Version 2020	DoD Manufacturing Readiness Levels (MRLs)									
Acquisition Phase	**Pre-Materiel Development Decision (Pre-MDD)**			**Materiel Solution Analysis (MSA)**	**Technology Maturation and Risk Reduction (TMRR)**		**Engineering & Manufacturing Development (EMD)**			**Low-Rate Initial Production (LRIP)**	**Full-Rate Production (FRP)**
Technical Reviews			MDD	ASR A	SRR/SFR	PDR B	CDR	PRR/SVR C		PCA FRP	
Thread	**Sub-Thread**	**MRL 1**	**MRL 2**	**MRL 3**	**MRL 4**	**MRL 5**	**MRL 6**	**MRL 7**	**MRL 8**	**MRL 9**	**MRL 10**
A - Technology and Industrial Base	**Technology Maturity**	Should be assessed at TRL 1.	Should be assessed at TRL 2.	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 7 or TRL 8.	Should be assessed at TRL 8 or TRL 9.	Should be assessed at TRL 9.
	A.1 Industrial Base	Global trends in emerging industrial base capabilities identified.	Potential industrial base capability gaps identified.	Industrial base capabilities for potential sources identified for system concepts. ~~to address technology needs. Understand state of the art.~~	Industrial base capabilities surveyed ~~and known gaps/risks/issues identified for preferred concept, key technologies, components, and/or key processes.~~ for preferred materiel solution, key technologies, components, and/or key processes. Industrial base capability risks and issues included in AoA.	Industrial base capabilities assessment initiated to identify potential manufacturing sources. Sole/single/ foreign source vendors and vendors of technologies with potential obsolescence issues identified and planning initiated to minimize risks.	Industrial base capabilities assessment for MS B completed. Industrial capability in place to support manufacturing of development articles. Plans to minimize sole/single/foreign sources and obsolescence issues complete. Need for sole/single/foreign sources justified. Potential alternative sources identified.	Industrial capability to support production analyzed. Sole/single/foreign sources, source stability, and obsolescence issues are assessed/monitored. Potential alternate sources developed if necessary.	Industrial base capability assessment for MS C completed. Industrial capability is in place to support LRIP. Sources are available, including multi-sourcing where cost-effective or necessary to mitigate risk.	Industrial capability assessment for FRP has been completed and capability is in place to support start of FRP.	Industrial capability supports FRP and is assessed to support modifications, upgrades, surge and other potential manufacturing requirements.
	A.2 Manufacturing Technology Development	Global trends in manufacturing science and technology identified (i.e., concepts, capabilities).	~~New manufacturing concepts and potential solutions identified.~~Potential manufacturing science and technology gaps identified.	Manufacturing technology ~~concepts~~ requirements identified ~~through experiments/models~~ to address potential capability gaps for system concepts.	~~Manufacturing Science & Advanced Manufacturing Technology requirements identified.~~ Manufacturing technology development initiatives defined for preferred materiel solution. Manufacturing technology development requirements considered in the AoA.	Required manufacturing technology development efforts initiated.	Manufacturing technology efforts continuing. Required manufacturing technology development solutions demonstrated in a production relevant environment.	Manufacturing technology efforts continuing. Required manufacturing technology development solutions demonstrated in a production representative environment.	Primary manufacturing technology efforts concluding. Improvement efforts continuing. Required manufacturing technology solutions validated on a pilot line.	Manufacturing technology process improvements efforts initiated for FRP.	Manufacturing technology continuous process improvements ongoing.
