INTERNATIONAL AIRCRAFT SYSTEMS FIRE PROTECTION WORKING GROUP MEETING

October 29-30, 2014

Tropicana Hotel-Casino, Atlantic City, New Jersey, USA

WEDNESDAY, OCTOBER 29, 2014 – Meeting Agenda

9:00-9:10 AM	Welcome/Meeting Logistics/Attendee Introductions
9:10-9:30 AM	Flight Deck Smoke Penetration Testing Update – (R. Morrison – FAATC)
9:30-9:50 AM	Modeling of Hidden Fire Smoke Signature in Aircraft– (E. Oztekin – TAMI)
9:50-10:10 AM	Status of NexGen Burner for Powerplant Testing – (S. Summer – FAATC)
10:10-10:25 AM	*Break*
10:25-10:45 AM	Updated Experimental Investigation of the NexGen Burner – (Ryan Hasselbeck – University of Cincinnati)
10:45-10:55 AM	Commercial Aviation Safety Team – (J. Gardlin - FAA)
10:55-11:15 AM	SAE/ISO Standards on Fire Containment Covers and Fire Resistant Containers (D. Blake – FAATC)
11:15-11:30 AM	Smoke, Fire, Fume Events Study – R. Hill (FAATC)
11:30 AM-1:30 PM	Lunch (on your own)
1:30-2:00 PM	Class E Cargo Compartment Fire Suppression Testing: FRC & Water Mist – (D. Dadia – FAATC)
2:00-2:20 PM	UPS Freighter Fire Protection Projects Update – (Bob Brown – UPS)
2:20-2:30 PM	Class C Cargo Compartment ULD Suppression Agent Penetration – (D. Blake – FAATC)
2:30-2:35 PM	Storage of E-Tablets in Galley Compartments and the Flight Deck– (T. Maloney –FAATC)
2:35-2:45 PM	Industry Working Group Updates – RTCA SC-225 (Lithium Batteries) and EUROCAE WG80/SAE AE-7AFC (H2 Fuel Cells) – (S. Summer FAATC)
2:45-3:05 PM	Consideration of Fuel Cells for Future Airplanes – (Al Carlo – Boeing)
3:05-3:20 PM	*Break*
3:20-3:50 PM	Battery Heat Release Testing – (R. Walters – FAATC)
3:50-4:20 PM	Lithium Battery Thermal Runaway Vented Gas Composition – (T. Maloney – FAATC)
4:20-4:50 PM	Lithium Battery Chemistry and Size Comparative Testing – (S. Summer/T. Maloney)

THURSDAY, OCTOBER 30, 2014

8:30-8:45 AM	Propagation of Lithium Battery Fire in an Inert Environment – (T. Maloney/S. Summer)
8:45-8:55 AM	ICAO Transport of Lithium Batteries/Multidisciplinary Meeting Update (R. Hill – FAATC)
8:55-9:15 AM	USTC and Boeing Fire Test Results of Li-ion and Li-metal Batteries – (Doug Ferguson –Boeing)
9:15-9:45 AM	Battery Safety Testing and R&D Programs at Sandia – (Chris Orendorff – Sandia)
9:45-10:05 AM	Maturity of AOA's Fire Extinguishing System – (Gerd Wedler – AOA-Dresden)
10:05-10:25 AM	Carbon Dioxide for Cargo Fire Suppression – (Paul Rohrbach/ Rainer Beuermann – Airbus)
10:25-10:35 AM	*Break*
10:35-11:05 AM	Environmental Update/Halon ARC Update – Tom Cortina (HARC)
11:05-11:25 AM	Engine Halon Replacement Testing Update/Future Plans –

(D. Ingerson – FAATC)

11:25-11:40 AM Handheld 2-BTP Halon Replacement Update
(Mike Madden-Boeing/ Bradford Colton-American Pacific)

