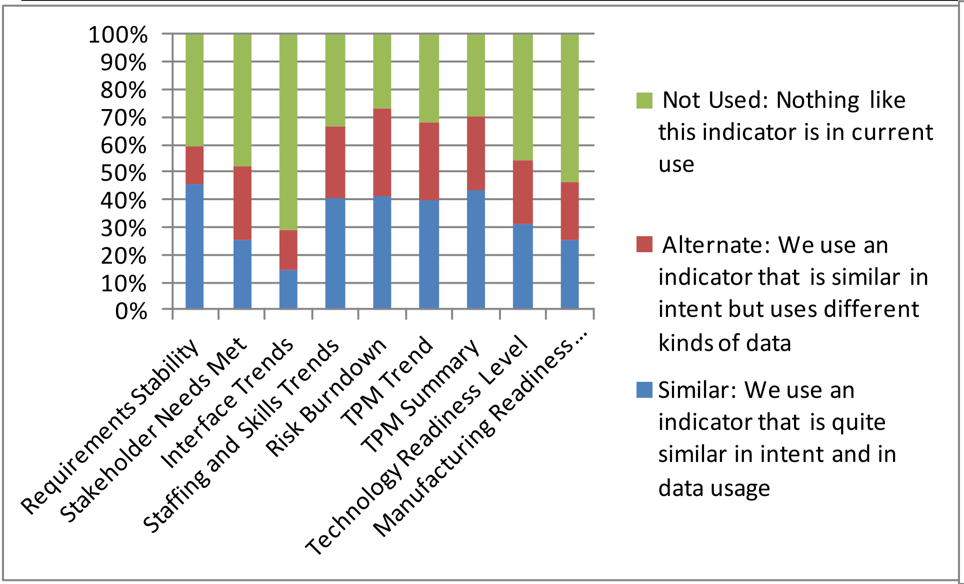
Yes!

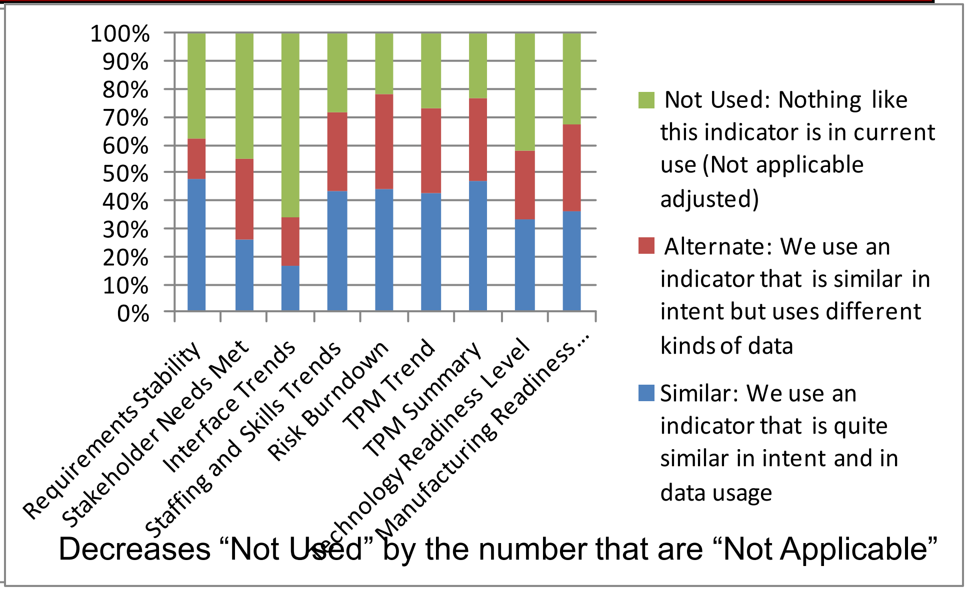
- All indicators have approx. 70% or greater somewhat useful, very useful or critical to success
- The TPM, Risk and Requirements indicators are approximately 90% or greater for the "useful" categories
- "Critical to Success" above 30% for Risk Burndown and TPM Trend

To be evaluated

- Is there a difference in usefulness between those using an indicator presently and those who are not?

Are these indicators frequently used today?