B - Design	**B.1 Producibility Program**	Hypotheses developed for cause-effect relationships between technology variables and producibility.	Studies performed to test hypotheses regarding cause-effect relationships between technology variables and producibility. Elements identified which have a potential impact to producibility (i.e., materials, processes, capabilities, limitations).	~~Relevant materials/processes~~ System concept elements evaluated for manufacturability and producibility using experiments~~/~~ and models~~ing, and simulation.	Initial producibility ~~and manufacturability~~ assessments ~~in selection~~ of preferred materiel solution completed. Results considered in ~~selection of preferred design concepts and reflected~~ AoA and documented in AS key components/ technologies.	Producibility and manufacturability assessments of key technologies and components initiated. Ongoing design trades consider manufacturing processes and industrial base capability constraints. Manufacturing processes assessed for capability to be tested and verified in production. Manufacturing processes assessed for influence on O&S.	Producibility assessments and producibility trade studies (performance vs. producibility) of key technologies/components completed. Results used to shape AS, SEP, manufacturing and producibility plans, and planning for EMD or technology insertion programs. Preliminary design choices assessed against manufacturing processes and industrial base capability constraints. Producibility enhancement efforts (i.e., DFM, DFA, etc.) initiated.	Detailed producibility trade studies using knowledge of key design characteristics and related manufacturing process capability completed. Producibility enhancement efforts (i.e., DFM, DFA, etc.) ongoing for optimized integrated system. Manufacturing processes re-assessed as needed for capability to be tested and verified. Manufacturing processes re-assessed as needed for potential influence on O&S.	Producibility improvements implemented on system. Known producibility risks and issues managed for LRIP.	Prior producibility improvements analyzed for effectiveness during LRIP. Producibility risks and issues discovered in LRIP managed for FRP.	Design producibility improvements demonstrated in FRP. Process producibility improvements ongoing. All modifications, upgrades, DMSMS and other changes assessed for producibility.
	B.2 Design Maturity	~~Manufacturing research opportunities identified.~~ Current capability deficiencies and gaps identified.	~~Applications defined. Broad performance goals identified that may drive manufacturing options.~~ Analyses performed to evaluate the feasibility of potential solutions to address capability gaps.	~~Top level~~ High-level performance, lifecycle, and technical requirements defined and evaluated for system concepts. Trade-offs in design options assessed based on experiments and initial MOEs. ~~Product lifecycle and technical requirements evaluated.~~	Form, fit, and function constraints identified, ~~and manufacturing capabilities~~ identified for preferred ~~systems concept~~ materiel solution. SEP and T&E Strategy recognize the need for the establishment~~/~~ and validation of manufacturing capability and management of manufacturing risk for the product lifecycle. Initial KPPs identified for preferred ~~systems concept~~ materiel solution. System ~~characteristics~~ technical requirements and measures to support required capabilities identified.	Lower level performance requirements sufficient to proceed to preliminary design. All enabling/critical technologies and components identified and the product lifecycle considered. Evaluation of the design for KCs initiated. Product data required for prototype component manufacturing released.	System allocated baseline established. Product requirements and features are well enough defined to support PDR. Product data essential for subsystem/ system prototyping has been released, and all enabling/critical components have been prototyped. Preliminary KCs for the design identified and mitigation plans initiated.	Product design and features are well enough defined to support CDR, even though design change traffic may be significant. All product data essential for component manufacturing released. Potential KC risks and issues identified with mitigation plans in place.	Detailed design of product features and interfaces completed. All product data essential for system manufacturing released. Design change traffic does not significantly impact LRIP. KCs are attainable based upon pilot line demonstrations.	Major product design features and configuration are stable. System design has been validated through operational testing of LRIP items. PCA or equivalent complete as necessary. Design change traffic is limited. All KCs are controlled in LRIP to 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 FRP to appropriate quality levels.