11:40 AM-12:00 PM Industry Collaboration/Consortium (IC) Research Effort to Develop a Single, Industry-Wide Non-halon Fire Extinguishing Agent for Engine and Auxiliary Power Unit Fire Zones. A proposal of the IC's structure, statement of work, deliverables, and schedule will be discussed. (Alan Macias - Boeing)

12:00-12:20 PM International Coordinating Council Aerospace Industries Association Cargo Compartment Halon Replacement Working Group Overview (ICCAIA CCHRWG) (Robin Bennett - Boeing)

12:20-12:40 PM Working Group Member Presentations

12:20-12:30 PM PlaneGard™– Capture and Contain PED Fires – (Mike Gilchrist - PlaneGard™)

12:30-12:40 PM Fire Containment of Runaway Lithium Metal Cells – (Tim Riley -PyroPhobic Systems)

12:40 PM Additional Discussion/Closing

WEDNESDAY, OCTOBER 29, 2014

Flight Deck Smoke Penetration Testing – R. Morrison

Objective: Determine if current flight deck smoke penetration certification testing is adequate for freighter aircraft. Rob provided the background for this test program. Photos from test series were shown. The interim fire safety 727 test results were presented. The planned work in the FAATC Fire Safety 747SP was described. Ferguson: is there a particular scenario envisioned that this is representative of, or is this more a challenge to see where things get difficult? Morrison: We haven't picked a specific scenario, so this is more of a challenge. We are using our helium injected box as a tool because it was available. We are taking the equipment what the AC already has set out to do R&D. Ferguson: What is your philosophy behind generating smoke in the upper cabin? Morrison: We are working with generalities right now. We have not configured this test to a 747 freighter yet. We started with testing in our 727 and now, since we have made some headway, we are going to move to our 747SP and do some testing in it.

Modeling of Hidden Fire Smoke Signature in Aircraft – A Case Study for 747 Overhead Area – E. Oztekin

After providing background for this project, Ezgi described the two Solvers available: NIST (Fire Dynamics Simulator) or FM Global (fireFOAM) and reviewed the methodology. We have selected the fireFOAM solver. Completed: selection of CFD solver, characterization of a fire source, and CAD model for the B747 overhead area. Current work: mesh generation for the modeled geometry and acquiring computational resources. Future work: solution and analysis. Question: are you going to assume uniform heat source? Oztekin: we will still use combustion model. We also assign a heat release rate. Chattaway: do you plan to consider ventilation in the open area? Oztekin: I am not sure if we have ventilation in that area or not. If you have any information about ventilation in the overhead area, please let me know. I am trying to find out.
Blake: Ezgi is looking for input from anyone who can provide computational mesh information. We would like to generate some interaction for this project.

Next Generation Fire Test Burner for Powerplant Fire Testing Applications – S. Summer

Steve reviewed the background and FARs that mandate fire protection in aircraft powerplant fire zones. FAATC Fire Safety Branch was tasked by the FAA Transport Airplane Directorate to investigate a different/new burner for these tests. Steve discussed the previous work that included Round Robin testing as part of the Powerplants User Survey which resulted in initial burner configuration. Oil burner results vs. FAATC NexGen burner results were shown. The burner configuration was described: use of Flame Retention Head (FRH) as is used in the seat cushion

testing on the Materials side (see Tim Salter's Presentation in October 27-28, 2014, Materials Working Group section of FAATC Fire Safety website). We have some Round Robin testing currently underway looking at oil burners and NexGen burners – we are testing slug calorimeter; we are also looking at burnthrough time. Nine (9) labs are participating, 12 sets of materials have been sent out. We are waiting for results from 5 more labs. Once full results are received, data will be compiled by the FAATC and presented at the spring 2015 Systems Working Group meeting. Current Status of rewording of AC 20-135: a sub-group has been formed with the goal of developing proposed rewording of AC20-135 in parallel effort with NexGen burner development. After initial sub-group meetings, we decided industry should request a more formal group to include all necessary FAA parties to address this issue. The resulting chartered group will most likely be managed through the existing Systems Working Group and this Powerplant Task Group. Question: Proposed calibration method lab to lab – how do you propose to keep each lab in line lab to lab? Is there going to be any type of calibration check? Summer: We will most likely mimic what has been done on the Materials Side. We will specify configuration of the burner and, there will most likely be a temperature check.

