A comprehensive view of TRLs, R&D&I, definitions and adaptation to phama, hardware, software and machine learning projects.

	TRLs	Description	*Fit to R&D&i definitions* (a)	*Validation environment*	*Deployment status or availability in the market*	*Pharmaceutical industries***	*Hardware and system technologies***	*Software projects***	*Machine Learning projects***
technology Transference	9	***Actual system proven through successful mission operation***	innovation	real environment	Full deploy	Drug distributed and marketed	Product on market	Software fully available	Deployment. Need to monitor the current version and explicit considerations towards improving the next version.
	8	***Actual system completed and qualified through test and demonstration***			Product, process or service has valid certification(s), fulfils legal requirements and can be marketed (**minimum viable product** -MVP-)	New drug registration	Pre-serial manufacturing	All functionalities of the new software have been simulated and tested in realistic scenarios	Mission-ready. The technology is demonstrated to work in its final form and under expected conditions
	7	***System prototype demonstration in an operational environment***	development		Technological development to reach a valid prototype or demo design.	Phase 2 clinical trials	Approved prototype	Software ready for demonstration and testing within operational HW/SW systems	Integrations. Integrating the technology into existing production systems
knowledge valorisation	6	***System/subsystem model or prototype demonstration in a relevant environment***		simulation environment		Phase 1 clinical trials	Prototype tested in relevant environment	Software ready to be integrated into existing systems, and the algorithms can be executed on processors with characteristics similar to those found in an operating environment	Application Development. Significant software engineering to bring the code up to product-caliber
	5	***Component and/or breadboard validation* in laboratory environment***				Pilot drug produced	Pre-prototype tested in lab	Software is ready to be integrated into existing systems, and the algorithms can be executed on processors with characteristics similar to those of an operating environment	Machine learning "capability". The technology is more than an isolated model or algorithm, it is a specific capability
	4	***Component and/or breadboard validation* in laboratory environment***		laboratory environment/scale		Demonstrate proof of concept	Pre-prototype	The various components of the core software are starting to be integrated to demonstrate their ability to function interdependently	Proof of Concept (PoC) development. This stage is the seed of application-driven development
	3	***Analytical and experimental critical function and/or characteristic proof of concept***	research		Proof-of-concept Industrial research Basic research	Design proof of concept	Proof of concept	The feasibility of the new software begins to be demonstrated through analytical studies and laboratory experiments	System development. Includes checkpoints that push code development towards interoperability, reliability, maintainability, extensibility, and scalability
	2	***Technology concept and/or application formulated***				Research idea	Analytical study	Research into the potential practical applications of the new software begins, although the potential applications are still speculative	Proof of Principle (PoP) development. Active R&D is initiated, mainly by developing and running in testbeds: simulated environments and/or simulated data that closely matches the conditions and data of real scenarios
	1	***Basic principles observed (either reported or privately held)***				Findings reviewed	Define basic properties	research on a new software domain at the basic research level. This level includes the development of basic uses as well as the basic properties of the software architecture, mathematical formulations, and general algorithms.	Goal-oriented research. Progress from basic principles to practical use, we design and run low-level experiments to analyse specific model or algorithm properties

About the author: linkedin.com/in/jucasado **(a)** The limits and boundaries of these definitions are not always easy to stablish, these are approximations for general use. * The term 'breadboard validation' in the original classification refers to the fact that at this level, **modifications can be easily made at the component level**. ** https://euraxess.ec.europa.eu/career-development/researchers/manual-scientific-entrepreneurship/major-steps/trl *** Adapted from TECHNOLOGY READINESS LEVELS. TRLs. Juan Miguel Ibáñez de Aldecoa Quintana. **** Adapted from DOI link: https://doi.org/10.1038/s41467-022-33128-9