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RTCA Paper No. 297-18/SC230-035
Date: February 12, 2019

RTCA SC-230
Airborne Weather Detection Systems
Meeting #15 Minutes (Nov 6, 2018)

Attendance list:

Name	Company
DiVito, Stephanie*	Federal Aviation Administration (FAA)
Nguyen, Lee*	Federal Aviation Administration (FAA)
Machida, Shigeru	Japan Aerospace Exploration Agency (JAXA)
Caruhel, Camille	Airbus
LEFEZ, Thibault	Airbus
Ren, Yukun (Kenny)	The Boeing Company
Svoboda, Charles	The Boeing Company
Tschacher, Luke*	The Boeing Company
Avjian, Robert	The MITRE Corporation
Rossi, Angelo*	The MITRE Corporation
Lug, Matthew*	U.S. Air Force
Clark, Ivan	NASA
Harrah, Steven	NASA
Hunt, Patricia*	NASA
Proctor, Fred	NASA
Ratvasky, Tom	NASA
Switzer, George*	NASA
Fan, Xiao Zhu (Mike)	Honeywell International, Inc.
Gidner, Dawn	Honeywell International, Inc.
Lukáš, Jan	Honeywell International, Inc.
Finley, Jeff	Rockwell Collins, Inc.
Irimia, Marius*	Rockwell Collins, Inc.
Sishtla, Venkata	Rockwell Collins, Inc.
Smith, Mark*	Rockwell Collins, Inc.
Abe, Masatoshi	Mitsubishi Electric US
Kameyama, Shumpei	Mitsubishi Electric US
Kogo, Yuichiro	Mitsubishi Electric US
Spaeth, Lisa*	Ophir
Strapp, Walter*	Environment Canada
Hofmann, Karan	RTCA, Inc.

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*Virtual
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11/6/2018 Morning

Introduction and Admin:

RTCA opening remarks

Agenda and intro from Jeff.

HIAC focus on 11/6/18

Jeff offered to review meeting minutes from SC-230 at May 2-3, 2018. Reviewed history of SC-230 and the different WGs which yielded DO-213A and DO-220A

WG-10 scope and deliverable Review by Jeff.

Proposed deliverable to WG-10:

> Update to DO-220 Ch1 HAIC MOPS -> Potentially DO220-B. WG-10 deliverable and schedule review. Due date (2021) is Finish FRAC

Camille present HAIC conference pitch (reference to pitch available through workspace):

[**Action**] Camille to upload the HAIC conference pitch to workspace slides

Summary:

HAIC is a 4 years European project led by Airbus comprising of 39 partners which mains to:

- Optimize cloud microphysics probes to measure ice crystals conditions during flight test and to calibrate icing wind tunnels.
- Characterize microphysical properties of deep convective clouds.
- Upgrade European icing wind tunnels for reproduction of icing conditions
- Understand physical phenomena and develop numerical models and tools
- Assess the proposed mixed phase and glaciated icing environment as defined in Appendix D/P
- Improve aircraft operation by developing detection and awareness technologies to be fitted on aircraft and alert the flight crew when an aircraft is flying in or in vicinity of ice crystals areas

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Presentation Focused on HAIC SP4 – HIWC Detection and Awareness activities

- Aim:
  Develop and validate mixed phase and glaciated icing conditions awareness and detection technologies to alert the crew of flight in these particular icing conditions or to adapt the flight path well in advance I order to avoid such weather conditions

- Organization:
  - WP4.1: SP4 Coordination
  - WP4.2: Awareness & Detection technology specification
  - WP4.3: Awareness system development
  - WP4.4: Detection system development

OEM requirements:

- Main requirements:
  - Crew awareness at least 80 NM before encounter (detection range)
  - Function available above 30,000ft and below -30°C (activation envelope)
  - Two level of Ice Crystal threat to be displayed
    - Severe TWC >= 3g/m^3
    - Moderate TWC >= 1g/m^3
  - Performance request:
    - Correct annunciation: greater than 80%, ideally 95%
    - Missed annunciation/False annunciation: lower than 20%, ideally 5%
  - Architecture based on current certified WXR to ease the retrofit
  - Dedicated HMI without interference with existing WXR display symbology (Reflectivity, PWS, Turbulence and Hazard)

Request retrofit and forward fit, more HMI studies need to be done to ensure the WXR display is not overly cluttered. On the flight test campaign, to turn off the icing function, the de-clutter button was pressed, which turned off hail/lightening/icing/turb and everything…

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Steve/NASA presents HIWC Radar Flight Campaign summary

Info from Tom (NASA): Engine flame out occurs once or twice a month. (EIWG, engine icing working group/ICC Ice Crystal Consortium)

Jeff inquires about engine icing data. WG-95 only characterized 1 single engine.