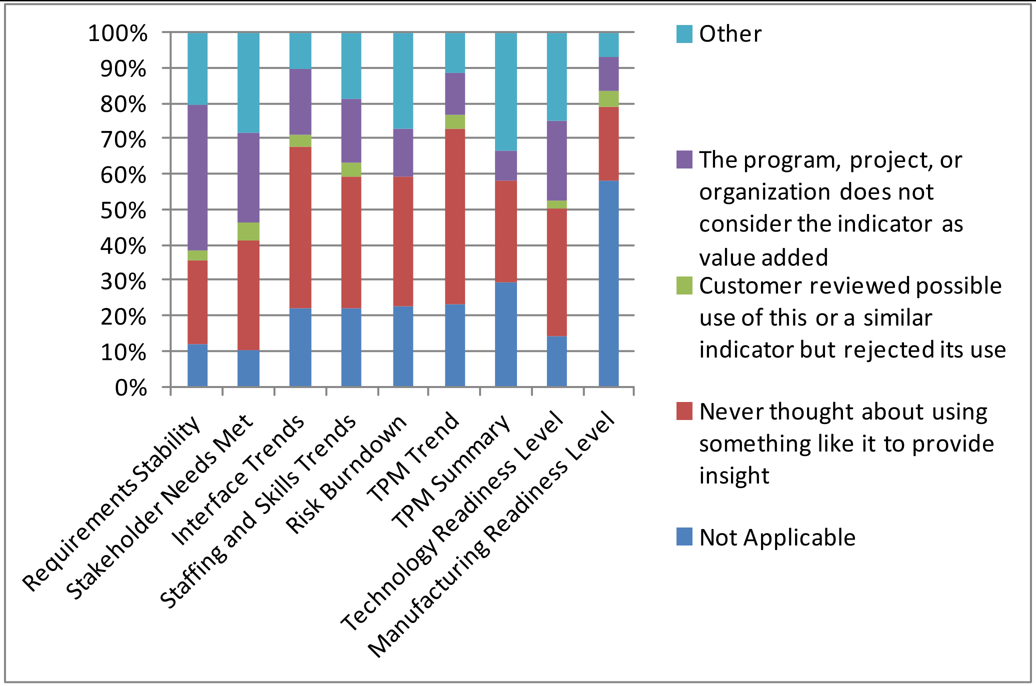




Yes!

- All indicators, except Interface Trends, have approximately 50%+ similar or alternate usage; several are approximately 70%.
- Interface Trends has the lowest usage; may imply a need to evolve indicator details, although this version of this indicator has not previously appeared in source documents used by the SDPM working group.

What are the reasons for non use?



- MRLs are frequently not applicable (probably software intensive systems)
- Requirements Stability in particular, but Stakeholder Needs Met and TRLs as well, have “high negatives” in the sense of frequently not being regarded as value added

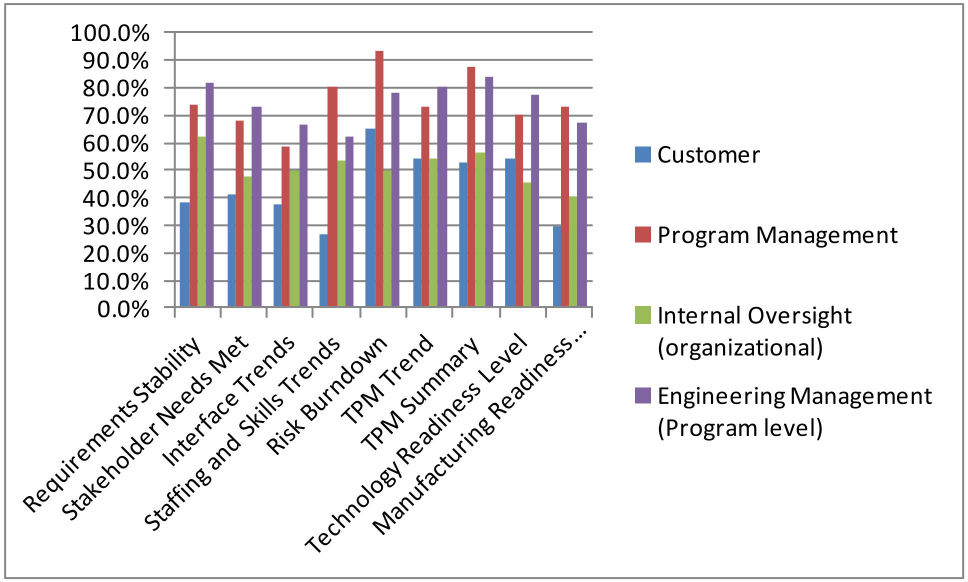
To be evaluated

- The textual responses when “Other” was selected
- How those who never thought about using an indicator regarded the importance of that indicator

Who uses these indicators for decision making?

