Raytheon

Customer Success Is Our Mission

Technology & Manufacturing Readiness Assessments @ RMS

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- History of Technology & Manufacturing Readiness Assessment (T&MRA) Activities at RMS
- T&MRA Project
- Lessons Learned

History of T&MRA Activities at Raytheon Missile Systems (RMS) – 2005 & 2006

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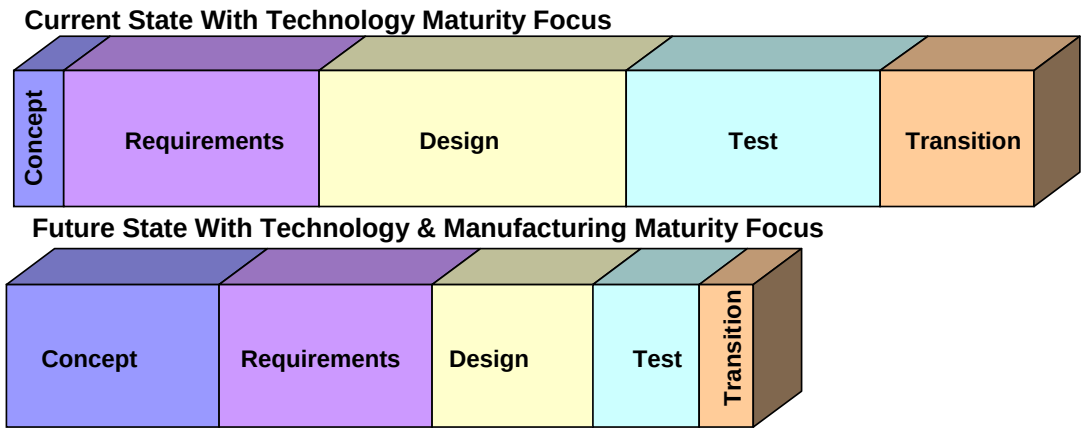
- **2005**
  - RMS leader attended Defense Acquisition University course…first delivery of Manufacturing Readiness Level (MRL) materials
  - ManTech white papers, quad charts & proposals require MRLs & notional MRL Maturity Plans (MMP)
- **2006**
  - RMS employees attended MRA training course established by Air Force Research Lab (AFRL)
  - 2-Part Pilot MRAs conducted by AFRL on AMRAAM Program
  - RMS Kicked-off T&MRA Project with Raytheon Six Sigma Team
  - Full Time MRA Manager assigned to Air-to-Air Product Line
  - Joint Service ManTech Program Awarded, required MMP
  - Conducted first independent T&MRA on Radome portfolio
  - T&MRA @ RMS website goes live

It Simply Makes Good Business Sense!

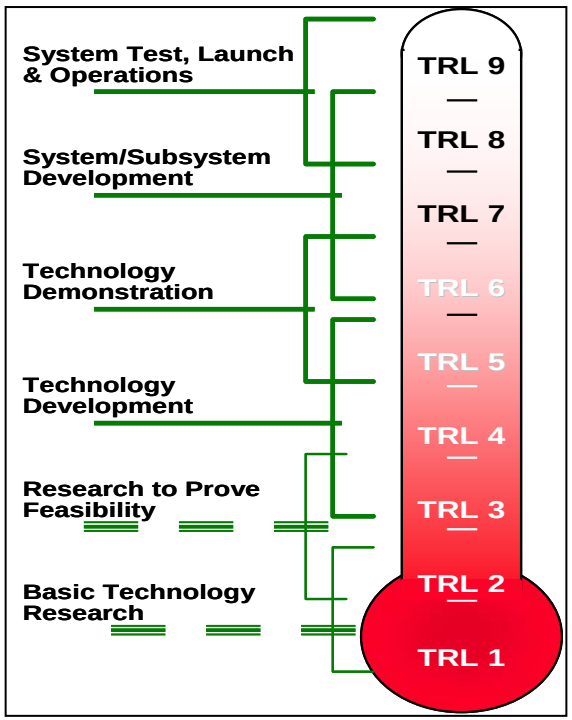
- Establishing TRLs, MRLs and maturity plans in accordance with the DoD's TRA & MRA requirements is not only necessary to support customer led assessments, but also:
  - T&MRA processes can change the culture by driving a collaborative partnership between programs, design and manufacturing engineering earlier in the product development life cycle where maturity efforts can have greatest impact on improving program affordability and predictability
  - Lower risk designs lead to shorter development cycles with fewer design re-starts, more accurate delivery dates, and lower overall development costs
    - Can mitigate 20% post CDR cost growth trend noted in GAO reports
    - Cost reductions of 30% or more can be achieved