Updated Experimental Investigation of the NexGen Burner – R. Hasselbeck (U of Cincinnati)

Ryan reviewed the Project Objective, Previous Work, and Overview of the Project. The Current Approach was described. He reviewed the effect of fuel flow rate – burnthrough, effect of air mass flow rate – temperatures, effect of fuel temperature- temperatures, effect of fuel temperature – burnthrough, effect of air temperature- temperatures, and effect of air temperature – burnthrough. The results of the Comparison of Burner Cones were presented: FAA Cone vs. UC cone manufactured by Inconel. Conclusions and Recommendations were reviewed: Fuel and Air mass flow rates have significant impact on burnthrough times. No significant effect of fuel and air temperatures, as long as mass flows are maintained constant. Burner cone design impacts the burnthrough time. Question: what was the difference between the cones? Hasselbeck: FAA cone is stainless steel and has small tabs along the side. The inside geometry is the same for both cones. The dimensions were in spec for both cones when measured after use. Harriram: when we have these calibrated once, do we have to calibrate them every time? Hill: that's the intent. Hasslebeck: That's the reason for the temperature check. Question: Do you intend to do any more work to determine effect of burner cone? Hasslebeck: Yes, we do, and we welcome any input from this group. Busch: Does cone deformation have influence on results? Hasslebeck: yes, it will. You may want to look at the cone material that will give you the longest life. Summer: we will look into how to specify when cone needs to be replaced possibly based on measurements or something. This is something we plan to do as we continue with this work. Dawson: has there been any influence because of elevation – has this been looked into? Hasslebeck: we have not looked into that. Question: can you give us a time range when AC20-135 will be revised? Summer: sometime in the future. J. Smith: burner cone from seat discussions we had yesterday. There was a study done on the ceramic coating, and it does make a difference. Clamping flat edges of cone extends the life of the cone.

Commercial Aviation Safety Team (CAST) – J. Gardlin

Jeff provided a brief background on the structure of CAST. SE 126: Cargo – Mitigations for Hazardous Material Fires – transportation of hazardous material as cargo. Output 1 –completed. Output 2 – just started: implementation of plan based on the results of Output 1, to encourage deployment and incorporation of currently available technology mitigations for hazardous materials cargo fires. Related Activity: Safety Enhancement 127 Cargo – Fire Containment.

SAE/ISO Fire Containment Covers (FCCs) and Fire Resistant Containers (FRCs) Standards Update – D. Blake

The recent TSO on this references SAE AS6453 standard with modifications. Joan Hughson (FAA HQ) worked on this TSO. SAE/ISO working group members are discussing revisions to the

original standard involving the requirement not to exceed 400° F at a distance of 4" away from outside surface of the FCC. If a change is made to the SAE standard, the TSO would also have to be changed if the FAA wants to incorporate the new version. Dave explained the two issues he has with this. Fire Resistant Containers (FRCs): SAE standard 6278 (and ISO/CD 19281) are still under development. Unresolved issues: should FRC standard still include the 14 CFR Part 25 Appendix F. Part III requirement (cargo liner oil burner test)? Lithium batteries? Possible delayed smoke detection from a fire originating in either a FCC covered pallet or inside an FRC. Preliminary Smoke Detection Test Results: Corona Aviator theatrical smoke generator was used in these tests. Ventilation system provided one air change in 4 minutes. Smoke detector alarm point was 96.5% LT/ft. Additional testing is planned under more representative fire conditions. Question: if I understand the TSO correctly two full-scale tests are required: one container with no damage and one with damage? Blake: the SAE standard may change that. Hughson: the damaged container is part of continued airworthiness, and that is why it is not part of the TSO.

