

Technology Readiness Levels, Explained

By Gideon Grudo, Digital Platforms Editor

Fielding new technology is quite an undertaking—one that normally starts at universities.

Within the Air Force, agencies will identify needs that seep into the walls of classrooms and labs, where experts will study them. From there, the technological journey progresses along a path of landmarks called Technology Readiness Levels, or TRLs, ranging from one to nine, the last one denoting the collateral is ready for operational use. As each level of readiness is achieved, the technology advances, flexing its muscles and trying to overcome its next set of challenges.

Jack L. Blackhurst, Air Force Research Laboratory director of plans and programs, explained the TRL process and its real world applications.

Blackhurst said, “You’re building expectations” along the various TRLs, seeing if potential new tech looks promising. Even if the science doesn’t pan out, as with all research, negative feedback can be valuable.

“We need some way to evaluate the maturity of technology” in the acquisition process, he said. Those discussions are almost always based on TRLs.

Here, we break down for you what the official definitions of the TRLs actually mean, using a fictional aircraft rocket (let’s call it RocketX).

You’ll also find the real-life maturation from TRL 1 to TRL 6 of a solid state semiconductor, as explained by AFRL. And we have the real life maturation from TRL 7 to TRL 9 of a collision avoidance system employed on F-16s. It has already saved at least two lives.

Staff illustrations by Mike Tsukamoto

TRL 1

Definition

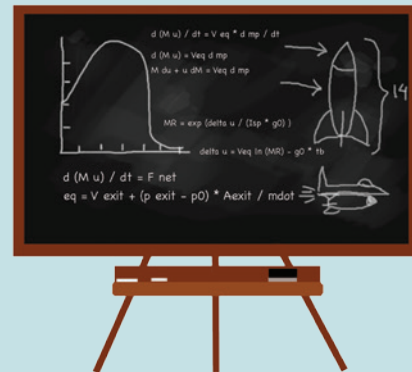
Basic principles observed and reported.

What That Means

Chemistry and physics theory in an academic setting. Think chalked equations and bubbling beakers examining the very concept of RocketX.

USAF Example

Researched material properties for a wide-bandgap semiconductor. The idea was to make devices that can handle high voltages, high current densities, high temperatures, and fast transients.



TRL 2

Definition

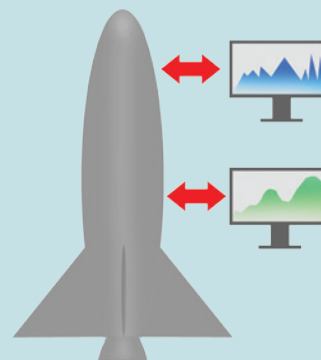
Technology concept and/or application formulated.

What That Means

It’s time to see if the theory behind RocketX works. A lab takes the research and puts it into capabilities testing.

USAF Example: SSCB

Conceptual circuits for a solid state circuit breaker (SSCB) are designed and analyzed.



TRL 5

Definition

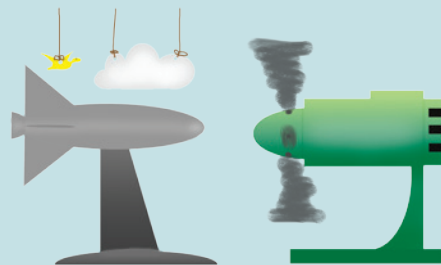
Component and/or breadboard validation in a relevant environment.

What That Means

The tests get real. RocketX is exposed to real life conditions.

USAF Example: SSCB

Tested a brassboard SSCB panel in a laboratory ground demonstration with simulated aircraft circuits.



TRL 6

Definition

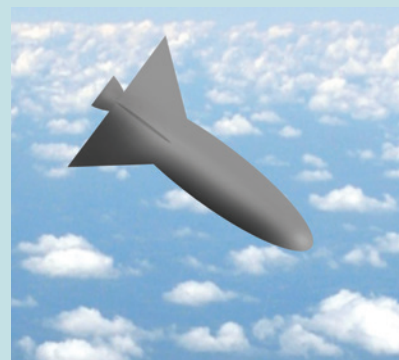
System/subsystem model or prototype demonstration in a relevant environment.