C - Cost & Funding	**C.1 Production Cost Knowledge (Cost modeling)**	Hypotheses developed regarding technology impact on affordability.	Cost model approach defined.	~~Initial cost targets and risks identified. High level process chart model developed. Technology cost models developed for new process steps and materials based on experiments.~~ Manufacturing cost estimates for system concepts developed. Initial cost models developed which include high-level process steps and materials.	Cost estimates refined based on anticipated production volumes associated with preferred materiel solution. ~~Manufacturing, material and special requirement cost drivers identified. Detailed process chart cost models driven by process variables.~~ Cost model updated with identified cost drivers (i.e., process variables, manufacturing, materials, and special requirements). Cost driver uncertainty quantified. Cost model supports AoA and ASR.	Prototype components produced in a production relevant environment, or simulations drive end-to-end cost models. Cost model includes materials, labor, equipment, tooling/STE/SIE, setup, yield/scrap/rework, WIP, and capability/capacity constraints.	Cost model updated with design requirements, material specifications, tolerances, IMS, results of system/subsystem simulations and production relevant prototype demonstrations.	Cost model updated with the results of systems/sub-systems produced in a production representative environment, production plant layout and design, and obsolescence solutions.	Cost model updated with results of pilot line build.	FRP cost model updated with result of LRIP build.	Cost model validated against actual FRP cost.
	C.2 Cost Analysis	~~Identify any manufacturing cost implications.~~ Initial manufacturing and quality costs identified.	~~Cost elements identified.~~ Potential manufacturing and quality cost drivers and system affordability gaps identified.	~~Sensitivity~~ Analysis conducted to ~~define~~ refine manufacturing and quality cost drivers, risks, and ~~production~~ development strategy (i.e. lab to pilot to factory). Potential cost reduction and system affordability gap closure strategies identified.	Producibility and lifecycle cost risks and issues assessed for preferred materiel solution. Initial cost ~~model~~ analysis supports AoA and ASR.	Costs analyzed using prototype component actuals to ensure target costs are achievable. Decisions regarding design choices, make/buy, capacity, process capability, sources, quality, KCs, yield/rate, and variability influenced by cost models.	Costs analyzed using prototype system/sub-system actuals to ensure target costs are achievable. Cost targets allocated to subsystems. Cost reduction and avoidance strategies developed. Manufacturing cost drivers for "Should-Cost" model provided.	Manufacturing costs rolled up to system/sub-system level and tracked against targets. Detailed trade studies and engineering change requests supported by cost estimates. Cost reduction and avoidance strategies underway. Manufacturing cost drivers for "Should-Cost" model updated.	Costs analyzed using pilot line actuals to ensure target costs are achievable. Manufacturing cost analysis supports proposed changes to requirements or configuration. Cost reduction initiatives ongoing. Manufacturing cost drivers for "Should-Cost" model updated.	LRIP cost goals met and learning curves analyzed with actual data. Cost reduction initiatives ongoing. Touch labor efficiency analyzed to meet production rates and elements of inefficiency are identified with plans in place for reduction.	FRP cost goals met. Cost reduction initiatives ongoing.
	C.3 Manufacturing Investment Budget	Potential manufacturing investment strategy developed.	Program/projects have reasonable budget estimates for reaching MRL 3 through experiment. Manufacturing investment budget ROM estimates identified to support industrial base and manufacturing capability gap closure strategies.	Program/projects have reasonable budget estimates for reaching MRL 4 by MS A. Preliminary manufacturing investment budget estimates for manufacturing gap closure recommendations developed.	Manufacturing technology budget initiatives ~~identified~~ developed and incorporated to reduce costs. Program has reasonable budget estimate for reaching MRL 6 by MS B. Estimate includes capital investment for production relevant equipment. All outstanding MRL 4 risks and issues understood with approved mitigation plans in place.	Program has updated budget estimate for reaching MRL 6 by MS B. All outstanding MRL 5 risks and issues understood with approved mitigation plans in place.	Program has reasonable budget estimate for reaching MRL 8 by MS C. Estimate includes capital investment for production-representative equipment by CDR and pilot line equipment by MS C. All outstanding MRL 6 risks and issues understood with approved mitigation plans in place.	Program has updated budget estimate for reaching MRL 8 by MS C. All outstanding MRL 7 risks and issues understood with approved mitigation plans in place.	Program has reasonable budget estimate for reaching MRL 9 by the FRP decision point. Estimate includes investment for LRIP and FRP. All outstanding MRL 8 risks and issues understood with approved mitigation plans in place.	Program has reasonable budget estimate for FRP. All outstanding MRL 9 risks and issues understood with approved mitigation plans in place.	Production budgets sufficient for production at required rates and schedule to support funded program.
