

Version 7.1		DoD Manufacturing Readiness Levels (MRLs)									
May 2009											
Acq Phase	Sub-Thread	Pro MSA	Pro MSA	Pro MSA	MSA - MS A	TD	EMD	EMD MS C	LIMP - FRP	FRP	
Thread	MRL 1	MRL 2	MRL 3	MRL 4	MRL 5	MRL 6	MRL 7	MRL 8	MRL 9	MRL 10	
Technology & Industrial Base	Technology Maturity	Should be assessed at TRL 1.	Should be assessed at TRL 3.	Should be assessed at TRL 4.	Should be assessed at TRL 5.	Should be assessed at TRL 6.	Should be assessed at TRL 7.	Should be assessed at TRL 8.	Should be assessed at TRL 9.	Should be assessed at TRL 10.	
	Technology Transition to Production		Potential sources identified for technology needs. (Understand state of the art).	Should be assessed at TRL 4. Gaps/risks identified for key technologies, components, and/or key processes.	Industrial Base assessed to identify potential manufacturing sources.	Industrial Capability Assessment (ICA) for MS B has been completed. Industrial capability in place to support mfg of development articles. Plans to minimize sole/foreign sources complete. Need for sole/foreign alternative sources justified. Potential alternative sources identified.	Industrial capability to support Sole/foreign sources stability is assessed/monitored. Developing potential alternate sources as necessary.	Industrial Capability Assessment (ICA) for MS C has been completed. Industrial capability in place to support LRRP. Sources are available, multi-sourcing where cost-effective or necessary to mitigate risk.	Industrial capability is in place to support start of FRP.	Industrial capability supports FRP. Industrial capability assessed to support mfg, upgrades, surge and other potential manufacturing requirements.	
	Manufacturing Technology Development		Manufacturing technology concepts identified through experiments / models.	Mfg science & advanced mfg technology requirements identified.	Required manufacturing technology development efforts initiated.	Manufacturing technology efforts continuing. Required manufacturing technology development solutions demonstrated in a production representative environment.	Manufacturing technology efforts continuing. Required manufacturing technology solutions validated on a pilot line.	Manufacturing technology efforts continuing. Manufacturing technology process improvement efforts initiated for FRP.	Manufacturing technology efforts continuing. Manufacturing technology improvements ongoing.	Manufacturing technology efforts continuing. Manufacturing technology improvements ongoing.	Manufacturing technology efforts continuing. Manufacturing technology improvements ongoing.
Design	Productivity Program		Relevant materials/processes evaluated for manufacturability using experimental results.	Productivity & Manufacturability assessment of design concepts completed. Results guide selection of design concepts for key components/technologies for Technology Development Strategy. Required Test Evaluation Strategy (TES) includes Design for Test during production.	Productivity & Manufacturability assessments of key technologies and components initiated. Systems Engineering Plan (SEP) requires validation of design choices against manufacturing process and industrial base capability constraints. Manufacturing processes assessed for capability to test and verify in production, and influence on Operations & Support (O&S).	Detailed productivity trade studies using knowledge of key design characteristics and related manufacturing process capability completed. Productivity enhancement efforts (e.g. Design For Mfg Assembly) initiated.	Detailed productivity trade studies using knowledge of key design characteristics and related manufacturing process capability completed. Productivity enhancement efforts (e.g. Design For Mfg Assembly) initiated.	Productivity improvements implemented on system. Known productivity issues have been resolved and pose no significant risk for LRRP.	Prior productivity improvements analyzed for effectiveness during LRRP. Productivity issues/risks mitigated and pose no significant risk for FRP.	On-going productivity improvements analyzed for effectiveness. Productivity refinements continue. All mfg. Sources & Material Shortages (DMSMS) and other changes assessed for productivity.	
	Design Maturity	Manufacturing opportunities identified.	Top level performance requirements defined. Trade-offs in design options assessed based on experiments. Product lifecycle and technical requirements evaluated.	Initial Systems Engineering Plan and Test and Evaluation Strategy recognize the need for the establishment/validation of manufacturing capability and management of manufacturing risk for the product lifecycle. Initial Key Performance Parameters (KPPs) identified.	Identification of enabling/critical technologies and components is complete and includes the product lifecycle. Evaluation of design Key Characteristics (KC) initiated.	Basic system design requirements defined. All enabling/critical technologies/components have been tested and validated. Product data required for prototype manufacturing released. A preliminary performance as well as focused logistics specification is in place. Key Characteristics and tolerances have been established.	Product requirements and features are well enough defined to support detailed systems design. All product data essential for manufacturing released. Major product design features are sufficiently stable such that key LRRP manufacturing processes will be representative of those used in FRP. Design change impact LRRP. Key characteristics are stable and have been demonstrated in SDD or technology insertion program.	Detailed design of product features and interfaces is complete. All product data essential for system manufacturing released. Major product design features are sufficiently stable such that key LRRP manufacturing processes will be representative of those used in FRP. Design change impact LRRP. Key characteristics are stable and have been demonstrated in SDD or technology insertion program.	Major product design features are proven in product testing. Design change traffic is limited to minor configuration changes. All KCs are controlled in production to 3-sigma or other appropriate quality levels.	Product design is stable. Design changes are few and generally limited to those required for continuous improvement or in reaction to obsolescence. All KCs are controlled in production to 6-sigma or other appropriate quality levels.	