Smoke, Fire, Fume Events on Transport Airplanes Study – R. Hill

Study involves collection and analysis of data related to smoke, fire, and fume event on US registered airplanes type certificated to FAR 25 and operating in accordance with FAR 121. Dick reviewed the objectives of the study. Data sources: FAA ASIAS, NTSB Accident Investigation Reports, and FAA SDRs. There are over 800,000 records that have to be initially analyzed. There are 16,000 of these records that are relevant and need to be read, interpreted and input into the database. Initial analysis has started. Harriram: does the database include pressurized and unpressurized sections of the airplane? Hill: yes, any area of the airplane that would be recorded in the three sources being used in this study.

Fire Suppression in a Class E Cargo Compartment - D. Dadia

Tests were conducted with Class-A fire loads in FCCs, FRCs, (with and without suppression) for a period of 4 hours. Similar tests were conducted with lithium battery fire loads in FCCs, FRCs, with suppression. Lithium metal fires breached the FCC within the first 15 minutes. Lithium metal fires breached the FRC with suppression within the first 15 minutes.
5000 Li-Ion Battery Test #2 conducted September 2014 video was shown.
AOA Water Mist System: to test the effectiveness of a water mist system in a Class E Cargo compartment. Dhaval described the Test Matrix. A video of the Class-A fire load test was shown. Pan Fire Test video was shown. Conclusion: aerosol suppression agent was not able to inert a lithium-ion battery fire in a FRC. Water mist system was able to extinguish pan fires and Class-A fires in Class-E compartments. Future work: 5000 lithium-ion battery fire under a FCC. Further test the water mist system against pan fires and Class-A fire loads. Question: What was the voltage of the batteries tested and state of charge? Dadia: 18650 batteries about 40% charged. Question: What are you trying to emulate with pan fires? Dadia: pan fires are a requirement for a class C cargo compartment. Ferguson: How much water was used during the pan fire? Dadia: about 45 kg of water. Rohrbach: what would you like to change for the future tests? Dadia: we want to first define something that will be more suited for a class E environment and the detection criteria as well.

Freighter Fire Protection During Smoke/Fire/Fume Events – Bob Brown (UPS)

Bob provided a description of the UPS/IPA Safety Task Force and explained the mitigation strategies for smoke/fire/fume events that are underway. UPS has a layered mitigation strategy: flight deck, pilot training, and aircraft containers. FCC Battery Testing: 5000 lithium-ion March 2014. 4800 lithium-metal batteries March 2014. Fire Resistant Container: UPS is pleased with the benefits of MACROlite FRCs including: weight savings, enhanced fire safety, reduced repair frequency and cost. In-container fire suppression: designing a solution for suppressing battery fires. ULD Suppression Advantages: both FedEx and UPS fire suppression systems recognize you have to fight the fire in the container; all aircraft positions covered; fire protection offered in

aircraft, truck, rail, etc., - it will be multi-modal. Future Testing Plans: UPS testing will continue; re-examining leakage rate and design of FRC; working to determine optimal configuration for large quantities of lithium-ion batteries.

Class C Cargo Compartment ULD Suppression Agent Penetration – D. Blake

Lithium-ion battery tests will be conducted in DC-10 below deck cargo compartment. Six aluminum AKE containers with flexible door coverings have been ordered to represent ULDs typically in use. 31 pounds HFC-125 extinguishing agent will be used in these tests. This is the same quantity of gas you would have if using Halon in this test. Dave described the planned tests. Input is requested on the availability of any other similar data as well as internal container loading. Dave is still working out what volume inside the container should be filled with cargo. Input on any data on this would be appreciated. If there is interest, we may form a small group to work on this. We hope to start this work within 2 months or so. Ferguson: We are required to maintain minimum of 3% Halon concentration in a compartment, so bear this in mind. Blake: I'd definitely welcome input on this. Harriram: I think the 3% Doug was talking about is a metered system, so it won't be depleting like you are talking about here. ***Blake: Maybe we should form a Task Group to make sure we get input from the group on this.***

