

Manufacturing Readiness Levels (MRL 1–10)

Research & Development

MRL 1 – Basic manufacturing implications identified.

Lowest level of readiness. Manufacturing challenges and opportunities are recognized during early research. Activities are limited to studies and theoretical analysis.

MRL 2 – Manufacturing concepts identified.

Concepts for manufacturing approaches are described. Applied research begins translating basic research into potential solutions. Feasibility and risk are emerging.

MRL 3 – Manufacturing proof of concept developed.

Validation of concepts starts through lab experiments or analysis. Materials and processes are characterized for manufacturability. Experimental hardware may exist with limited functionality.

MRL 4 – Capability to produce technology in a laboratory environment.

Processes and resources are sufficient to build technology demonstrators in a lab setting. Risks and mitigation plans are identified. Target cost objectives and producibility assessments are established.

MRL 5 – Capability to produce prototype components in a production-relevant environment.

Prototype components can be produced under conditions that simulate aspects of production. Industrial base is assessed, and manufacturing strategy refined. Cost models developed.

Production & Deployment

MRL 6 – Capability to produce a prototype system or subsystem in a production-relevant environment.

Preliminary system design is accepted. Most manufacturing processes are defined and characterized. Prototype systems or subsystems can be built under near-production conditions.

MRL 7 – Capability to produce systems, subsystems, or components in a production-representative environment.

Detailed design is nearly complete. Manufacturing processes and procedures are demonstrated in an environment that closely resembles actual production. Supply chain plans are in place.

MRL 8 – Pilot line capability demonstrated; ready for Low Rate Initial Production (LRIP).

System design is stable and ready for LRIP. All materials, tooling, facilities, and personnel are proven on a pilot line. Manufacturing and quality processes are under control.

MRL 9 – Low rate production demonstrated; capability in place for Full Rate Production (FRP).

System has successfully achieved LRIP and is ready for FRP. Design changes are minimal. All resources and processes meet production requirements. Cost targets validated.

MRL 10 – Full rate production demonstrated and lean practices in place.

Highest level of readiness. System is in full-rate production and meets all performance, quality, and reliability requirements. Lean practices and continuous improvement are established.