D - Components, Sub-assemblies and Sub-systems)	**D.1 Maturity**	New material properties and characteristics surveyed and identified for research (e.g., manufacturability, quality).	Potential effects of new material properties ~~and characteristics~~ on design application manufacturability and quality predicted based on research.	Effects of new material properties on design concept manufacturability and quality validated ~~and assessed for basic manufacturability~~ using experiments and models.	New ~~projected~~ materials and components for preferred materiel solution ~~produced~~ demonstrated in a laboratory environment.	Materials manufactured or produced in a prototype environment (may be in a similar application/program). Maturation efforts in place to address new material production risks for technology demonstration.	Material maturity verified through technology demonstration articles. Preliminary material specifications in place. Material properties adequately characterized.	Material maturity sufficient for pilot line build. Material specifications approved.	Materials proven and validated during EMD as adequate to support LRIP. Material specifications stable.	Materials controlled to specifications in LRIP. Materials proven and validated as adequate to support FRP.	Materials controlled to specifications in FRP.
	D.2 Availability	Global trends for material availability, obsolescence, and DMSMS surveyed and identified for research.	Material availability, obsolescence, and DMSMS gaps ~~assessed~~ identified.	Material ~~scale-up issues identified~~ availability, obsolescence, and DMSMS gap closure strategy defined.	Projected lead times identified for all difficult to obtain, difficult to process, or hazardous materials. Quantities and lead times estimated. Material availability risks and issues for preferred materiel solution considered in AoA. Mitigation plans incorporated in SEP for the preferred materiel solution.	Availability risks and issues addressed for prototype build. Significant material risks identified for all materials. Planning initiated to address scale-up issues.	Availability risks and issues addressed to meet EMD build. Long-lead items identified. Potential obsolescence issues identified. Components assessed for future DMSMS risk.	Availability risks and issues addressed to meet LRIP builds. Long lead procurements identified and mitigated. Obsolescence plan in place. DMSMS mitigation strategies for components in place.	Availability risks and issues managed for LRIP. Long lead procurement initiated for LRIP. Availability issues addressed to meet FRP builds.	Long lead procurement initiated for FRP. Availability risks and issues managed for FRP.	All material availability risks and issues managed.

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s (Raw Materials, C	**D.3 Supply Chain Management**	Global trends for supply chain capability and capacity surveyed.	Potential supply chain capability and capacity gaps identified.	~~Initial assessment of potential~~ Supply chain capability and capacity gap closure strategies defined.	Survey ~~for~~ of potential supply chain sources for preferred materiel solution completed. Supply chain capability and capacity analyses considered in the AoA.	Potential supply chain sources identified and evaluated as able to support prototype build.	Lifecycle Supply Chain requirements updated. Critical suppliers list updated. Supply chain plans in place (e.g. teaming agreements, etc.) supporting an EMD contract award.	Effective supply chain management processes defined, documented, and in place. Plan developed for predictive indicators. Assessment of critical first tier supply chain completed (i.e., capability, capacity, etc.).	Assessment of critical second and lower tier supply chain completed. Robust requirements flow down processes in place and verified. Supplier compliance with program requirements and changes validated. Plan for predictive indicators for use in production updated. Supply chain adequate to support LRIP.	Long term agreements in place where practical. Prime's supplier management metrics (including thresholds and goals) in place and used to manage risks. Predictive indicators to manage suppliers in place. Supply chain is stable and adequate to support FRP.	Supply chain proven and supports FRP requirements.

