ASSEMBLY — 40TH SESSION

TECHNICAL COMMISSION

Agenda Item 30: Other issues to be considered by the Technical Commission

HALON REPLACEMENT – CHALLENGES AND SOLUTIONS

(Presented by the International Coordinating Council of Aerospace Industries Associations)

EXECUTIVE SUMMARY

Action has been taken by the aerospace industry in line with previous agreements, to introduce halon alternatives for fire protection in aircraft and to engage stakeholders in finding solutions. The manufacturing industry has consistently worked toward these objectives and has been active in researching halon alternatives. Progress has been made in all areas, i.e. engines and auxiliary power units (APUs), hand held extinguishers and cargo compartments. Significant hurdles remain. This paper provides a status report and a summary of a recent technical assessment of potential cargo halon replacement technologies conducted by the Cargo Compartment Halon Replacement Advisory Group (CCHRAG).

Status by area:

a) with respect to engines/APUs, an industry consortium is underway and is expected to complete its work statement to select common solution(s) by late 2022;

b) with respect to cabin/cockpit handheld fire extinguishers, a solution is being implemented on new production aircraft; and

c) with respect to the cargo compartment, the industry is committed to supporting the 2024 deadline for halon replacement in cargo compartments of new type certificated aircraft with applications submitted after November 2024. The industry has conducted a technical assessment of potential technologies in order to determine if a conceptually validated halon-free fire suppression system will be available in time to meet that deadline. Assuming further development by the participants and timely government approvals, CCHRAG is optimistic that a solution will be available to meet the ICAO deadline.

Strategic Objectives:	This working paper relates to the Safety, Environmental Protection and Economic Development of Air Transport Strategic Objectives.
Financial implications:	NA
References:	Doc 10075, *Assembly Resolutions in Force (as of 6 October 2016)*

1. STATUS OF HALON ALTERNATIVES AND STAKEHOLDER ENGAGEMENT

1.1 Lavatory systems

1.1.1 For aircraft designed and produced by original equipment manufacturers (OEMs), manufactured by ICCAIA members, implementation of halon free lavatory fire protection systems has now been achieved in new type designs in accordance with Annex 8 — *Airworthiness of Aircraft*.

1.2 Cabin and flight deck handheld extinguishers

1.2.1 After nearly ten years of testing, development, multiple regulatory approvals and certification by aviation authorities, the industry is transitioning to a new environmentally preferred fire extinguishing agent, 2-BTP. Compared to the previously available alternatives, 2-BTP is the closest to a "drop-in" replacement in size and weight and does not contain any greenhouse gases or ozone depleting substances. 2-BTP extinguishers are available from two companies who are supplying to major aircraft manufacturers around the world.

1.3 Engine/APU systems

1.3.1 The civil aviation industry decided in 2013 to define common non-halon fire extinguishing solution(s) and formed the Engine/APU Halon Alternatives Research Industry Consortium (IC). In 2015, this was renamed the Halon Alternatives for Aircraft Propulsion Systems (HAAPS) consortium. The consortium consists of aircraft original equipment manufacturers (OEMs) Airbus, Boeing, Bombardier, Embraer, Textron, and the Ohio Aerospace Institute acting as administrator. Engagement with fire extinguishing suppliers and distributors, chemical companies, airline operators, engine manufacturers, universities, consultants and other stakeholders is planned.

1.3.2 The consortium has mapped out a three phase multi-year approach for alternatives development and completed Phase I (administrative start-up), with a signed Joint Collaboration Agreement (JCA) in October 2018. Phase II formally started in October 2018 has completed the initial FAA engagement, release of a design requirements document, completed supplier engagement non-technical documentation, released initial requests for information (RFIs) to prospective suppliers (firex system suppliers, firex agent suppliers, firex distributors, chemical companies), and released follow-on RFIs supporting detail review of alternatives down selected from the initial RFI engagements. Work in-progress includes definition of high level solution(s) strategy, design requirements for non-gaseous agents, performance validation, down selection criteria, regulatory requirements, certification path proposals, planning for next FAA engagement, and early development of Phase III supplier technical and non-technical engagement documentation. Phase II is expected to be complete no later than the end of October 2019 with agent down selection from the follow-on RFI candidate evaluations. Phase III will then establish supplier agreements for in-depth agent evaluation, testing, and other activities supporting final agent down selection(s) by the end of 2022.