Storage of E-Tablets in Galley Compartments and the Flight Deck – T. Maloney

Tests were previously carried out with CAAS which showed the risk of an e-tablet fire within a galley cart (see presentation 22 from 5/14/2014 Systems meeting @ www.fire.tc.faa.gov). E-tablets are used by flight attendants and pilots. Additional tests were conducted at the FAATC earlier this week. Future work: run further tests in the flight deck with magnesium alloy e-tablets. Develop methods of handling an e-tablet fire in the flight deck. Gehring: Are those e-tablets being used commercially available? Maloney: Yes, they are commercially available. Carlo: There have been some charging stations for 12 laptops or so delivered.

RTCA SC-225: Rechargeable Lithium Batteries and Battery Systems – S. Summer

RTCA SC-225 was formed to provide certification guidance for lithium batteries and battery systems that are permanently installed in aircraft. Steve reviewed the related previous RTCA documents. Currently, we are working on updating RTCA DO-311 to DO-311A. We will integrate coverage for all sizes of batteries.

EUROCAE/SAE WG80/AE-7AFC – Hydrogen Fuel Cells – S. Summer

The FAA (Steve Summer) has recently gotten involved in this group. Approach: short-term, medium-term, and long-term. Previous Documents: SAE AIR-6464 – Aircraft Fuel Cell Safety Guidelines. Current Status: working on MASPS/AS Document to more generally cover installation of any PEM H_2 fuel cell system.

Consideration of Fuel Cells for Future Airplanes – Al Carlo (Boeing)

More Electric Airplane – B 787: distributed – more electric architecture. Also looking at Potential Future Grid-Like Power Systems: similar to Ethernet system but for power. "More Electric" is industry trend. Al described the ecoDemonstrator 2012 and the RFC System Configuration that was placed in the aft cargo area of the B737-800. A photo of the unit installed in the aircraft was shown. The MEA technology enabler for energy generation, storage and conversion systems. Fuel cells require significant R&D to bring them to the level of development so that industry can then make them commercially viable for airplane application. ***I think we should consider a possible Task Group to discuss/work on fuel cells.*** Summer: you mentioned that the APU is probably going to be one of the first applications for the fuel cell, why would you target a less

critical area first? Carlo: I think the electrical folks liked the idea that it was located outside the aircraft even though it seems like the galley would be a good place to start.

Measuring Stored Chemical Energy in Lithium Ion Batteries using a Bomb Calorimeter – R. Walters

Objective: characterize chemical energy released from batteries at different states of charge. Rich reviewed the background. Rich investigated 18650 lithium-ion batteries in this project. Sean Crowley and Dr. Jim Quintiere of University of Maryland did some previous thermal runaway energy experiments work at FAATC with 18650 Li-Ion batteries. Rich showed photos of the battery charger used for charging up to 400 18650 batteries at a time. He also showed a photo of the smaller battery charger (charges 4 batteries at a time) he used in these experiments. He presented graph of discharge rate characteristics for NCR18650B. The design and operation of the bomb calorimeter was explained. The chemical energy measurements taken were explained. Rich presented additional data he collected including weight of gas discharged from one Li-ion battery; infrared gas spectra. Findings: Bomb: total amount of heat released from chemical reactions quantified. Exothermic runaway energy increases from 5 to 75 kJ with SOC. Future work: GC of gases; interpret FTIR to identify other gaseous components; measure pressures generated in bomb; test more batteries at different states of charge; examine energy from combustion more closely; energy balance calculations (reversible – irreversible). Harriram: what about looking at the peak pressures that are generated so we can have containment for these batteries? Walters: you may want to talk to Dr. Jim Quintiere and take a look at his presentation from the December 2013 Triennial Fire and Cabin Safety Research Conference "Thermal Dynamics of 18650 Li-ion Batteries" available in the Conference Proceedings on the FAA Fire Safety website.