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D - Materials	**D.4 Special Handling (i.e. GFP, shelf life, security, hazardous materials, storage environment, ESH, etc.)**	Hazardous materials identified and safety procedures in place.	~~Initial evaluation of potential regulatory requirements and special handling concerns.~~ Raw materials and components assessed for special handling and potential regulatory requirements.	ESH compliance risk identified. List of hazardous materials identified and alternatives evaluated. Special handling procedures applied in the lab. Special handling concerns assessed.	ESH compliance risk mitigated in lab environment. List of hazardous materials updated and alternatives assessed. Special handling procedures applied and disposal procedures evaluated. Special handling requirements identified, analyzed, and documented in the SEP.	ESH requirements and special handling procedures applied in production relevant environment. Special handling requirement gaps identified. New special handling processes demonstrated in lab environment.	ESH requirements addressed and documented. Special handling procedures demonstrated in production relevant environment. Plans to address special handling requirement gaps, risks, and issues complete. Manufacturing assessed for material storage and waste handling risks.	ESH compliance demonstrated in production representative environment. Special handling procedures applied in production representative environment. Special handling procedures developed and annotated on work instructions for pilot line. Hazardous material storage and disposal plan in place for the pilot line.	ESH compliance demonstrated in pilot line production. Special handling procedures applied in pilot line environment and demonstrated in EMD or technology insertion programs. Special handling risks and issues managed for LRIP. All work instructions contain special handling provisions as required. Hazardous material storage and disposal plan evaluated and in place for LRIP.	ESH compliance demonstrated in LRIP. Special handling, and hazardous material storage and disposal procedures demonstrated in LRIP environment. Special handling, and hazardous material storage and disposal risks and issues managed for FRP.	ESH compliance demonstrated in FRP. Special handling and hazardous material storage and disposal procedures effectively implemented in FRP.
E - Process Capability & Control	**E.1 Modeling & Simulation (Product & Process)**	Modeling and simulation approaches/tools identified to support manufacturing and quality activities.	~~Initial models developed, if applicable.~~ Modeling and simulation development initiated.	~~Identification of proposed manufacturing concepts or producibility needs based on high-level process flow chart models.~~ Manufacturing and quality gaps for system concepts identified using modeling and simulation.	~~Production~~ Modeling ~~&~~and simulation ~~approaches for process or product are identified.~~ tools utilized to define manufacturing and quality requirements for preferred materiel solution. Modeling and simulation results considered in the AoA.	Initial modeling & simulations (product or process) developed at the component level and used to determine constraints.	Initial modeling & simulations developed at the sub-system or system level, and used to determine system constraints.	Modeling & simulations used to determine system constraints and to identify improvement opportunities.	Modeling & simulations verified by pilot line build. Results used to improve process and demonstrate that LRIP requirements can be met.	Modeling & simulations verified by LRIP build, assist in management of LRIP, and demonstrate that FRP requirements can be met.	Modeling & simulations verified by FRP build. Production simulation models used as tools to assist in management of FRP.
	E.2 Manufacturing Process Maturity	Hypotheses developed regarding cause-effect relationships between process variables and process stability and repeatability.	Studies performed to test hypotheses regarding cause-effect relationships. ~~Identification of material and/or~~ Initial process approaches identified.	~~Document high level manufacturing processes. Critical manufacturing processes identified through experimentation.~~ Cause-effect relationships between process control variables and process stability and repeatability validated through laboratory experiments. Critical process control variables identified.	~~Survey to determine the current state of critical processes completed~~. Maturity of critical processes for preferred materiel solution assessed. Process capability requirements and improvement plans developed and documented in the SEP.	Process Maturity assessed on similar processes in production. Process capability requirements identified for pilot line, LRIP and FRP.	Manufacturing processes demonstrated in production relevant environment. Collection or estimation of process capability data from prototype build and refinement of process capability requirements initiated.	Manufacturing processes demonstrated in a production representative environment. Collection and/or estimation of process capability data and refinement of process capability requirements ongoing.	Manufacturing processes for LRIP verified on a pilot line. Process Capability data from pilot line meets target. Process capability requirements for LRIP and FRP refined based upon pilot line data.	Manufacturing processes are stable, adequately controlled, capable, and have achieved program LRIP objectives. Variability experiments conducted to show FRP impact and potential for continuous improvement.	Manufacturing processes are stable, adequately controlled, capable, and have achieved program FRP objectives.