1.4 Cargo compartment system

1.4.1 Since ICCAIA provided a status report on the work of the Cargo Compartment Halon Replacement Advisory Group (CCHRAG) at the last Assembly, the group agreed to support ICAO with periodic reviews on the status of conceptually validated aircraft cargo compartment halon replacement candidate systems taking into account the associated specific challenges to ensure the technology readiness level (TRL)(as defined by NASA) is aligned with the ICAO deadline for halon replacement in cargo compartments of new type certificated aircraft with applications submitted after November 2024.

1.4.2 In 2017, the CCHRAG met monthly to develop a technical assessment approach and met with over fifty stakeholders (fire suppression system and agent suppliers, airworthiness authorities and research institutions) to solicit participation in a questionnaire on potential cargo halon replacement technologies. In 2018, eight participants agreed to submit detailed, non-proprietary, information on nine technologies. The CCHRAG compiled the information and summarized the results in time to prepare a report for ICAO by 2019.

1.4.3 The findings of the assessment (*detailed in the Appendix*) indicate that there is at least one candidate system with prototype components for the cargo compartment that has been defined and laboratory validated (i.e. having reached TRL 4 or 5) at this time. Assuming further development by the participants and timely government approvals, ICCAIA is optimistic that a solution will be available to meet the 2024 deadline and therefore, does not propose a revised date at this time.

1.4.4 If a candidate system has not been demonstrated to be application ready (actively being worked in TRL 7) by the 41st Session of the ICAO Assembly, the reasons for not adhering to the timeline will be identified and ICCAIA will indicate the consequences on the 2024 deadline.

2. **CONCLUSION**

2.1 The aircraft manufacturing industry has established mechanisms for stakeholder engagement, essential to achieve safe, environmentally responsible and cost-effective solutions for replacement of halon. Implementation of halon replacement in handheld fire extinguishers has been initiated but was delayed due to complex agency approvals. While much work has been done, implementation of halon replacement in engine/APU fire suppression applications is dependent upon further testing and certification by regulatory authorities. These are risks in the context of timely compliance with Annex 6 and 8 Standards.

2.2 While challenges remain for cargo compartment fire suppression applications, a concerted effort involving all stakeholders under ICCAIA leadership has resulted in the identification of potential halon replacement(s) to meet the 2024 deadline.

2.3 This ICCAIA working paper conveys the manufacturing industries' assessment of halon replacement technologies for normally unoccupied cargo compartments in new aircraft types. This industry-led effort to achieve common solutions and realistic timeframes is worthy of recognition and collaboration/support by States.

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APPENDIX

ICCAIA CARGO COMPARTMENT HALON REPLACEMENT ADVISORY GROUP TECHNICAL ASSESSMENT

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1. EXECUTIVE SUMMARY

The Cargo Compartment Halon Replacement Advisory Group (CCHRAG) is committed to supporting the ICAO 2024 deadline for halon replacement in cargo compartment fire suppression for new type certification aircraft applications submitted after 28 November 2024. Recently, the group has performed a technical assessment of potential technologies in order to determine if a conceptually validated halon-free fire suppression system will be available in time to meet that deadline. Assuming further development by the participants and timely government approvals, CCHRAG is optimistic that a solution will be available to meet the ICAO deadline. However, if a candidate system has not been demonstrated to be application ready (actively being worked at Technology Readiness Level 7) one year before the 41st Session of the ICAO Assembly, ICCAIA will indicate the potential consequences with respect to the 2024 deadline.