[**Action**] NASA (Tom) to provide NASA EIWG contacts/work to Jeff/Dawn

[**Action**] Contact **Melissa Bravin** (Boeing) to get the updates on EIWG activities.

EIWG MOPS development on engine icing test threshold

Get the actual engine icing requirement

Ultimately, define WXR icing detection threshold

Steve Harrah present NASA HIWC Radar Flight Campaign

[**Action**] NASA to provide the slides and reference materials to WG-10

Polarimetric measurements using dual pole radar was not conducted due to availability of hardware

NRC CNRC Canadian study on Zdr/Kdp correlation

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Camille presents HAIC Final Forum presentation for SC-230 (reference workspace slides)

WG95 EUROCAE

[**Action**] Camille to upload the HAIC Final Forum slides

- Main task is to create a report on the Ice Crystals Long Range Awareness capabilities by Weather Radar (WXR), including
  - Description of the intended function and its operational needs
  - Assess the maturity of the Ice Crystals function by Weather Radar
  - Identify possible standardization activities by defining minimum acceptable performance and V&V approach.
  - Provide recommendations on the way forward of the sub-group and the way to standardize Icing WXR functions using new or existing EUROCAE / RTCA documents
- Coordination of RTCA SC-230 for preliminary MOPS activities preparation (DO-220A potential update)
- Context of the study for Ice Crystals function with WXR:
  - Ice Crystals' impacts on aircraft
  - Projects launched for Ice Crystals characterization
  - Radar technology status
- Intended Radar function from OEMs perspective
  - Need for awareness on different Ice Crystals concentrations (currently: moderate, above $1g/m^3$ and servere, above $3g/m^3$)
  - Definition of the awareness envelope for altitude and temperature (focus is done on cruise, above 25,000 ft and below -25^oC)
  - Performance definition (awareness function with 80% detection and 20% missed/false alerts)
  - Operational procedure definition (avoid severe IWC areas)
  - 'Retrofitability' constraints (request to have the minimum impact on already certified WXR products)

Final report was submitted meeting in February 2017 and finally released in September 2017 (RTCA FS-1) and march 2018 (EUROCAE ER-105)

WG-95 provided recommendation to start MOPS development.

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11/6/2018 Afternoon

Steve: Radar 2 presentation:

"SWERLing" – Concept

IWC vs Index of Dispersion seems to have little range dependency.

Index of dispersion vs time and IWC vs time plot closely map each other

[Issue] Unusual to find 3 g/m^3 at flight level, 3g/m^3 sample size is extremely small

Committee: Future studies on flights over land/terrain on the SWERL method needs to be performed

[**Action**] NASA will distribute the data and build IWC models for distribution amongst the radar suppliers.

Jan Lukas presented Honeywell Artificial Intelligence method:

The flight test campaigns all lack data points at high IWC levels (>3g/m^3)

Jeff: Questions on dual level IWC alerting, whether it's really needed since current radar already detects storm tops. NASA found that the IWC is most prevalently observed at the overshoot of storm tops.

Camille presented Airbus HAIC SC-230 campaign pitch

Airbus looking for funding to perform another flight campaign using a different IWC detection sensor

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WG-10 after [actions]:

WG10- **meeting cadenc**e/frequency: **every 2 weeks**

- Coordination with other WGs & Committees

Divide meeting topics between research and MOPS development activities

Telecom topics to be MOPS specific:

Turb detection maybe a good starting point for the new MOPS

Review the structure of the exiting MOPS, ensure the new info integrates smoothly.

HIAC will be a separate section in parallel to Turb and etc.

Add appendix similar to PWS which describes test cases and test methodologies.

Informational Decomposition:

- Hazard Definition (Engines and Probes)
- Operational Requirements/Justifications
- Radar Estimation Technique(s)
- Certification Testing
- HMI
- Other categories?