	E.3 Process Yields and Rates	Hypotheses developed regarding future state manufacturing yields and rates.	Studies performed to test hypotheses regarding yields and rates.	Initial estimates of yields and rates for system concepts identified through laboratory ~~based on~~ experiments ~~or state of the art~~. Yield and rate gaps for system concepts identified.	Yield and rate assessments on preferred materiel solution ~~proposed/similar processes~~ completed and ~~applied within~~ considered in the AoA. Yield and rate gap closure strategies identified for the preferred materiel solution and documented in the SEP.	Target yields and rates established for pilot line, LRIP, and FRP. Yield and rate issues identified. Improvement plans developed/initiated.	Yields and rates from production relevant environment evaluated against targets and the results feed improvement plan.	Yields and rates from production representative environment evaluated against pilot line targets and the results feed improvement plans.	Pilot line targets achieved. Yields and rates required to begin LRIP refined using pilot line results. Improvement plans ongoing and updated.	LRIP yield and rate targets achieved. Yields and rates required to begin FRP refined using LRIP results. Yield improvements on-going.	FRP yield and rate targets achieved. Yield improvements on-going.
F - Quality	**F.1 Quality Management**	Quality management considerations surveyed and included in early planning activities	Quality management needs assessed, analyzed, and validated.	Quality management requirements for system concepts identified.	Quality strategy ~~identified as part of the AS and included in SEP.~~ for the preferred materiel solution developed, considered in the AoA, and documented in the SEP and the AS.	Quality strategy updated to reflect KC identification activities.	Initial Quality Plan and QMS are in place. Quality risks, issues, and metrics have been identified and improvement plans initiated.	Quality targets established. QMS elements (i.e., control of nonconforming material, corrective action, etc.) meet requirements of appropriate industry standards. Program-specific Quality Program Plan developed.	Program-specific Quality Program Plan established. Program Quality Manager assigned. Quality targets assessed against pilot line, results feed continuous quality improvements.	Quality targets verified on LRIP line. Continuous quality improvement on-going. Management review of Quality measures conducted on regular basis and appropriate actions taken.	Quality targets verified on FRP line. Continuous quality improvement on-going. Statistical controls applied where appropriate.
	F.2 Product Quality	Quality metrology state of the art surveyed. Hypotheses developed regarding cause-effect relationships between technology variables and quality.	Studies performed to test hypotheses regarding cause-effect relationships between technology variables and quality. Elements identified which have a potential impact on quality (i.e., materials, processes, capabilities, limitations).	System concept elements evaluated for quality using experiments, modeling and simulation. Initial product quality requirements, risks, and issues identified. Inspection technologies identified.	Product quality requirements and the inspection and acceptance testing strategy for the preferred materiel solution ~~identified identified as part of the AS and included in SEP.~~ considered in AoA and documented in the AS. Product quality risk and issue mitigation plans documented in the SEP.	Roles and responsibilities identified for acceptance test procedures, in-process and final inspections, and statistical process controls for prototype units.	KC management approach defined. Initial requirements identified for acceptance test procedures and in-process and final inspection requirements for EMD units. Appropriate inspection and acceptance test procedures identified for prototype units.	Quality data from the production representative environment collected and analyzed and results used to shape improvement plans. Control plans completed for management of KCs. Test and Inspection plans being developed for EMD units.	KCs managed. Measurement procedures and controls in place (e.g. SPC, FRACAS, audits, customer satisfaction, etc.). Pilot line data meets capability requirements for all KCs. Test and Inspection plans complete and validated for production units.	Data from LRIP demonstrates production processes, for all KCs and other manufacturing processes critical to quality, are capable and under control for FRP.	KCs controlled at rate. Results achieve targeted statistical level on all KCs. Results reflect continuous improvement.