2. INTRODUCTION

The CCHRAG was formed in 2013 to promote the advancement of halon replacements for aircraft cargo compartment fire protection and to recommend to ICAO a deadline for new type certificate airplanes to transition away from halon. After documenting all the requirements for cargo fire protection, developing a technology readiness timeline, and coordinating with numerous stakeholders (representatives from system and chemical suppliers, consultants, universities, research institutes, military, regulatory agencies, etc.) during multiple meetings, a deadline of 2024 was recommended and accepted at the 2016 ICAO General Assembly. Upon the adoption of the deadline, ICAO requested that the CCHRAG continue to promote replacements and periodically report back on its progress.

In May 2017, the CCHRAG held a meeting in Cologne, Germany with numerous stakeholders to introduce a plan to conduct a technical assessment (TA) of potential cargo compartment halon replacement technologies. The assessment would be used to report to the 2019 ICAO Assembly on progress toward meeting the new 2024 deadline for cargo halon replacement.

As a result of the stakeholder meeting, eight organizations offered to participate (participants) and completed a data collection spreadsheet with information on their respective technologies. Because one participant submitted information on two different technologies, a total of nine technologies were assessed. Follow up teleconferences were held with each of the participants to provide status on the assessment, answer questions, and/or collect additional information.

Throughout the assessment, no proprietary information was submitted and the participant's identities remained anonymous. Moreover, the assessment does not recommend any specific technologies, but provides a review of the current technologies against the previously identified requirements and their status against the technology readiness timeline.

Among the technologies are three chemical agents, multiple inerting gas agents (solid propellant and onboard gas generators, tanked) and two combined (water and gas, foam and gas).
Information on each technology was documented on a spreadsheet listing over 30 different criteria related to firefighting performance, physical properties, environmental, health & safety, production and schedule requirements. The participants indicated if their technology had met the criteria (was "compliant") and/or provided notes with status or more details. Because the wide variety of responses and varying degrees of compliance, the CCHRAG members voted amongst themselves on the top ten criteria to reduce the complexity of the final assessment. The following sections summarize that assessment.

3. FIREFIGHTING PERFORMANCE

3.1 OVERVIEW

The technical assessment of the firefighting performance properties of the extinguishing agent was covered by the following items:

- cup burner fire extinction/suppression concentration established (ISO, NFPA);
- other industry Standards met (UL, ANSI, NFPA, etc.);
- FAA Minimum Performance Standard for Aircraft Cargo Compartment Halon Replacement Fire Suppression Systems (Ref. DOT/FAA/TC-TN12/11 - May 2012) (MPS) testing concentration determined; and
- test method determined to demonstrate compliance with 14CFR paragraph 25.851(b)(2).

3.2 IDENTIFICATION OF KEY CRITERIA

Some of these criteria have been identified to be of key importance to the industry. The CCHRAG has voted on the importance of the individual assessment items and has identified the following items to be of major relevance, i.e. key criteria:

- cup burner fire extinction/suppression concentration established (ISO, NFPA);
- FAA MPS testing concentration determined; and
- test method determined to demonstrate compliance with 14CFR paragraph 25.851(b)(2).

3.2.1 Cup burner fire extinction/suppression concentration established

The majority of participants stated compliance either by conducting cup burner testing or referring to existing standards.

Three of the participants have not established a concentration for a full system due to the non-gaseous state of their agent. The cup burner concentration should be conducted prior to FAA MPS testing. Depending on the exact nature of the agent, evaluation in a cup burner may not be possible, and some other action might need to be performed prior to FAA MPS.

The CCHRAG concludes that participants' interest has been demonstrated by conducting preliminary tests on several solutions.

3.2.2 FAA MPS testing concentration determined

One participant states compliance with FAA MPS testing, having performed the test at the FAA premises, one other participant has performed the exploding aerosol can test (one of the most critical MPS tests) at their own facilities. Other participants have stated non-compliance.

Since successful MPS testing is necessary to meeting FAA and EASA certification requirements, the core group concludes that the majority of the solutions assessed are still contingent on passing critical testing demonstrations.