Suggest a day of the week and time, suggest 10/11am EST, and let Karan know:

First Telecom Logistics:

12/04/2018

Duration: 1 hour

[First Telecom topic] Fred to present NASA database/HAIC model in first telecom

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Action item recap [Nov 06, 2018]

[**Action**] Camille to upload the presented materials to workspace

[**Action**] NASA to provide the slides and reference materials to WG-10 workspace

[**Action**] NASA (Tom) to provide NASA EIWG contacts/work to Jeff/Dawn

[**Action**] Contact **Melissa Bravin** (Boeing) to get the updates on EIWG activities.

[**Action**] NASA will distribute the data and build IWC models for distribution amongst the radar suppliers.

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Date: February 12, 2019

RTCA SC-230 Meeting Minutes (Nov 7, 2018)

Attendance list:

Name	Company
Nguyen, Lee*	Federal Aviation Administration (FAA)
Machida, Shigeru	Japan Aerospace Exploration Agency (JAXA)
Avjian, Robert	The MITRE Corporation
Lug, Matthew*	U.S. Air Force
Caruhel, Camille	Airbus
LEFEZ, Thibault	Airbus
Ren, Yukun (Kenny)	The Boeing Company
Svoboda, Charles	The Boeing Company
Clark, Ivan	NASA
Harrah, Steven	NASA
Proctor, Fred	NASA
Fan, Xiao Zhu (Mike)	Honeywell International, Inc.
Gidner, Dawn	Honeywell International, Inc.
Lukáš, Jan	Honeywell International, Inc.
Finley, Jeff	Rockwell Collins, Inc.
Irimia, Marius*	Rockwell Collins, Inc.
Sishtla, Venkata	Rockwell Collins, Inc.
Smith, Mark*	Rockwell Collins, Inc.
Abe, Masatoshi	Mitsubishi Electric US
Kameyama, Shumpei	Mitsubishi Electric US
Kishi, Yoshikazu	Mitsubishi Electric US
Kogo, Yuichiro	Mitsubishi Electric US
Spaeth, Lisa*	Ophir
Hofmann, Karan	RTCA, Inc.

*Virtual

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Date: February 12, 2019

11/7/2018

Jeff opens at 9:10am:

Need to review terms of reference of SC-230 to support the development the development of feasibility report for WG-11 LIDAR

Jeff presents the opening slides:

WG-11 scope and deliverable:

Determine realistic goals for airborne LIDAR for the use as a CAT detection function,

Explore OEM needs.

Feasibility study will be a communication b/t LIDAR manufacturers and OEMs

Feasibility report due March 2020

WG-11 LIDAR Schedule:

Feasibility Report Completion: March 2020

Recommend:

- General announcement to SC-230 alerting committee to presence of WG-11 and schedule for upcoming working group meetings.
- Find other LIDAR industry partipants
- Venkata Sishtha and Shumpei Kameyama working group co-chair to meet and work out detailed plan and schedule for research monitoring, flight data evaluation, validation model development and MOPS development
- Schedule periodic working group telecons to carry out plan. (Meeting every 2 weeks has worked well in the past).

Present results at SC-230 plenary sessions (next is scheduled November 6-7).

Lidar contacts:

[**Action**] Gather LIDAR contacts recommendations from NASA (Ivan) and invite to WG-11

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Shumpei presents Mitsubishi product overview:

[Action]: Shumpei to upload presentation material to workspace

Shumpei Kameyama presents Lidar industry overview:

[Action]: Shumpei to upload presentation material to workspace

Discussed Airborne LIDAR applications and history of development as well as current state of the industry

