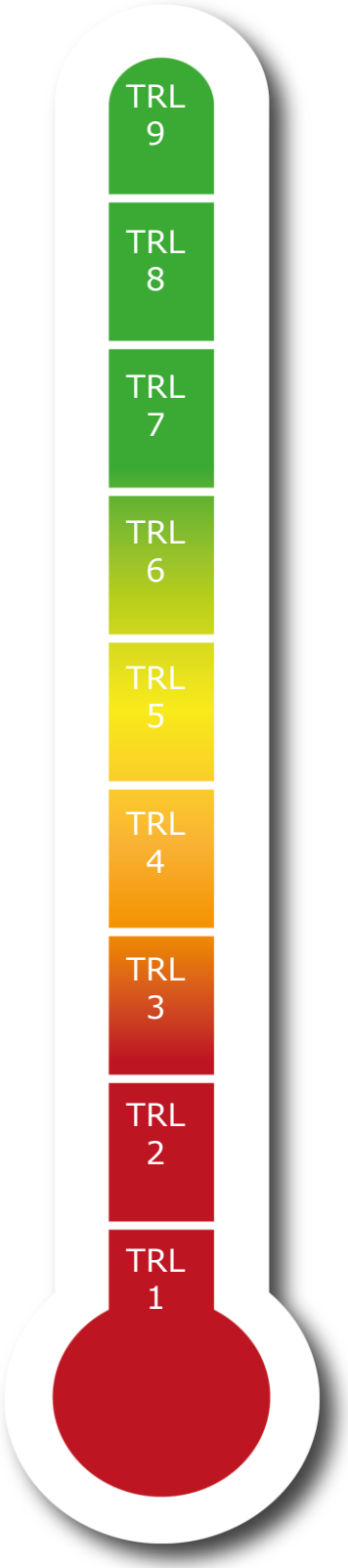
Technology Readiness Level – TRL



TRL 9	Actual Technology system proven in operational environment
TRL 8	Actual Technology system completed and qualified through test and demonstration
TRL 7	Technology prototype demonstration in an operational environment
TRL 6	Technology demonstration in a relevant environment
TRL 5	Technology validation in relevant environment
TRL 4	Technology validation in laboratory
TRL 3	Analytical and experimental proof-of-concept of critical function and/or characteristics
TRL 2	Technology concept and/or application formulated
TRL 1	Basic principles observed

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Level	Description
9	- Actual application of the technology in its final form and under mission/operational conditions, such as those encountered in operational test and evaluation. Technology is ready for commercial deployment. - Software: readily repeatable and reusable. The software based on the technology is fully integrated with operational hardware/software systems. All software documentation verified. Successful operational experience. Sustaining software engineering support in place.
8	- Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development - Software fully integrated with operational hardware and software systems, development documentation is complete. All functionality tested in simulated and operational scenarios.
7	- Prototype near or at planned operational system. Requiring demonstration of an actual system prototype in an operational environment (e.g., in an aircraft, in a vehicle, or in space). Normally only performed when the technology and/or subsystem is mission critical and relatively high risk. - Critical technological properties are measured against requirements in an operational environment. - Readiness in an operational environment requires evidence of the acceptable performance under operational factors, including, for example for a software system loading, user interaction, security etc.
6	- Representative model or prototype system, tested in a relevant environment. Represents a major step up and requires evidence of performance on full-scale, realistic problems. - For software: level at which the engineering feasibility of a software is demonstrated. This level extends to laboratory prototype implementations on full-scale realistic problems in which the software technology is partially integrated with existing hardware/software systems. - Examples: testing a prototype in a high-fidelity lab environment or simulated operational environment.
5	- Basic technological components integrated with reasonably realistic supporting elements so they can be tested in a simulated environment. Fidelity of breadboard technology increases significantly. - Integrated components provide a representation of a system/subsystem for to determining concept feasibility and to develop technical data. Lab use to validate the technical principles of interest. - Software: Module and/or subsystem validation in relevant environment. Ready to start integration with existing system, conforms to target environment/interfaces. System software architecture established and all components and elements affecting the operation of the critical software element. - Examples: a new type of solar photovoltaic material promising higher efficiencies used in an actual fabricated solar array that would be integrated with power supplies, supporting structure, etc., and tested in a thermal vacuum chamber with solar simulation capability.
4	- Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared with the eventual system. System concepts considered and results from testing laboratory scale breadboard(s). Only limited and initial information about the end product function. - Software: module and/or subsystem validation in a laboratory environment (i.e. software prototype development environment). Basic software components are integrated to establish that they will work together. Architecture development initiated (e.g. interoperability, reliability). - Example: demo of a 'fuzzy logic' approach to avionics by testing algorithms in a partially computer-based, partially bench-top components to demo in a controls lab using simulated vehicle inputs.
3	- Active R&D is initiated to develop the technology/product further.. Analytical studies and laboratory-based or experimental studies are performed to physically validate that analytical predictions are correct. Lab tests are performed to measure parameters of interest and compare to analytical predictions. - Software: limited functionality environments to validate critical properties/analytical predictions using non-integrated software components and partially representative data. - Example: super-cooled hydrogen as a propellant where the concept-enabling temperature/pressure for the fluid was achieved in a lab. Software algorithms run on a surrogate processor in lab environment.
2	- The potential technology/product concept is defined and described. - Practical applications can be defined/ researched but are speculative and no proof or detailed analysis. - Software: analytic studies, studies on synthetic date, small code units - Example: observation of high critical temperature superconductivity, potential applications of the new material in instruments (e.g. telescope sensors) defined.
1	- Published research that identifies the basic principles that underlie a technology. - Scientific research begins to be translated into more applied research and development. - Example: studies of basic properties e.g. tensile strength as a function of temperature for a new material