Only one agent has completed the MPS test and even though it is a key criterion, it does not address the challenge of designing and integrating that agent and system into the aircraft prior to certification plan submittal. Therefore, it is essential that more agents successfully complete MPS testing no later than 2020 to reduce the risk of not meeting the 2024 deadline.

3.2.3 Test method determined to demonstrate compliance with 14CFR paragraph 25.851(b)(2)

Paragraph 25.851(b)(2) requires that:

> "The capacity of each required built-in fire extinguishing system must be adequate for any fire likely to occur in the compartment where used, considering the volume of the compartment and the ventilation rate. The capacity of each system is adequate if there is sufficient quantity of agent to extinguish the fire or suppress the fire anywhere baggage or cargo is placed within the cargo compartment for the duration required to land and evacuate the airplane."

Industry, regulators, and academia performed extensive testing of Halon 1301 to ensure that the inerting concentration required to meet this regulation is well understood. The FAA Cargo MPS tests have been developed to ensure that the protection provided by any replacement agent will be shown equivalent to Halon 1301. For agents that behave differently or have different physical properties than Halon 1301, compliance with this regulation may require testing beyond the FAA MPS tests.

Over half of the participants responded that their solution test method was not yet determined. Some of those with compliant responses assumed a given method would be appropriate.

The core group concludes that regulatory agencies will need to confirm specific test methods for compliance with paragraph 25.851(b)(2) well in advance of implementation since the test methodology may take time for development, calibration, determination of the means of compliance (MOC), and certification demonstration and approval.

3.3 ASSESSMENT SUMMARY

The CCHRAG provides the following summary based on our current understanding of the solutions provided by the participants. Please note the definitions for their conclusions.

- **Not Achievable:** Technology, including mitigating measures, cannot meet criteria within compliance timeframe.
- **Achievable:** Technology, including mitigating measures, can meet criteria within compliance timeframe.

Criterion	Conclusion	Remarks
Cup burner fire extinction/suppression concentration established (ISO, NFPA)	Achievable	
FAA MPS testing concentration determined	Achievable with conditions	More agents need to pass to reduce risk of not meeting 2024 deadline
Test method determined to demonstrate compliance with paragraph 25.851(b)(2)	Achievable with conditions	Specific test methods need to be confirmed

While demonstration of an agent and its support system's firefighting performance may be achievable, ensuring that performance on an aircraft under extreme conditions may pose significant challenges to the system design and aircraft integration requirements. Continued technology development and refinement is needed to guarantee successful certification.

4. PHYSICAL PROPERTIES OF EXTINGUISHING AGENT

4.1 OVERVIEW

The technical assessment of the physical properties of the extinguishing agent was covered by the following items:

- agent and system weight is less than or equal to halon system;
- agent and systems size is less than or equal to halon system;
- long & short range applicability;
- clean agent (gaseous) - no clean up required;
- boiling point;
- no damage to aircraft materials after agent discharge;
- freezing point is less than normal operating conditions;
- freezing point is less than minimum operating/storage conditions;
- decomposition temperature is greater than fire conditions (or HF formation and thermal decomposition products are under the dangerous toxic level for humans);
- not thermally conductive;
- not electrically conductive;
- no aircraft hydromechanical interfaces required (e.g. bleed air, fuel tank inert gas, etc.);
- operational impacts have been identified and mitigated; and
- system (knockdown & metered) available whenever airplane is powered.

4.2 IDENTIFICATION OF KEY CRITERIA

Some of these criteria are of key importance to the industry. The CCHRAG has identified the following items to be of major relevance (key criteria):

- no damage to aircraft materials after agent discharge;
- system (knockdown and metered) available whenever airplane is powered;
- agent and system weight is less than or equal to halon system; and
- clean agent (gaseous) - no clean up required.

4.2.1 No damage to aircraft materials after agent discharge

An important item for the industry is the cleanliness of the agent. In the case of an inadvertent activation of the system, e.g. in case of system failure or after a spurious smoke alarm, the residues of the agent shall not lead to a degradation of the aircraft systems and structure. Furthermore, significant damage or loss of baggage should also be avoided in a non-fire event.

