

Appendix A

NASA TECHNOLOGY READINESS LEVELS

The following is the description of the Technology Readiness Levels presented in the TPF Technology plan [Lindensmith, 2003]:

Technology Readiness Levels (TRLs) are a systematic metric/measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology. The TRL concept is based on a general model for technology maturation that includes: (a) research in new technologies and concepts (targeting identified goals, but not necessary specific systems), (b) technology development addressing specific technologies for one or more potential identified applications, (c) technology development and demonstration for each specific application before the beginning of full system development of that application, (d) system development (through first unit fabrication), and (e) system 'launch' and operations.

TRL 1: Basic principles observed and reported

Transition from scientific research to applied research. Essential characteristics and behaviors of systems and architectures. Descriptive tools are mathematical formulations or algorithms.

TRL 2: Technology concept and/or application formulated

Applied research. Theory and scientific principles are focused on specific application area to define the concept. Characteristics of the application are described. Analytical tools are developed for simulation or analysis of the application.

TRL 3: Analytical and experimental critical function and/or characteristic proof-of-concept

Proof of concept validation. Active Research and Development (R&D) is initiated with analytical and laboratory studies. Demonstration of technical feasibility using breadboard or brassboard implementations that are exercised with representative data.

TRL 4: Component/subsystem validation in laboratory environment

Standalone prototyping implementation and test. Integration of technology elements. Experiments with full-scale problems or data sets.

TRL 5: System/subsystem/component validation in relevant environment

Thorough testing of prototyping in representative environment. Basic technology elements integrated with reasonably realistic supporting elements. Prototyping implementations conform to target environment and interfaces.

TRL 6: System/subsystem model or prototyping demonstration in a relevant end-to-end environment (ground or space)

Prototyping implementations on full-scale realistic problems. Partially integrated with existing systems. Limited documentation available. Engineering feasibility fully demonstrated in actual system application.

TRL 7: System prototyping demonstration in an operational environment (ground or space)

System prototyping demonstration in operational environment. System is at or near scale of the operational system, with most functions available for demonstration and test. Well integrated with collateral and ancillary systems. Limited documentation available.

TRL 8: Actual system completed and "mission qualified" through test and demonstration in an operational environment (ground or space)

End of system development. Fully integrated with operational hardware and software systems. Most user documentation, training documentation, and maintenance documentation completed. All functionality tested in simulated and operational scenarios. Verification and Validation (V&V) completed.

TRL 9: Actual system "mission proven" through successful mission operations (ground or space)

Fully integrated with operational hardware/software systems. Actual system has been thoroughly demonstrated and tested in its operational environment. All documentation completed. Successful operational experience. Sustaining engineering support in place.