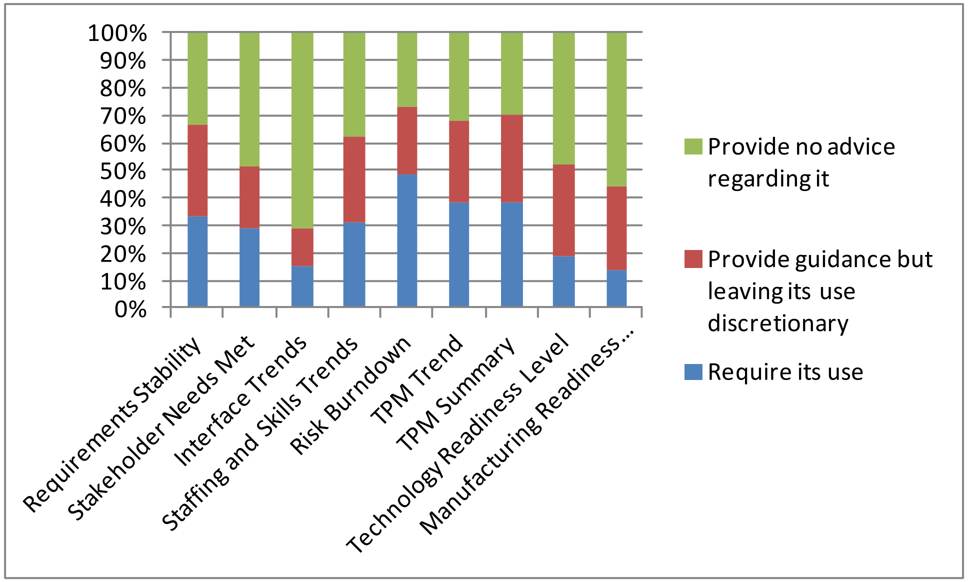
Percentages of those indicating use of a similar or alternate indicator

Respondents checked off as many as applied



- Program management is strong across all indicators with Staffing, Risk, and TPM Summary exceeding 80%
- Usage for internal oversight is decent across the indicator set, although it would seem some organizations have an opportunity to introduce/improve quantitative based oversight
- Engineering Management usage is strong exceeding PM where one would expect and trailing PM slightly as one would also expect
- Respondents provided 84 comments on “Examples of Decision Making” over the nine indicators
- Some examples of these comments are in the Backup slides

Regarding the use of this indicator, does your organization:



Risk and TPM indicators most frequently required followed by Staffing, Requirements Stability, and Stakeholder Needs Met.

To be evaluated:

Does organization perspective affect usage?

Does program cost affect response?

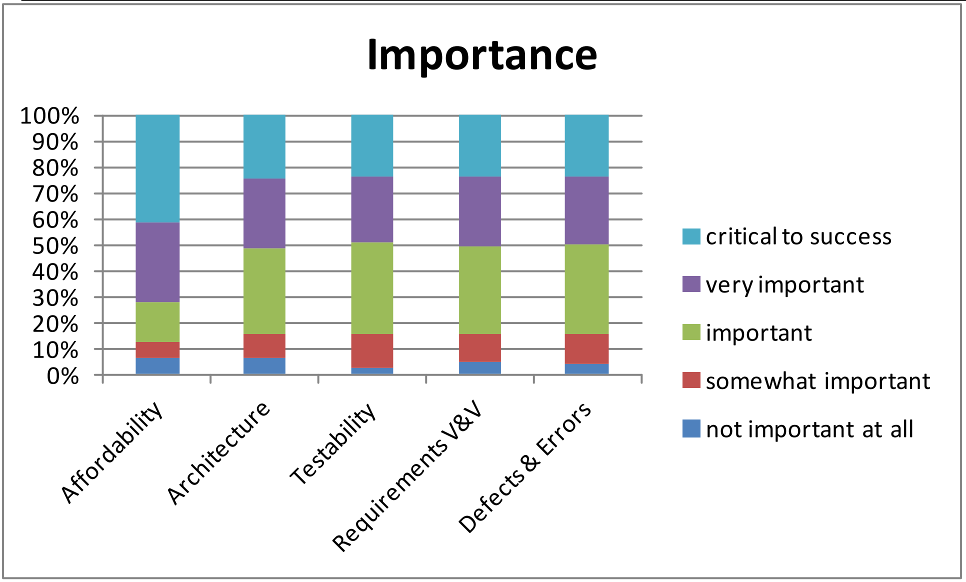
Doe complexity affect response?