	F.3 Supplier Quality/ Management	Supplier quality and quality management systems state of the art surveyed.	Initial supplier quality and quality management systems evaluated.	Supplier quality and quality management system requirements for system concepts identified.	Potential supplier ~~base~~ quality capabilities, risks, and issues identified for the preferred materiel solution, including subtier suppliers ~~quality management~~. Supplier quality management system requirements defined, and documented in the AS.	Supply base quality capabilities and risks identified, including subtier supplier quality management.	Supply base quality improvement initiatives identified addressing supplier QMS shortfalls, including subtier supplier quality management.	Key supplier QMSs meet appropriate industry standards. Supplier quality data from production representative units collected and analyzed. Strategy for audits of critical supplier processes outlined.	Supplier program-specific QMSs adequate. Supplier products qualification testing and first article inspection completed. Acceptance testing of supplier products adequate to begin LRIP. Plan for subcontractor process audits in place and implemented by prime contractor.	Supplier quality management of KCs and other critical manufacturing processes demonstrates capability and control for FRP. Acceptance testing of supplier products reflects control of quality adequate to begin FRP. Subcontractor quality audits performed as necessary to ensure subcontractor specification compliance.	Supplier quality data reflects adequate management of KCs and control of critical manufacturing processes, including quality management down to subtier suppliers. Results achieve high statistical level (e.g., 6-sigma) on all critical dimensions. Subcontractor quality audits performed as necessary to ensure subcontractor specification compliance.
G - Manufacturing Workforce (Engineering & Production)	**G.1 Manufacturing Workforce (Engineering & Production)**	Workforce skill sets to support emerging trends in manufacturing and technology surveyed.	Workforce skill sets to support emerging trends in manufacturing and technology evaluated.	~~New manufacturing skills identified.~~ Workforce skill set requirements for system concepts identified. Workforce skill set capability gaps identified.	~~Manufacturing~~ Workforce skill sets ~~identified and production workforce~~ requirements ~~(technical and operational)~~ for the preferred materiel solution identified and considered in the ~~evaluated as part of~~ AoA. Workforce training and development requirements to close skill set gaps defined. Availability of ~~process development~~ workforce for TMRR Phase determined.	Skill sets identified and plans developed to meet prototype and production needs. Special skills certification and training requirements established.	Manufacturing workforce skills available for the production relevant environment. Resources (quantities and skill sets) identified and initial plans developed to achieve requirements for pilot line and production.	Manufacturing workforce resource requirements identified and plans developed to achieve pilot line requirements. Plans to achieve LRIP workforce requirements updated. Pilot line workforce trained in production representative environment.	Manufacturing workforce resource requirements identified and plans developed to achieve LRIP requirements. LRIP personnel trained on pilot line where possible. Plans to achieve FRP workforce requirements initiated based on pilot line.	LRIP personnel requirements met. Plan to achieve FRP workforce requirements implemented.	FRP personnel requirements met. Production workforce skill sets maintained in spite of workforce attrition.
H - Facilities	**H.1 Tooling/STE/SIE**	State of the art tooling, test and inspection equipment surveyed.	Potential tooling, STE, and SIE requirements identified.	Tooling, STE, and SIE requirements and gaps for system concepts identified.	Tooling/STE/SIE requirements for the preferred materiel solution ~~are~~ considered as part of AoA.	Tooling and STE/SIE requirements identified with supporting rationale and schedule.	Prototype tooling and STE/SIE concepts demonstrated in production relevant environment. Requirements development efforts for production tooling and STE/SIE complete.	Design and development efforts for production tooling and STE/SIE initiated with STE/SIE validation plans complete. Manufacturing equipment maintenance strategy developed.	Tooling, test and inspection equipment proven on pilot line and additional requirements identified for LRIP. STE/SIE validated as part of pilot line validation IAW validation plan. Manufacturing equipment maintenance demonstrated on pilot line.	All tooling, test and inspection equipment proven in LRIP and additional requirements identified for FRP. Manufacturing equipment maintenance schedule demonstrated. STE/SIE validation maintained as necessary.	Proven tooling, test and inspection equipment in place to support maximum FRP. Planned equipment maintenance schedule achieved. STE/SIE validation maintained as necessary.