Aircraft degradation or damage might be caused by corrosion if residues of the agent are not or cannot be adequately removed because they have penetrated into non-accessible areas. For most agents, gaseous and non-gaseous, the relevant properties have to be analyzed and compatibility has to be determined.

Hence, a few of the participants who are investigating non-gaseous agents have stated that this point is to be defined. One participant who uses a non-gaseous agent has stated compliance without verifying this statement.

The CCHRAG assesses that gaseous agents are preferable in the context of potential damage to aircraft materials.

4.2.2 System (knockdown & metered) available whenever airplane is powered

System availability is of key importance. Fire protection has to be available during all flight phases. Today's Halon 1301 cargo fire suppression systems have this capability and are available whenever the airplane is powered, thereby helping to ensure fire protection during all flight phases. However, if the fire extinguishing system relies on engine bleed air or other aircraft systems like the fuel tank inerting systems (On Board Inerting Gas Generation System (OBIGGS), or Nitrogen Generating System (NGS)) to acquire additional inert gas, the required amount of gas might not be available during certain flight phases, including ground operations and taxiing. This assessment criteria is linked to the item "No aircraft hydro-mechanical interfaces required (e.g. bleed air, fuel tank inert gas, etc.)." This especially becomes relevant if future technology trends like more electrical aircraft are developed.

About half of the participants responded that their technology complies with this criteria. Other participants were either to be determined or non-compliant. The group recommendation is that a halon replacement system should be independent from other aircraft systems.

For nitrogen-based inerting systems, it is essential to find ways for on-board gas generation with reliable availability whenever the aircraft is powered. Inert gas suppression (solid gas propellant devices, bottled nitrogen, etc.) could be potential solutions but technical maturity is lacking.

Current inerting systems (OBIGGS, NGS), which could potentially be used for metered fire suppression may become viable in the future but the inerting systems in use today take a significant amount of time to warm up and generate nitrogen-enriched air of sufficient purity. Until more reliable inerting systems with improved availability (no warm-up time required) have been developed, these systems remain nonviable. Further consideration on this might be beneficial as more research and testing is conducted on the newer gas-inerting technologies. It should be noted that not all commercial aircraft require OBIGGS or NGS for fuel tank inerting.

4.2.3 Agent and system weight is less than or equal to halon system

In order to minimize the CO2 emission caused by increased fuel burn due to increased system weight, this criterion has been rated of high importance by the CCHRAG. Also, this criterion is important because it will aid in system integration providing a quicker, less costly transition to clean fire suppression agents for the growing fleet.

The majority of participants who have performed preliminary integration studies have indicated difficulty in compliance with weight criteria. A couple participants who state compliance have not investigated the system layout in detail.

The CCHRAG concludes that a weight increase cannot be avoided for any of the halon replacement solutions presented. The development challenge is to find the lowest weight solution.

A couple of participants who are not experienced in delivering aircraft systems stated compliance to this requirement. The CCHRAG anticipates a weight increase associated with non-halon cargo fire suppression systems after detailed integration studies.

4.2.4 Clean agent (gaseous) - no clean up required

It is important that the aircraft stays clean after a fire extinguishing discharge to minimize damage to the aircraft and cargo contained in the compartment. This is especially relevant in case of a spurious discharge when no actual fire occurred. Participants report that all gaseous agents are compliant. Participants that proposed non-gaseous agents identified the need for further investigation. This especially holds true for agents other than pure water.

Based on survey results, CCHRAG anticipates that for most non-gaseous agents, there will be a need for additional maintenance efforts within the compartment after agent discharge. The participants have not provided details of the maintenance procedure at this stage of the assessment.

4.3 ASSESSMENT SUMMARY

CCHRAG provides the following summary based on our current understanding of the solutions provided by the participants. Please note the definitions for their conclusions.