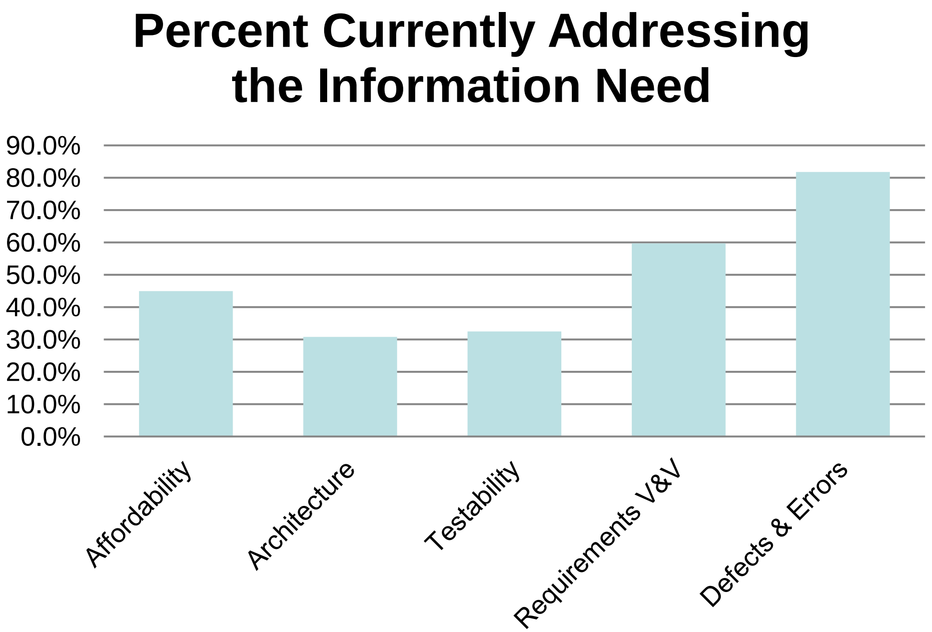
Information Needs

- **Affordability:** Understand the balance between performance, cost, and schedule as well as the associated confidence or risk
- **Architecture:** Evaluates the architecture from the perspectives of quality, flexibility, and robustness. Stability. Adequacy of design rules.
- **Testability:** Evaluates the degree to which a system(or product) of interest supports testing in a given test context. (Better testability usually results from testability being considered during architecting and design. In the case of electronics, it may include features such as probe points, electronic test circuits and test ports. In the case of software, it may include features such as triggers that turn on certain output recording, and telemetry. For mechanical systems, condition monitoring sensors and associated readouts can be included, examples are vibration sensors in engines or strain gauges in structures)
- **Requirements Verification and Validation:** Understand whether requirements are being validated with the applicable stakeholders, and verified relative to plan, at each level of the system development.

  Understand if the V&V plan/execution is feasible within acceptable risk.
- **Defects and Errors:** Understand the proportion of defects being found at each stage of the development process of a product or the execution of a service. Understand opportunities for finding defects earlier in the development process and reducing the number of defects created. Reduce latent defects delivered to the field.

Are these information needs important? Are we addressing these needs now?





80%+ regarded each information need as important, very important or critical to success

To be evaluated: Do those currently addressing the need evaluate importance differently than those who are not?

60% + are addressing Requirements V&V and Defects and Errors

To be evaluated: textual responses regarding indicators currently used or recommended

Benchmarking

Repositories (nine responses)

- Company internal
- Reifer Consultants
- International Software Benchmarking Standards Group (ISBSG)
- DoD Cost Assessment and Program Analysis (CAPE) Software Resource Data Request (SRDR).
- Defense Acquisition Management Information Retrieval (DAMIR) system (programmatic measures)
- Performance Assessment and Root Cause Analysis (PARCA) is in the process of defining systems engineering measures for performance assessment

Benchmarks Desired (nine responses)

- Productivity
- Duration
- Delivered Defect Density
- Ratio of SE to Total
- SE Profile by Time
- Labor Breakdown by Phases including Sustainment
- SE Skill Levels
- Product Complexity
- Requirements Stability
- Feature deferral, abandonment
- Peer review effectiveness