Lithium Battery Thermal Runaway Vent Gas Composition – T. Maloney

Tom gave a brief background. Tom described the initial test. The set-up of the initial test was described. Video of Max Pressure: 28 PSI test shown. Later Tests (vent gas analysis) done in a smaller 21.7 L combustion sphere to characterize the type and quantity of gasses emitted. The test procedure and data processing method were explained. The results were presented. Several chemistries were investigated.
Summary: vented gases from cells can produce a pressure pulse of at least 28psi. Volume of gases emitted from cells decreases with SOC. Vented gas composition varies with differing cell chemistries. Future work: run verification tests with less nitrogen dilution. Test additional cell chemistries. Combust vent gases in air to determine pressure increase. Verify LFL readings with a flammability analyzer. Run a large scale test with halon 1301. Chattaway: Slide 13: what do you think is the reason for the variation? Maloney: The third test is the most accurate, because I refined my test by the third test. I didn't let the chamber cool down in between the first two tests.

Aircraft Installed Lithium Battery Hazard Analysis – S. Summer

Background was provided. 45 different cells were tested. The tests were conducted in the $10m^3$ pressure chamber. Steve reviewed the testing details: heat source for each type of cell; ignition source; propagation. Test Progress: we have conducted over 200 tests have been conducted. There are still 2 or 3 cells we are waiting to obtain for testing. A significant difference between certain cell chemistries and how they behave has been observed. Differences in cell construction have also been observed. $LiFeS_2$ cells: through testing, shown to be one of the 'safer' chemistries – however: storage incident $LiFeS_2$ – a thermal runaway event occurred while in storage for about 6 months. This was an unplanned incident with AA sized $LiFeS_2$ cells while in storage. We were fortunate, because we have thousands and thousands of Lithium batteries stored in this facility. Ferguson: a need to have a performance-based test? Summer: the main driver for these tests was not for transport of batteries, it was for aircraft installed batteries. As far as performance standards, if you look at some of the RTCA standards, it really points to that you can't make a generalization, you really need to test each given cell that you are looking to use.

THURSDAY, OCTOBER 30, 2014

Propagation of Lithium Battery Fire in an Inert Environment – S. Summer

Argon propelled foam was proposed as a means of mitigating a lithium battery fire. Would argon be more effective than nitrogen at suppressing lithium battery fires in an inert environment? The tests were conducted in the FAATC pressure chamber. 200 CR123a LimonO2 cells were used in these tests. Steve reviewed the results for air, nitrogen, and argon in chamber. Question: why did you go to 9%? Summer: It was just what we selected. This was just a comparison test. We thought 9% is something we thought you definitively fight the fire.

ICAO Transport of Lithium Batteries/Multidisciplinary Meeting Update – R. Hill

ICAO sets standards for transport of hazardous materials that are used by most of the world. The ICAO Dangerous Goods Panel is responsible for putting together requirements for the transport of lithium and lithium-ion batteries. Many of the members do not have aviation backgrounds. The DGP has separated batteries into several different groups, however, the way you are allowed to pack the batteries and the SOCs that you can use are consistent with the way the FAATC Fire Safety Branch sets them up in their fire tests. The DGP decided to create a multidisciplinary group to include some airworthiness representatives and some industry folks from multiple disciplines. The group's recent meeting was held in Cologne in September 2014. Dick reviewed some of the recommendations that came out of the meeting. One of the recommendations was explosion testing of lithium-ion batteries. A lithium-ion cell has an ignition source, so time is much shorter than with an aerosol can that does not have an ignition source. Question: were there any discussions of the packaging technologies that were presented at the Triennial conference last year? Hill: In the first multidisciplinary meeting packaging was discussed but not in this meeting. Minimum performance standards are being discussed. Quintiere: in view of the explosion that occurred in the FAATC test, have there been any thoughts on having a vented container or to what effect that would have on the aircraft? Hill: Yesterday, Tom Maloney presented results of a number of tests conducted at the FAATC. Question: what is the process and when do you think the MPS would be revised to include lithium batteries? Hill: I really don't know. We would have to see what ICAO comes up with after these recommendations go back to their groups.