Application	Clear air turbulence detection	Aircraft control		Wind shear detection	Wake vortex detection	Formation flight	Helicopter-borne
		Feed-forward control	Air data sensor				
Function	Prediction of encounter to CAT	Turbulence measurement for optimized blade control	Angle of attack, Side-slip measurement for feed-back control	Prevention of encounter to wind shear	Prevention of encounter to wake vortex of forward airplane	Detection of turbulence of forward airplane for formation flight	True-airspeed sensor, detection of down wash, etc.
Operation altitude	Cruising	Cruising	Cruising	Go-around	Go-around	Cruising	Near the ground
Measurement distance	Long	Short	Very short	Middle	Middle	Short	Short
Representative past works (Organization: Project name)	Michigan Univ.: [1] NASA (US): ACLAIM [2] DLR (GE): DELICAT [3,4] JAXA (JP): Safety-avionics [5,6,7]	CTI (US): [8] Airbus (FR): AWIATOR [9]	ONERA (FR): AIM2 [10] Thales (FR): DANIELA [11] NCAR (US): LAMS [12,13] Honeywell (US): OADS [14] Boeing (US): OADS eval. [15] Ophir (US): [16] BAE SYSTEMS (UK): [17]	JAXA (JP): [18] NASA (US): [19,20]	NASA (US): [21] DLR (GE): [22]	ONERA (FR): [23]	JAXA (JP): [24] Airbus (FR): [25]

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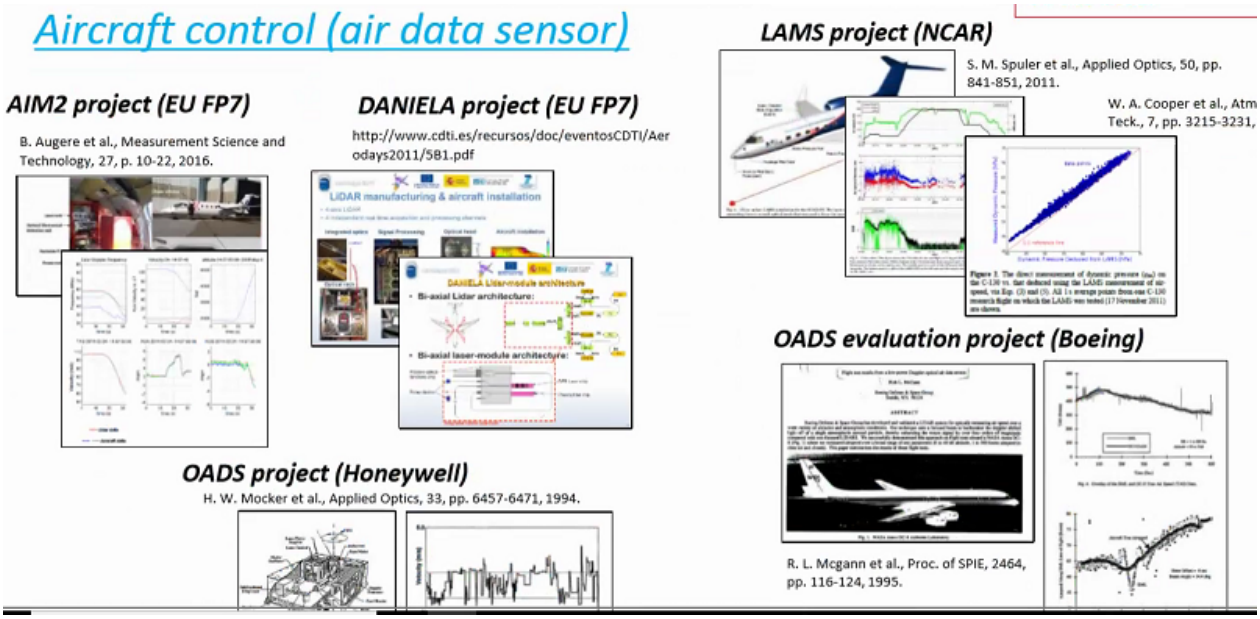

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WG-11 activity proposal:

- Discussion on the scope of work:
  - Which applications should be included in this feasibility study?
- Understandings of the past works:
  - What have been accomplished / not been accomplished in the past works?
  - What is the barrier for the practical use?
- Discussion on the required specification for each application:
  - Needs (from airline company, aircraft supplier, avionics system provide) v.s. Seeds (from LIDAR supplier)
  - What parameters should be denoted in the standard?
- Decision on the applications which should be the scope in the next (standardization) step

Potential LIDAR related topics to be discussed:

- Atmospheric condition
- Distance measurement (max & min)
- Range resolution
- Measurement rate (line-of-sight)
- Num of measurement ranges
- Wind speed precision
- Wind speed accuracy
- Scanning angle (Horizontal and/or Vertical)
- Scanning speed
- Detection probability and/or Data availability

Jeff inquired about the reason why LiDAR was not chosen to be used for W/S detection in SC-173:

SC-173 reasons for not using lidar:

- No commercial standards for LiDAR
- Lidar at the time was large/heavy/power hungry, not viable aviation product
- Performance limitation

Jeff comments: PMC wants to ensure that **CAT** should be the prime emphasis of the feasibility report, LiDAR's other weather applications can be discussed towards the end of the feasibility report. For the windshear detection function, LiDAR should be used in complementary to WXR due to the LIDAR's penetrating issues at rainy conditions.