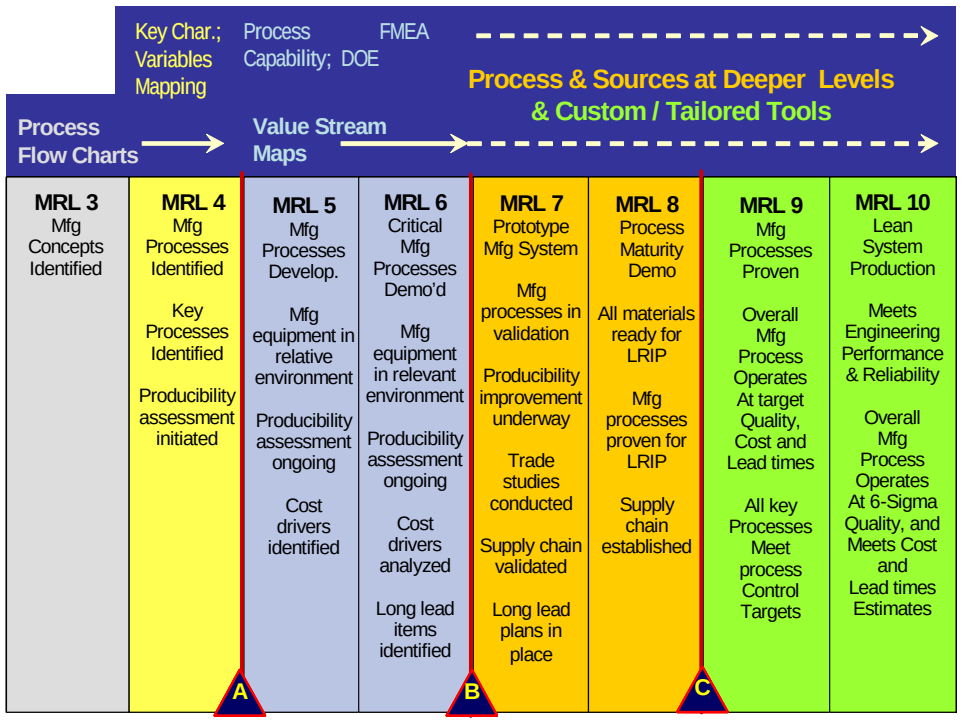
T&MRA @ RMS Project Vision

Technology & Manufacturing Readiness is integrated and measured in RMS business practices and culture.

Established TRA Process:
Technology Readiness Assessment



New MRA Process:
Manufacturing Readiness Assessment



T&MRA @ RMS Project Focus Areas

- Awareness & Training
  - T&MRA socialization across RMS & Raytheon
  - T&MRA preparation and facilitation training
- T&MRA Knowledge Management
  - Environmental scanning, knowledge capture, information warehousing & easy access (e.g. website, docushare and eRooms)
  - Capture lessons learned from internal & external cycles of learning
  - Assist DoD in the shaping MRA regulations, policies, and processes
- Standardization of T&MRA @ RMS Processes
  - 10-Step process created (includes capture of lessons learned)
  - Aligned with DoD MRA process, combined with DoD's TRA
- Directive System Support
  - Modify Directives, Proposals, Contracting, Practices, Instructions, etc. to support consistent and compulsory deployments

T&MRA Website for Knowledge Capture & Reuse

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Links

- Defense Acquisition University
- Defense Acquisition Guidebook
- Acquisition Community Connection
- DAU - Manufacturing Readiness Assessments
- DoD ManTech
- MRL Assist

T&MRA Tool Box

- MRL Matrix & Definitions+
- T&MRA Baseline & Planning Workbook
- TRL HW & SW Definitions (DAG October 2004)
- T&MRA Summary Report Template

Reference Materials

- 2007 Defense Manufacturing Conference
- 2007 Technology Maturity Conference
- AFRL MRA Workshop - 2006 DMC
- DoD Integrated Management Framework - Back
- DoD Integrated Management Framework - Front
- GAO-07-706SP Assessments of Selected Weapon Programs, March 2007
- Manager's Guide to Technology Transition in an Evolutionary Acquisition Environment, Version 2.0, June 2005
- Misc. T&MR Presentations
- Senate Report 109-254, National Defense Authorization Act for Fiscal Year 2007, May 9, 2006
- T&MRA Process Training
- T&MRA Overview
- Technology Readiness Assessment (TRA) Deskbook, May 2005