University of Science and Technology (USTC) China and Boeing Test Results of Li-ion and Li-metal Batteries – Doug Ferguson (Boeing)

Purpose: understand and characterize key parameters for fires involving lithium-ion and lithium-metal batteries. Evaluate various mitigation strategies for carrying lithium batteries as cargo on aircraft with this understanding. Doug reviewed the goals of this research. A series of lithium battery fire characterization tests were conducted. Doug reviewed the results of the test series. Achievements: we successfully captured the heat release rate doing some bulk tests and an indication of the pulse rate. Observations: the total HR/initial battery mass from the primary lithium batteries was greater than the value for the secondary lithium batteries by 40% or more. The peak HRR increased with the number of batteries involved in the fire. During the heater cartridge testing, the total HR/initial battery mass increased with an increasing quantity of batteries. Next Steps: Testing of larger quantities of batteries by other organizations could be added to this data to build a model that would predict HRR for larger bulk quantities of batteries. Quintiere: Did you always ignite these or did you let it ignite by itself? Ferguson: we did not do anything special to ignite the flame beyond the initial ignition source. Petzinger: you used batteries from 2 different manufacturers –was there a significant difference between them? Ferguson: no, not really. You could pick out some differences, but in a very general way but not significant to make a note of. Summer: the chemistry of the batteries – was it the same? Ferguson: all the primary batteries were CR123a and all the secondary batteries were 18650. We don't know the specific electrolytes. They're as similar as they can be by two different manufacturers. Busch: do you have data

available regarding the time for these events? And the temperature at which the first explosion happened? Ferguson: yes, we do have the data. We were not trying to determine at what time an individual battery went into thermal runaway, so we don't have that data.

Battery Safety R&D at Sandia National Laboratories – Chris Orendorff (Sandia National Labs)

Chris described the laboratory capabilities at Sandia related to battery safety and the types of battery R&D they conduct. Lithium-ion materials issues: energetic thermal runaway; electrolyte flammability. Calorimetry of lithium-ion cells (understanding the thermal runaway response of materials in cells for 18650 cells -- graphs were presented). Materials-level and Systems-level battery safety work at Sandia were discussed during this presentation. Ferguson: thermal modeling question: is that thermal modeling for the external fire and the effect on the batteries getting involved in the fire? Orendorff: it can be both. Busch: do you have experience with different cell separators? Orendorff: yes, we have a lot of experience in evaluating various separating materials over the years. Sandia published an article on this in 2007. Quintiere: it seems that you focused on the auto-ignition element what about hot surface ignition? Orendorff: we've done both.

Maturity of AOA's Fire Extinguishing System – Dr. Gerd Wedler (AOA)

AOA's Water Mist Nitrogen Fire Suppression System to meet the Cargo Compartment Class C MPS Tests. Two phase: 1) knock down and 2) fire suppression. Gerd shared a diagram of their system and provided a description of the system. The full-scale fire verification was conducted at DLR Test Center. Class E Tests were conducted at the FAA Technical Center Fire Safety test facility. We also have a simulation model of our system. The simulation model helps predict: critical temp behavior and in-flight pressure increase. Summary: AOA's watermist + nitrogen has shown the proof of concept now (TRL3). Successful external tests with optimized system @ DLR test center Trauen "Class C/@ FAA Technical Center Class E"). System design-FMEA almost done, safety analysis started now. Carlo: Do you have any plans to test it with containers or covers? Wedler: We tested it with the MPS. We did approximately 50 tests.