- **Not Achievable:** Technology, including mitigating measures, cannot meet criteria within compliance timeframe.
- **Achievable:** Technology, including mitigating measures, can meet criteria within compliance timeframe.

Criterion	Conclusion	Remarks
No damage to aircraft materials after agent discharge	Achievable	
System (knockdown & metered) available whenever airplane is powered	Achievable with conditions	In the case that the system relies on other aircraft systems, the required amount of agent supply might not be available during certain flight phases.
Agent & System Weight is less than or equal to Halon system	Not Achievable	A weight increase cannot be avoided for any of the halon replacement solutions presented. A consequence is an increased CO_2 emission caused by higher fuel burn.
Clean agent (gaseous) - no clean up required	Achievable	

System architectures and the correlated operational impact on the aircraft might differ for different aircraft models. For example, some aircraft models already are equipped with fuel tank inerting systems, which can be used to support fire suppression if the level of availability is adapted. Other aircraft models cannot benefit from this opportunity.

Based on the survey results, our assessment is that a halon replacement system will most likely require an increase in weight.

5. PRODUCTION

5.1 OVERVIEW

The CCHRAG assessed the production properties of the various technologies with the following items:

- currently used in other industries and/or applications;
- supply chain established;
- agent readily available;
- agent modification not needed for aircraft application; and
- risks for system adaptation is mitigated or low.

5.2 COMPLIANCES

All participants indicated that their solutions are currently in use in other, non-aviation, applications, although only seven participants stated that a supply chain has been established for the agents and/or technology, while two agents are not readily available for aircraft cargo fire suppression. Five participants stated that risk mitigation for system adaptation is yet to be defined.

5.3 ASSESSMENT SUMMARY

The CCHRAG group concludes that the solutions assessed are in various states of production readiness. Our assessment is that the participants are aware of the current ICAO requirements.

We note that no information was collected from the participants about future development plans, in order to avoid potentially competition-sensitive information. Therefore, timing to establish aerospace-specific production capability and/or a roadmap/plan to establish supply chain support and logistics is unknown at this time. Without this information, the CCHRAG is unable to assess production schedule readiness.

6. ENVIRONMENTAL, HEALTH & SAFETY

6.1 OVERVIEW

The CCHRAG assessed the environmental, health, and safety properties of the extinguishing agent by the following criteria:

- not a Montreal Protocol listed ODS;
- not a Kyoto Protocol listed GHG;
- not GHS-listed hazardous material;
- US EPA SNAP approved;
- US EPA TSCA inventory listed;
- EU REACH registered, authorised, and/or restricted;
- not a PBT, POP, or endocrine disrupter;
- present on other regulatory lists;
- US OSHA regulated;
- not a carcinogenic, mutagenic, repro-tox substance (CMR);
- cardiac sensitization: LOAEL, NOAEL is greater than or equal to Halon 1301; and
- oral, inhalation, dermal toxicity is lower than or equal to Halon 1301.

6.2 COMPLIANCES

The participants' responses to the twelve criteria varied. Much of the variation was likely due to the differences in solution development status, agent properties (naturally occurring vs. novel chemistry), and current breadth of use (both application type and geographic location). While most solutions are not considered ozone depleting substances (as is the case for Halon 1301), only four are considered compliant with US EPA SNAP.

6.3 ASSESSMENT SUMMARY

While over half of the solutions are compliant with over half of the criteria, the CCHRAG's assessment was that full compliance will take time and resources. It should be noted that some of the technologies appear to meet human health and safety criteria, but appear to have environmental trade-offs (e.g. lower NOAEL, LOAEL, and/or increased toxicity vs. Halon 1301). While other solutions (nitrogen inerting, watermist, foam) appear to meet most of these criteria, there are trade-offs with the other criteria described elsewhere in this assessment (e.g. weight, material compatibility, clean up).

At this time, based on limited data, the CCHRAG believes most of the solutions still have multiple environmental and health impacts that are yet to be evaluated.