	H.2 Facilities	Current facility capabilities and capacity surveyed.	Potential facility capabilities and capacity requirements identified.	~~Specialize~~ Facility capabilities and capacity requirements~~/needs~~ and gaps for system concepts identified.	Capability and availability of manufacturing facilities for prototype development and production of the preferred materiel solution evaluated ~~as part of~~, included in the AoA, and documented in the AS and SEP. Human factors & ergonomics and safety requirements for manufacturing (personnel, processes & equipment) identified.	Manufacturing facilities identified and plans developed to produce prototypes. Human factors & ergonomics and safety requirements for manufacturing (personnel, processes & equipment) assessed.	Manufacturing facilities identified and plans developed to produce pilot line build. Human factors & ergonomics and safety requirements for manufacturing (personnel, processes & equipment) verified in a production relevant environment.	Manufacturing facilities identified and plans developed to produce LRIP build. Human factors & ergonomics and safety practices for manufacturing (personnel, processes & equipment) validated in a production representative environment.	Pilot line facilities demonstrated. Manufacturing facilities adequate to begin LRIP. Plans in place to support transition to FRP. Workplace safety is adequate. Human factors & ergonomics and safety practices for manufacturing (personnel, processes & equipment) demonstrated on a pilot line.	Manufacturing facilities in place and demonstrated in LRIP. Capacity plans adequate to support FRP. Human factors & ergonomics and safety practices for manufacturing (personnel, processes & equipment) demonstrated in LRIP .	Production facilities in place and capacity demonstrated to meet maximum FRP requirements. Human factors & ergonomics and safety requirements for manufacturing (personnel, processes & equipment) demonstrated in FRP.
I - Manufacturing Management	**I.1 Manufacturing Planning & Scheduling**	Manufacturing management considerations surveyed and included in early planning activities.	Manufacturing management needs assessed, analyzed and validated.	Manufacturing management requirements for system concepts identified.	Manufacturing strategy for the preferred materiel solution developed, considered in the AoA, and documented in ~~integrated with~~ the AS. Prototype schedule risk mitigation efforts ~~incorporated into the AS~~ documented in the SEP.	Manufacturing strategy refined based upon preferred concept. Prototype schedule risk mitigation efforts initiated.	Initial manufacturing approach developed. All system design related manufacturing events included in IMP/IMS. Manufacturing risk, and issue mitigation approach for pilot line and/or technology insertion programs defined.	Initial Manufacturing Plan developed and included in IMP/IMS. Manufacturing risks and issues integrated into mitigation plans. Initial work instructions developed. Effective production control system in place to support pilot line.	Manufacturing Plan updated for LRIP. All manufacturing risks and issues identified and assessed with approved mitigation plans in place. Work instructions finalized. Effective production control system in place to support LRIP.	Manufacturing plan updated for FRP. All manufacturing risks and issues managed. Effective production control system in place to support FRP.	All manufacturing risks and issues managed.
	I.2 Materials Planning	Materials planning state of the art surveyed.	Initial availability, lead time, handling and storage requirements for potential materials and components evaluated.	Materials and components list for system concepts developed. Initial materials planning requirements (i.e., availability, lead times, handling, and storage) identified.	~~Technology development article component list developed with associated lead time estimates.~~ Materials and components list for the preferred materiel solution with estimates for availability, lead times, handling and storage requirements developed and considered in the AoA.	Make/buy evaluations initiated and include production considerations for pilot line, LRIP, and FRP needs. Lead times and other materials risks and issues identified.	Most material make/buy decisions complete, material risks and issues identified, and mitigation plans developed. BOM initiated.	Make/Buy decisions and BOM complete for pilot line build. Material planning systems in place for pilot line build.	Make/Buy decisions and BOM complete to support LRIP. Material planning systems proven on pilot line for LRIP build.	Make/Buy decisions and BOM complete to support FRP. Material planning systems proven in LRIP and sufficient for FRP.	Material planning systems validated on FRP build.