International Civil Aviation Organization

WORKING PAPER

CONFERENCE ON AVIATION AND ALTERNATIVE FUELS

Rio de Janeiro, Brazil, 16 to 18 November 2009

Agenda Item 2: Technological feasibility and economic reasonableness

PROPOSAL TO ADOPT A GLOBAL FUEL READINESS LEVEL (FRL) PROTOCOL

(Presented by United States)

SUMMARY

The quest for Sustainable Alternative Fuels for Aviation is providing many opportunities to multiple production processes and many different feedstocks using those processes. Synthetic Paraffinic Kerosenes from a wide range of feedstocks have now been certified. Fuels from processes as pyrolysis or feedstocks such as cellulosic materials are in their infancy for aviation use. This Working Paper presents a scale that measures the technical and production maturity of candidates under the name of Fuel Readiness Level. The proposed scale is based upon risk management processes and scales long in use by the aircraft and engine producers called Technology Readiness Level.

The conclusions for the conference are in paragraph 5 and recommendations in paragraph 6.

1. INTRODUCTION

1.1 Aviation and aerospace projects are characterized by extraordinary needs for risk management discipline as a critical tool to govern the creation of high technology products that have parallel requirements for uncompromised levels of safety and high efficiency, and that also create an acceptable environmental footprint. Owing to the high cost and need to manage risk in the complex aviation and aerospace technical and production sector, as a part of the Systems Engineering principles, a gated approach to risk management through the use of Technology Readiness Level criteria has evolved.

2. RISK MANAGEMENT IN AVIATION THROUGH THE CONCEPT OF TECHNOLOGY READINESS LEVEL

2.1 As it applies to new aircraft, engine and space system development, the technology readiness scale initially used by the United States Air Force and National Aeronautics and Space Administration in the U.S. and subsequently by the commercial sector, has been in use for decades.

2.2 This technology readiness scale is growing in use in Europe by aircraft and engine manufacturers for risk management purposes. The scale, however, does not exist in any European standards.

2.3 Together these tools are a proven means of:

a) characterizing conceptual research from the creation phase throughout the development of sub-elements and components to allow researchers to identify what phase a project is in as well as identifying potential sources of funds for that research;

b) ensuring that manufacturing is scalable to levels needed for production levels that are both economically viable and environmentally acceptable at pilot plant levels, once proven at the subscale and component level;

c) supporting the certification for air worthiness; and

d) supporting deployment across the entire industry in a manner that provides a sustainable business model.

3. TRANSITION FROM TECHNOLOGY READINESS LEVELS (TRL) FOR EQUIPMENT TO FUEL READINESS LEVELS (FRL)

3.1 In the case of alternative jet fuels, in contrast to equipment production, the risk resides in separate arenas of both the chemistry of the fuel itself and its compatibility with the aircraft product and fuelling infrastructure. For this reason, use of the existing TRL process was not deemed adequate or appropriate to address this new challenge facing the industry.

3.2 The case for a new risk management tool for fuel was initially raised by Airbus (ref. S. Remy to Future Fuels Aviation Conference in London, April of 2008) retaining the name of technology readiness levels.

3.3 During the last quarter of calendar year 2008 the United States Air Force – identifying differences between aircraft product and fuel product development from feedstocks and processes – proposed parallel technology readiness and manufacturing readiness scales.

3.4 In January of 2009 at a meeting of the Commercial Aviation Alternative Fuel Initiative (CAAFI) research and development initiative incorporating participants from both European and Air Force experts, it was agreed by CAAFI Research and Development (R&D) and Certification team sponsors that the Air Force efforts and Airbus proposal could be brought together as a single Fuel Readiness Level (FRL).

3.5 The following FRL scale is proposed for adoption by the conference as the net result of the combined factors described in 3.1 through 3.5.

FRL	Description	Toll Gate	Fuel Quantity+
1	Basic Principles Observed and Reported	Feedstock /process *principles* identified.	
2	Technology Concept Formulated	Feedstock /*complete* 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)

4. POTENTIAL USES OF FUEL READINESS LEVEL SCALE

4.1 In addition to its use as a risk management tool FRL has added potential uses as:

a) a communications tool to policy makers to establish if and when the use of fuels currently in the R&D phase can be envisioned as true production options;

b) for government agencies, laboratories, or universities to establish if and how they can participate given their organizations role in R&D; and

c) a tool to identify for private and public investment sources whether and where they should invest in deployment among all available options.

5. CONCLUSIONS

5.1 The Fuel Readiness Level scale has been developed by CAAFI sponsors and modified in consultation with a key energy supplier, an OEM stakeholder, and a fuel process technology developer. It provides a gated process to govern communication of technology maturity leading to qualification, production and, deployment readiness.

5.2 The Conference is invited to conclude that the FRL is appropriate for:

a) managing and communicating research status and development needs for R&D investors;

b) managing and communicating the readiness for airworthiness authorities and appropriate timing for complementary and required environmental assessments;

c) managing and communicating the practicality of deploying fuels for use in production aircraft, engines and aviation infrastructure; and

d) use as a process for aviation fuel development and deployment risk mitigation.

6. RECOMMENDATIONS

6.1 The conference is invited to recommend that:

a) The Fuel Readiness Level (FRL) be adopted as a best practice to govern communication of technology maturity leading to qualification, production and, deployment readiness.

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