7. SCHEDULE

7.1 OVERVIEW

The CCHRAG assessed the schedule of the technology with the following criteria:
- current TRL is greater than 3; and
- aviation authority certification experience.

7.2 IDENTIFICATION OF KEY CRITERIA

One of these criteria has been identified to be of key importance and relevance to the industry:
- current Technology Readiness Level (TRL) is greater than 3.

7.2.1 Current technology readiness level (TRL) is greater than 3

All but one of the participants have stated that their technical solutions have reached TRL3, the discovery phase, for technology development, which confirms the proof of concept.
Four of the eight participants are chemical agent manufacturers with little or no experience in supplying the aerospace industry. These participants have stated a TBD compliance in the context of experience with the aviation authorities certification process.

The assessment on technology readiness of non-aerospace experienced participants might not be as mature as assessments provided by participants that have been closely involved in industrial and development processes applied by aircraft manufacturers.

Technical solutions based on nitrogen inerting are stated to be beyond TRL3/4, which is proven by successfully passed minimum performance standard tests and use in other applications. However, the reliance on NGS or OBIGGS will present significant challenges with regard to technical maturity.

Other gaseous fire suppression systems are currently undergoing minimum performance standard testing.

7.3 ASSESSMENT SUMMARY

The CCHRAG provides the following summary based on our current understanding of the solutions provided by the participants. Please note the definitions for their conclusions.

- **Not Achievable:** Technology, including mitigating measures, cannot meet criteria within compliance timeframe.
- **Achievable:** Technology, including mitigating measures, can meet criteria within compliance timeframe.

Criterion	Conclusion	Remarks
Current Technology Readiness Level (TRL) is greater than 3	Achievable	All but one of the proposed solutions has reached TRL3

Because only one participant's technology has not met TRL3, our assessment is that this criteria is achievable but further development is needed to meet the necessary timeframe.

8. SUMMARY

All participants have either documented the technology readiness level to TRL3 for their solutions or are promoting solutions that could potentially be adapted to aircraft cargo compartment fire protection. For most, much developmental work still remains and acceptance is dependent on performance and economic viability to justify a strong business case.

Criterion	Conclusion	Remarks
Cup burner fire extinction/suppression concentration established (ISO, NFPA)	Achievable	
FAA MPS testing concentration determined	Achievable with conditions	More agents must pass to reduce risk of not meeting 2024 deadline
Test method determined to demonstrate compliance with paragraph 25.851(b)(2)	Achievable with conditions	Specific test methods need to be confirmed
No damage to aircraft materials after agent discharge	Achievable	
System (knockdown & metered) available whenever airplane is powered	Achievable with conditions	In case that the system relies on other aircraft systems, the required amount of agent supply might not be available during certain flight phases.
Agent & System Weight is less than or equal to Halon system	Not Achievable	A weight increase cannot be avoided for any of the halon replacement solutions presented. A consequence is an increased CO_2 emission caused by higher fuel burn.

Clean agent (gaseous) - no clean up required	Achievable	
Current Technology Readiness Level (TRL) is greater than 3	Achievable	

It is anticipated that other new agents are under development and may be available for assessment in the coming year. The CCHRAG will consider whether this assessment should be expanded and/or updated after the 40th Session of the ICAO Assembly in 2019.

9. FUTURE OUTLOOK

While the CCHRAG continues to promote stakeholder engagement in the identification and development of halon replacements, the drive for improved safety and fire protection on aircraft is increasing. Aviation authorities are challenged to ensure all fire threats are addressed and seek opportunities to better understand the risks and investigate potential mitigations.

In October 2018, the FAA announced that a new Cargo Fire Suppression MPS Task Group had been formed to work on improvements to MPS testing procedures and capabilities. The CCHRAG welcomes the new venue and will participate to ensure alignment as new technologies are actively undergoing research and testing to meet current cargo fire suppression requirements (equivalent level of performance to halon). The challenge for all will be to work cooperatively and efficiently such that progress remains on track to support the ICAO 2024 deadline.

— END —