

Fuel Readiness Level (FRL)

FRL	Description	Toll Gate	Fuel Quantity+
1	Basic Principles Observed and Reported	Feedstock /process <i>principles</i> identified.	
2	Technology Concept Formulated	Feedstock / <i>complete</i> process identified.	
3	Proof of Concept	Lab scale fuel sample produced from realistic production feedstock. Energy balance analysis executed for initial environmental assessment. Basic fuel properties validated.	0.13 US gallons (500 ml)
4.1 4.2	Preliminary Technical Evaluation	System performance and integration studies entry criteria/specification properties evaluated (MSDS/D1655/MIL 83133)	10 US gallons (37.8 litres)
5	Process Validation	Sequential scaling from laboratory to pilot plant	80 US gallons (302.8 litres) to 225,000 US gallons (851,718 litres)
6	Full-Scale Technical Evaluation	Fitness, fuel properties, rig testing, and engine testing *	80 US gallons (302.8 litres) to 225,000 US gallons (851,718 litres)
7	Fuel Approval	Fuel class/type listed in international fuel standards**	
8	Commercialization Validated	Business model validated for production airline/military purchase agreements – Facility specific GHG assessment conducted to internationally accepted independent methodology	
9	Production Capability Established	Full scale plant operational++	

+ Quantities required for risk mitigation reference

* As referenced in ASTM approved protocols

** As listed in original equipment manufacturers' manuals for aircraft and engines

++ color coding reference Phase of development green (technology phase), yellow (qualification phase), blue (deployment phase)

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FRL Description:

The leadership of the Commercial Aviation Alternative Fuels Initiative (CAAFI) needed a way to classify and track progress on research, certification, and demonstration activities. A variety of scales were in use by CAAFI organizations including TRL (Technology Readiness Level) used by industry, NASA, and the Air Force and Manufacturing Readiness Level (MRL) used by the Air Force and others. Originally, an Airbus CAAFI representative developed a special TRL scale for fuel development, but it was a mixture of research achievements and production development. The CAAFI leadership team wanted a new fuel development scale that would allow for parallel fuel research activities and certification activities, as well as clearly showing how to transition activities between the CAAFI R&D, Certification, and Business & Economics teams. Also, CAAFI desired to show how these new Fuel Readiness Levels (FRL) mapped to the TRL and MRL scales also in use.

The leaders of the CAAFI Certification and R&D teams developed the FRL table contained in this document. It includes descriptions that are customized to fuel research and certification events and includes specific items of interest to CAAFI members, including required fuel quantities. Note that the fuel quantities listed are from CAAFI Certification guidelines, and the Air Force uses different fuel quantities in their military fuel certification process. Color coding used to show the transition points between the CAAFI R&D, Certification, and Business & Economics teams. The CAAFI teams operate with the realization that overlap will occur, with R&D leading FRL 1-5, Certification FRL 6-7, and Business & Economics FRL 8-9. Environment Team assessment requirements will also overlap with the FRL. Preliminary assignments of environmental touchpoints are reflected in steps 3 and 8.

The roadmaps and milestone databases developed and maintained by CAAFI use FRL to help organize and track the research and development milestones and the process of developing, certifying, and supplying alternative fuels to commercial aviation.

The FRL was endorsed at the United Nations' International Civil Aviation Organization (ICAO) Commercial Aviation Alternative Fuels (CAAF) meeting in Rio de Janeiro in November 2009. The outcomes of that meeting can be found at: <http://www.icao.int/CAAF2009/Docs.htm>.

For further information and details about the FRL levels, please contact us at info@caafi.org.