- In general, respondents are not aware of systems engineering repositories.
- Benchmarks desired are about as expected

Observations/Conclusions

- A survey approach is an effective and efficient mechanism for validating the indicator set
- As a whole the indicator set is regarded as important and in frequent use in some form
  - There may be need to revise a few indicators and enrich usage considerations based on textual remarks provided in the survey
- The additional information needs currently targeted are all regarded as important
- Industry benchmarking measures in systems engineering are pretty much non-existent

Way Forward

- Survey
  - Complete additional analysis
  - Process all textual comments
    - Reasons for not using an indicator
    - Examples of decision making
    - Other remarks about an indicator
    - Lists of indicators used or recommended for additional information need
  - Complete a survey report
- Complete recommendations regarding additional information needs
  - Affordability
  - Architecture
  - Testability
  - Requirement Verification and Validation
  - Defects and Errors
- Possible change to existing indicator set
- NDIA/ ODASD(SE) Joint Action Plan for leverage indicators into routine use

Points of Contact

- For further information on the Working Group, please contact any of the following core team members:
  - Mr. Peter McLoone, NDIA SED, Working Group Industry Chair (peter.j.mcloone@lmco.com)
  - Mr. Martin Meth, DASD (SE) (mmeth@rsadvisors.com) and Working Group OSD Laison
  - Mr. Garry Roedler, NDIA SED, Working Group Industry Adviser (garry.j.roedler@lmco.com)
  - Ms. Cheryl Jones, PSM, Working Group Collaboration Co-chair (cheryl.jones5@us.army.mil)
  - Mr. Stephen Henry, NDIA Systems Engineering Division (SED) Chair (Stephen Henry@ngc.com)
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  - Mr. James B Stubbe, Raytheon (James_B_Stubbe@Raytheon.com)

Backup

Examples of Decision Making(1)

84 comments over the nine indicators

- Requirements Stability: *Given that the level of requirements stability correlates well with projected effort, the Requirements Stability indicator was used to quantify and justify a staffing increase early enough in the development process to have positive impact.*
- *Requirements Stability: Allocation of risk reduction resources (budget and schedule) were adjusted based partially on this metric. Requirements stability is a significant indicator as to whether the program has exited the 'discovery phase' and whether sufficient baseline control processes are in place and being used effectively.*
- Stakeholder Needs Met and TPMs: *The program provides a TPM trending chart for different products. The performance threshold was forecasted as turning yellow 2 months in the future. This allowed the program to asses the performance testing currently in place, and perform additional testing to bring the performance back to the green threshold value.*
- Stakeholder Needs Met: *This is key for the verification / validation activity tracking to determine resource loading (are we completing tests per schedule for example). The MOE RYG status is used to assess if our system is ready for the next release phase (moving from experimental to design/development to limited production to full production release).*
- Stakeholder Needs Met and TPMs: *Technical Performance Metric related to power consumption/thermal dissipation led to to a decision to change to a lower-power ASIC technology. Decision made during HDL(ASIC code) application development.*

Examples of Decision Making(2)

- Risk Burndown: *We have experienced multiple situations where planned implementation options and product/vendor selections required specific, measurable mitigation actions to meet program requirements. Identifying these situations early in the program and managing them as Watch Items or Risk Items required us to develop mitigation plans and to identify resources to support execution of the mitigation steps.*
- TPM Trend: *Monitoring and analysis of performance TPMs from our infrastructure and mission applications led us to the implementation of processing algorithm improvements and the introduction of additional data sources. Monitoring started with the first drop of application code to the integration lab and continued through formal qualification testing.*
- TPM Trend: *This is one of the most valuable of all currently practical and widespread metrics. This metric enforces design changes, budget changes and does it in a timely fashion. When a program had a shortfall in availability, this metric drove a major architectural change to re-partition the system to co-locate resources which could then be used as redundant strings, where they had previously been isolated and non-redundant.*
- TRLs/MRLs*: The use of this metrics is driven by the customer requirements. When these are customer requirements or risk areas the TRL/MRL construct is used to assess the amount of effort required to reach maturity needed for the next phase. They provide a common framework for discussion on the maturity of systems. The absolute value is not the driving factor. It is the common understanding and agreement with our customer on what need to achieve a needed level of maturity at acceptable risk.*