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Process Capability & Control	Modeling & Simulation (Product & Process)		Initial models developed, if applicable.	Identification of proposed manufacturing concepts or producibility needs based on high level process flow chart models.	Production modeling & simulation approaches for process or product are identified.	Initial simulation models (product or process) developed at the component level and validated.	Initial simulation models developed and validated at the technology, sub-system or system level.	Simulation models used to determine system constraints and identify improvement opportunities.	Simulation models verified by SDD article build. Results used to improve process and determine that LRP requirements can be met.	Simulation model verified by LRP build. Production simulation models used as tool to assist in management FRP.		
	Manufacturing Process Maturity		Identification of material and/or process approaches.	Document high level manufacturing processes. Critical manufacturing processes identified through experimentation.	Complete a survey to determine the current state of critical processes.	Maturity has been assessed on similar processes in production. Process capability requirements have been identified.	Manufacturing processes demonstrated in production relevant environment.	Manufacturing processes verified for LRP on a pilot line. Process capability data being collected or estimated.	Manufacturing processes & procedures are established and controlled in production to 3-sigma or other appropriate quality level.	Manufacturing processes & procedures are established and controlled in production to 6-sigma or other appropriate quality level.		
	Process Yields and Rates			Initial estimates of yields and rates based on experiments or state of the art.	Yield and rates assessment on proposed processes complete and applied within the Analysis of Alternatives (AoA).	Target yield and rates established for production. Yield and rate issues identified. Improvement plans developed/updated.	Yield and rates evaluated in production relevant environment. Improvement plans on-going and updated.	Yield and rates estimated in production representative environment.	Yield and rates required to begin LRP verified using SDD articles.	Yield and rate targets achieved. Yield improvements on-going.	Yield and rate targets achieved. Yield improvements on-going.	
Quality Management	Quality Management including Supplier Quality.				Quality strategy identified as part of the Technology Development Strategy.	Quality strategy refined in the System Engineering Plan and Key Characteristics are identified during technology demonstrations.	Initial Quality Plan and Quality Management System are in place. Quality risks and metrics have been identified.	Demonstrate ability to collect and analyze quality data (process and system) in the production representative environment.	Quality targets demonstrated on pilot line.	Quality targets verified on production line. Continuous quality improvement begins.	Quality targets verified on production line. Continuous quality improvement on-going.	
	Mfg Personnel			New manufacturing skills identified.	Mfg skill sets identified to overcome production barriers	Special skills certification and training requirements quantified	Mfg workforce skills available for production in a relevant environment. Training resources identified for production workforce.	Mfg workforce resource requirements identified for pilot line. Training resources identified for special skills deficiencies and LEAN 6-sigma training on special skills	Mfg workforce resource requirements identified for LRP. Ability of mfg workforce to produce repeatable products and measure workforce quality. Training initiated for certification on special skills	LRP personnel requirements met. FRP personnel requirements identified..	LRP personnel requirements met. FRP personnel requirements maintained due to attrition of workforce.	
Facilities				Specialized facility requirements/needs identified.	General industrial base (IB) capability identified for key technologies.	IB capabilities and gaps to support SDD and LRP identified. Plan in place to fill gaps.	Mfg facility and facility development plans adequate to support SDD or technology insertion programs.	Facility capabilities for LRP and FRP identified. Plan in place to fill gaps. Plant layout and design initiated.	Mfg facilities exist and are adequate to begin LRP. Plans in place to support transition to FRP.	Mfg facilities in place and demonstrated in LRP. Capacity plans adequate to support FRP decision.	Production facilities in place and capacity demonstrated to meet maximum FRP requirements. Executable facilities surge plan available.	
	Mfg Planning & Scheduling				Mfg strategy developed and integrated with acq strategy. Prototype schedule risk mitigation efforts incorporated into Technology Development Strategy (TDS).	Mfg strategy refined. Prototype schedule risk mitigation efforts initiated.	Initial mfg approach developed. All system design related mfg events included in integrated Master Plan/Schedule. Mfg risk mitigation approach for SDD or technology insertion programs defined.	Initial mfg plan developed. Mfg risks integrated into Risk Mitigation Plan.	Mfg plan completed. All key manufacturing risks have been validated & mitigated using SDD or technology insertion program work products.	Mfg plan updated and validated for FRP. All manufacturing risks have been validated and mitigated using FRP articles.	All manufacturing risks have been validated and mitigated using FRP articles.	
Mfg Management	Materials Planning				Parts list in development with associated lead time calculations.	Parts list maturing and make/buy evaluations ongoing. Lead times, quality, cost and other risks identified.	Most material decisions made (make/buy), material risk identified and plans made to mitigate. Bill Of Materials (BOM) initiated.	Analyses for make/buy decisions & BOM complete. Material planning systems in place for pilot line build.	Make/buy decisions & BOM complete to support FRP. Material planning systems validated on LRP build.	Make/buy decisions & BOM complete to support FRP. Material planning systems validated on LRP build.	Program is in FRP with only process improvement/obsolescence make/buy or BOM changes allowed. Material planning systems validated on FRP build.	
	Tooling / Special Test and Inspection Equipment (STE/SIE)				Tooling / Special Test Equipment (STE) / Special Inspection Equipment (SIE) requirements are considered.	Identify tooling (STE/SIE reqts & schedule) provide supporting rationale and schedule.	Prototype tooling concepts demonstrated in relevant mfg environment.	Production tooling and STE/SIE design and development efforts initiated.	All tooling, test and inspection equipment proven on pilot line. Multiple tooling reqts identified for LRP.	All tooling, test and inspection equipment proven on LRP. Multiple tooling reqts identified for FRP.	Proven tooling, test and inspection equipment in place to support maximum FRP.	