What That Means

AFRL is confident in RocketX and pushes for the fuel to be developmentally and operationally tested.

USAF Example: SSCB

Flight tested the SSCB panel in an aircraft electrical power system used to protect actual aircraft circuits/equipment.



TRL 3

Definition

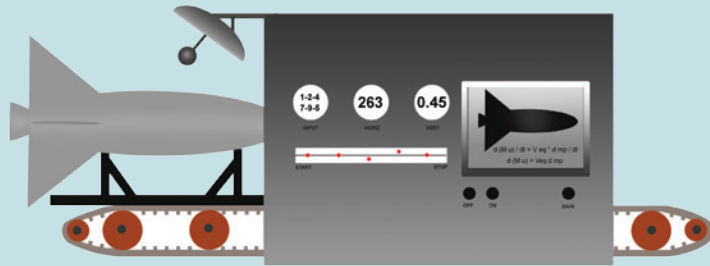
Analytical and experimental critical function and/or characteristic proof of concept.

What That Means

AFRL might investigate if RocketX has an Air Force application. It may even fabricate a prototype of the rocket and run it through tests.

USAF Example: SSCB

Fabricated and successfully tested an SSCB capable of fast fault detection and interruption.



TRL 4

Definition

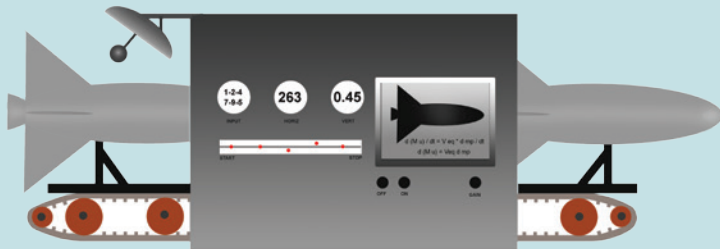
Component and/or breadboard validation in a laboratory environment.

What That Means

We've reached low fidelity testing on RocketX. The technology will be produced en masse sufficient for meaningful results.

USAF Example: SSCB

Built and tested an SSCB panel.



TRL 7

Definition

System prototype demonstration in an operational environment.

What That Means

RocketX is installed and tested on various aircraft. The idea is to build yet more confidence by placing the rocket in a place where humans rely on it.

USAF Example: Auto-GCAS

Installed Automatic Ground Collision Avoidance System (Auto-GCAS) software on an F-16 and completed 103 flights to prove it would protect against a majority of controlled flight into terrain mishaps and allow nuisance-free operation.

TRL 8

Definition

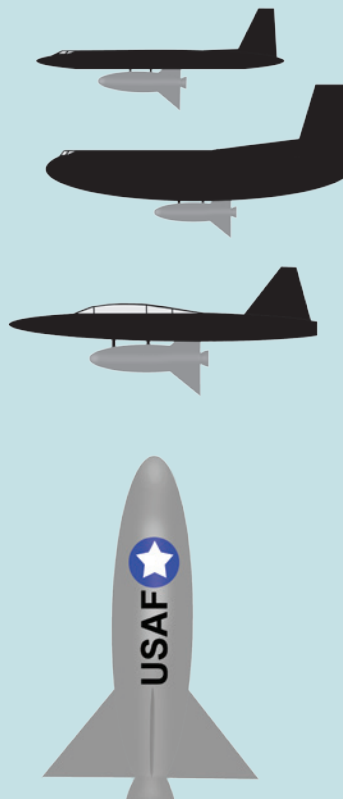
Actual system completed and qualified through test and demonstration.

What That Means

After testing RocketX on various aircraft, USAF decides this new technology is "the right way to go" and installs it on aircraft.

USAF Example: Auto-GCAS

F-16 program completed integration and test of the Auto-GCAS system for installation on operational aircraft.



TRL 9

Definition

Actual system proved through successful mission operations.

What That Means

Under actual mission conditions, RocketX proves itself worthy of passing all nine TRLs.

USAF Example: Auto-GCAS

Auto-GCAS was fielded on Block 40/50 F-16s in fall 2014. System was integrated on more than 600 Block 40/50 F-16s and has saved at least two pilots' lives since.