History of T&MRA Activities at RMS - 2007

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- T&MRA 10-Step Process developed – aligned with MRA
- T&MRA awareness seminars conducted across RMS
- Project Lead attended 2-week DAU course with DoD PMs; teams conducted notional MRAs from GAO facts & data
- MRAs considered good Management practice - not plus-ups
- T&MRL baselines in 3 major proposals (lessons learned)
- T&MRA added to RMS Manufacturing Excellence Model
- Early T&MRL requirements for Architectural Review Boards
- Participated in JDMTP's MRA Working Group with Industry
- "T&MRA @ RMS" presented at Raytheon Symposiums and Defense Manufacturing Conference
- MRL maturity included in Operations Strategy and Reviews

Combined "Technology & Manufacturing Readiness Assessment" Model

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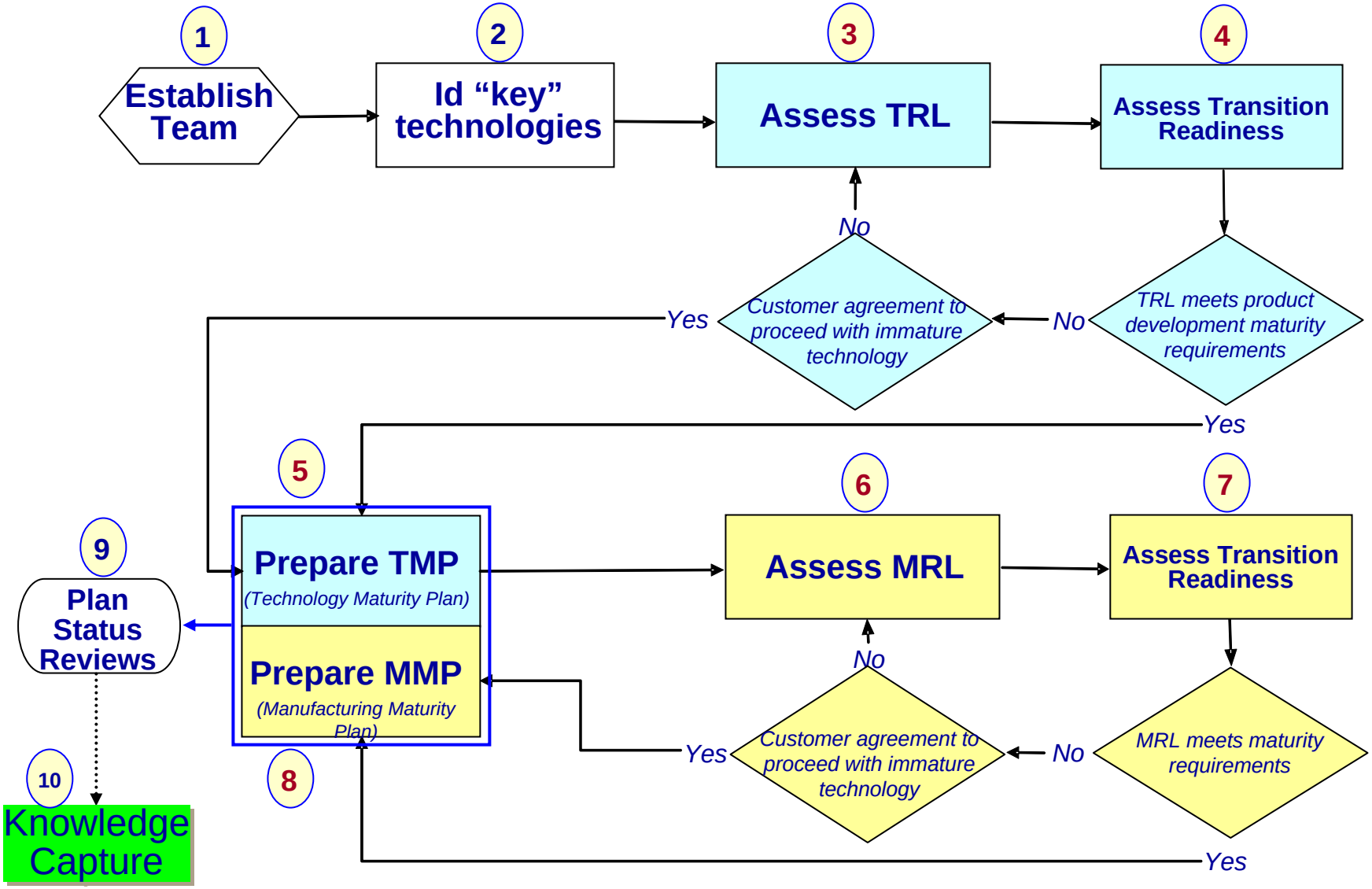