Carbon Dioxide as Cargo Hold Fire Suppression Agent – Paul Rohrbach (Airbus)

Paul described the system identified the technical challenges and the approach to address the technical challenges. Preliminary MPS tests are scheduled for Q1-2015. A video of CO_2 discharge tests was shown. The System Concept was described. Potential health and safety issues will be addressed. Any thoughts or comments from this group? Chattaway: are you storing CO_2 and nitrogen in the same cylinders? Rohrbach: yes, but it is not 50-50. Blake: Do you plan on doing the MPS testing in the DLR facilities? Rohrbach: yes, Blake: Isn't their volume different than what the MPS calls for? Rohrbach: It is an A330 cargo compartment, so it is the same as we use for many previous tests. Blake: Is it for your own knowledge or an attempt to get EASA certification? Rohrbach: no, it is not for certification at this point.

Environmental Update – Dan Verdonik (Hughes RJA) for Tom Cortina

Dan reviewed the International Dates for Halon Replacement: EU and ICAO. He also reviewed climate change – science and evidence that it is man-made. He discussed the EPA SNAP Program to move to lower potential climate changing agents; the Montreal Protocol amendments proposed in 2014 that would add HFCs to MP and slowly phase down their production; EU F-gas Regulation; Japan's HFC Policy; Australian Carbon Tax update.

FAA Halon ARC – R. Hill

Aircraft Rulemaking Committee (ARC) was chartered on July 2, 2013, to advise the FAA on halon replacement. Objectives and Tasks of this ARC were reviewed. Halon ARC will submit a report

detailing recommendations to the FAA in the near future (draft to be submitted to FAA in November 2014). ARC did not begin until November 2013. Its charter was extended until February 2015.

Halon Replacement, Aircraft Engine Nacelle – Halon Replacement Aircraft Powerplant – D. Ingerson

New halon replacement project is underway at FAATC. The nacelle fire simulator has been restored and is operable. Preliminary testing was conducted in July/August 2014. Testing will be in accordance with the MPS available on the FAA Fire Safety website. This halon replacement project is prime focus, all else is paused at this time. Anyone with specific interest, please contact me directly.

Halon Replacement for Airplane Portable Fire Extinguishers – Mike Madden (Boeing)

2-BTP is a new environmentally progressive halon 1211 replacement agent. Next steps to commercialization: US EPA Toxic Substances Control Act (TSCA inventory listing; EPA SNAP approval; ASTM standard for BTP. Mike reviewed the 2-BTP timeline. Blake: is EPA SNAP the main issue left? Madden: Yes, that's it. We are waiting on SNAP approval. Everything hinges on SNAP approval.

Industry Collaboration/Consortium (IC) Research Effort to Develop a Single, Industry-Wide Non-Halon Fire Extinguishing Agent for Engine and Auxiliary Power Unit Fire Zones – Alan Macias (Boeing)

A proposal of the IC's structure, statement of work, deliverables, and schedule was discussed.

International Coordinating Council Aerospace Industries Association Cargo Compartment Halon Replacement Working Group Overview (ICCAIA CCHRWG) Update – Robin Bennett (Boeing)

This is an update of the May 2014 presentation at the Systems WG meeting in Bremen, Germany. First deliverables: requirements document and timeline documents have been completed. We have been working on an Action Plan since our last meeting in May 2014. The Action Plan leads to ICAO Recommendation.

Working Group Member Presentations

PlaneGard™ – Capture and Contain PED Fires – Mike Gilchrist (Highwater Innovations)

Fire Containment of Runaway Lithium Metal Cells – Tim Riley (PyroPhobic Systems Ltd.)

Next Meeting

We are looking for a host (international) for the May 2015 Systems Working Group meeting.

Additional Comments:

Al Carlo suggested allowing time for Task Group meetings for some of the new Task Group ideas that were brought up.