History and Plans for T&MRA Activities at RMS - 2008

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- T&MRA detailed 10-step process training developed
- T&MRA tools refined and added – to assess current state, develop maturity plans, report progress and document T&MRA
- Corporate IPDS Change Review Board scheduled to review T&MRA for potential incorporation into IPDS to ensure consistent and compulsory deployment in 2008
- T&MRA project lead scheduled to present *"T&MRA @ RMS"* at this year's:
  - National Defense Industry Association (NDIA) Science & Engineering Technology Conference in April
  - Enterprise Process Group Workshop in July

Tool to Capture, Plan and Status T&MRLs and Maturity Plans

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- Tool created to demo important T&MRA planning & reporting characteristics
  - Facilitates and documents the Baseline & Current State T&MRLs by MRL Matrix Thread
  - Potential to roll-up 10 separate technology assessments to an assembly level TRL & MRL
  - Transition Risk Color Coding based on DoD Best Practices for each phase of PDLC

Program: example: HyperSonic Missile Program
Product Description: example: Guidance & Navigation Unit (GNU)
Product Development Phase: Technology Development
Transition Readiness Goals: 6
T&MRL Valuation Method: **Lowest T&MRL Values**
Most Recent Assessment Date: None

Roll-Up T&MRLs

All **Baseline** Values				All **Current** Values			
Low TRL	4.0	Low MRL	3.0	Low TRL	6.0	Low MRL	3.0
High	8.0	High	5.0	High	6.0	High	3.0
Avg	5.8	Avg	4.0	Avg	6.0	Avg	3.0

T&MRL Assessments (Max. 10 Technologies per Roll-Up)

#	MRL Matrix Evaluation Threads	#	MRL Matrix Sub-Thread	Acronym 1		Acronym 2		Acronym 3		Acronym 4	
				Baseline	Current	Baseline	Current	Baseline	Current	Baseline	Current
1	Technology & Industrial Base	1	Technology Readiness Level (TRL)	5	6	4		6		8	
		2	Technology Transition to Production	4	5	4		6		7	
		3	Manufacturing Technology Development	4	5	4		6		7	
2	Design	4	Producibility Program	5	6	4		6		7	
		5	Design Maturity	5	5	3		6		5	
3	Materials	6	Maturity	3	5	3		6		5	
		7	Availability	5	5	4		6		6	
		8	Supply Chain Management	5	5	5		6		6	
		9	Special Handling	7	7	7		5		6	
4	Cost & Funding	10	Production Cost Knowledge (Cost Modeling)	4	5	4		5		6	
		11	Unit Production Costs	4	4	4		6		6	
		12	Manufacturing Investment Budget	3	4	3		6		7	
5	Process Capability & Control	13	Modeling & Simulation (Product & Process)	3	3	3		6		7	
		14	**Manufacturing Process Maturity**	5	5	4		6		7	
		15	Manufacturing Technology Initiatives					8		7	
		16	Process Yields & Rates	5	5	4		5		5	
6	Quality Management	17	Quality Management Including Supplier Quality	5	6	4		6		6	
7	Manufacturing Personnel	18	Manufacturing Personnel	6	6	5		6		6	
8	Facilities	19	Facilities	7	7	6		8		7	
9	Manufacturing Management	20	Manufacturing Planning & Scheduling	5	5	4		7		7	
		21	Materials Planning	6	6	6		7		7	
		22	Tooling & Special Test Equipment	5	6	5		6		7	
			Baseline MRL (excludes TRL):	3.0		3.0		5.0		5.0	
			Current MRL (excludes TRL):		3.0		-		-		-
			High MRL (excludes TRL):	7.0	7.0	7.0	0.0	8.0	0.0	7.0	0.0
			Low MRL (excludes TRL):	3.0	3.0	3.0	0.0	5.0	0.0	5.0	0.0
			Average MRL (excludes TRL):	4.8	5.3	4.3	#DIV/0!	6.1	#DIV/0!	6.4	#DIV/0!

Transition Readiness Risk Guide by PLC Phase

CR	TD	SDD	LRIP
4	6	8	9
1	1	1	1
2	2	High Risk	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
Low Risk	8	8	8
9	9	9	9
10	10	10	10

T&MRL Maturity Planning for Each Technology Assessed

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- Plan vs Actual TRL and MRL with transition readiness risk color codes
- Detailed tasks, POC, rationale, dates, funding, and sources of funding
- "What-if?" analysis capability

Program: Hypersonic Missile Program
Product Description: Guidance & Navigation Unit
Product Development Phase: Technology Development
Transition Readiness Goals: 6
T&MRL Valuation Method: **Lowest T&MRL Values**

Key Technology Assessed: Sensor **Acronym:** Acronym 1

Manufacturing Readiness Level - MRL

Item #	Task Description	Rationale/Evidence/Risks to Completion	Responsible POC	Plan Due Date	Complete Date	MRL Increase	Funding Req'mts	Funding Type	Funded (Y/N)	MRL Base Plan	MRL Act'l
1.00	Baseline MRL	Rationale/Evidence/Risks to Completion	Name		10/07					3	3
1.01	Maturity Advancement Action 1	Rationale/Evidence/Risks to Completion	Name	12/07	11/07		$100 K	IRAD	Y	3	3
1.02	Maturity Advancement Action 2	Rationale/Evidence/Risks to Completion	Name	01/08	12/08		$20 K	IRAD	Y	4	3
1.03	Maturity Advancement Action 3	Rationale/Evidence/Risks to Completion	Name	01/08	01/08		$45 K	Contract	Y	4	3
1.04	Maturity Advancement Action 4	Rationale/Evidence/Risks to Completion	Name	02/08	01/08	1	$30 K	Contract	Y	5	4
1.05	Maturity Advancement Action 5	Rationale/Evidence/Risks to Completion	Name	02/08	02/08	1	$10 K	Contract	Y	5	5
1.06	Maturity Advancement Action 6	Rationale/Evidence/Risks to Completion	Name	03/08	02/08		$25 K	Contract	Y	6	5
1.07	Maturity Advancement Action 7	Rationale/Evidence/Risks to Completion	Name	03/08			$25 K	Contract	Y	6	0
1.08	Maturity Advancement Action 8	Rationale/Evidence/Risks to Completion	Name	05/08			$1,200 K	Capital	N	7	0
1.09	Maturity Advancement Action 9	Rationale/Evidence/Risks to Completion	Name	07/08			$260 K	Contract	Y	7	0
1.10	Maturity Advancement Action 10	Rationale/Evidence/Risks to Completion	Name	08/08			$50 K	Contract	N	8	0
1.11											0
1.12											0
1.13											0
1.14											0
1.15											0
1.16											0
1.17											0
1.18											0
1.19											0
1.20											0

MRL funding plan: $1,765 K — Current MRL: 5
Funded: $515 K — MRL Plan Complete? N
Unfunded: ($1,250 K) — In Risk Register? Y

Key Lessons Learned

- Cultural change...T&MRA is a means to facilitate earlier collaborations between design engineering, manufacturing and supply chain during any phase of PDLC
- Leadership & Assessment Team alignment required before T&MRA deployments
- TRLs & MRLs should be established at the critical technology levels (best practice)
- Wherever possible, the T&MRA should be completed prior to developing a proposal to ensure technology, design & manufacturability risks are accounted for:
  - Assess program feasibility and technology transition readiness (risks)
  - Program cost and schedules should include maturity plans and goals
  - Identify key manufacturing processes that need to be matured for program success

Key Lessons Learned

- Command media revisions required for consistent & compulsory use
- Tailoring of assessment based on fidelity level desired
- MRA and Production Readiness are not the same
- Systems Engineering organization to own the T&MRA process
- Need further development and integration of tools and management systems to capture, plan and report T&MRL progress
- MRL Matrix can be enhanced further to focus on Manufacturing Process Maturity
- **Low MRLs are not necessarily an issue…not having a maturity plan is!**

In Summary…

- TRLs are part of our culture at Raytheon…more discipline required
- MRLs are relatively new…Industry is still in early stages of adoption
  - Sense of urgency within the DoD – TRA & MRA processes are being taught to and deployed by our customers…and for very compelling reasons
  - Acquisition Policy, Guidance and Legislation associated with TRA & MRA are in place and/or currently under revision & development for 2008 release
- The use of T&MRA processes will not guarantee program success
- T&MRA processes and tools will:
  - Change culture - bridge the divide between engineering & manufacturing
  - Provide insight into current state technology & manufacturing maturity and capability
  - Identify contributing factors & issues driving the “Gaps” in T&MRL maturity
  - Identify the type and significance of risks to program cost, schedule and performance
  - Lead to more accurate, time phased, and priced maturity plans
  - **Improve program affordability and predictability**

T&MRA @ RMS

If you have any questions, feel free to contact me at:

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