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LIDAR turbulence functionality DISCUSSION:

[**Note**] Feasibility study is not MOPS, so it is suitable to explore all problem space.

What is CAT:

Is Wake-vortex also considered as CAT?

1. OEM should concentrate on operational requirements on the CAT vs Wake
2. LIDAR supplier should present how CAT is different from Wake from LIDAR perspective

Wake-vortex discussions:

LIDAR Wake detection problem space exploration:

- Range: 90 seconds rule for Turbulence detection (12NM)
- The added cost to implement LIDAR based wake turbulence detection feature if LIDAR is capable of detecting wake at high altitude.
- What are the operational benefit of real time wake turbulence detection?
- Feed-forward Active control loop mitigation using Real time LIDAR turbulence data
    - [**Action**] **OEMs/Avionics manufacturers** to investigate on feed forward studies using LiDAR Turb detection (current activities/operational needs/feasibility)
- [**Action**] **OEMs/Avionics manufacturers** to brainstorm operational concepts on the LiDAR technologies discussed given the current TRL on the various technologies. Especially Wake/Wave vs traditional turb

Wake-turbulence avoidance using operational methods:

- Air Traffic Management
- ADS-B IN application for special separation

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Feasibility study for LiDAR/CAT document structure/content discussion:

Executive summary: save for after later part discussion

TOC:

Dawn: OEM question display symbology, does CAT need to be different from normal TURB?

Section 1. Introduction section:

CAT incident reporting:

E-PIREPs (electronic pilot reports) in addition to pilot reports of CAT is OK

Definition of Turbulence, CAT:

[**Action**] study on the sources/phenomenon which need to be included in CAT [**Ven**]

Convective VS Clear-air induced turbulence:

- What is Turbulence? Discuss turbulence in the same context as radar. Should there be an HMI difference between radar and lidar?
- What is Clear (invisible to Radar (<7dbz? eye?))

LiDAR specific Turbulence definition:

- Need to verify LiDAR's turbulence definition. Radar (severe) turbulence induce 1G peak load on the aircraft. .3G RMS on 5 seconds' integration.
- If the different CAT phenomenon are detected the same way (similar threshold) and have the same operational effects, they can be considered as the same category?

Wake turbulence specific topics:

- CAT and Wake have different operational effects on the aircraft. At this point, LiDAR is allowed to display CAT of all sorts as Turb, or display wake-turb separately from "normal" CAT
- [**Action**] **OEMs** to Study the operational needs for Wake detection in addition to FAA suggested separation criteria based on aircraft weight/speed/altitude etc info.

Section 3. Intended functions section:

"LIDAR shall provide CAT detection for the purposes of xxx." Similar to WG-10.

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Section 4. Operational and performance goals section (OEM)

OEM specified performance goals:

To define the performance goals, should the committee include airline participation? (Similar to DO-220?):

[**Action, Jeff/Karan**] Send out call for participation to airlines

Note: it has been difficult to get airline's active participation

WG-10 Icing aside – call for airlines to participate in WG-10 icing, Rocky Stone et al

[**Action, Jeff/Karan**] RTCA and Chair to send out official letter of invite to airlines to participate in WG-10/11 activities. Include some operational benefits in the invite to draw some interest.

Discuss LiDAR wind detection capability:

1/2/3 D wind?

Range? Resolution?

[**Action, OEMs**] include in the notes: aircraft level threshold of CAT, to hopefully make the threshold similar to WXR Turb.

Operational considerations:

Eye Safety:

- On-ground: potential harm to maintenance personnel
- In-air: potential harm to pilot when other airplane is illuminated by LiDAR
- Need a paragraph to define eye-safe requirement (nominal ocular Hazard distance) (NOHD), (function of wavelength and power)
- [**Action**] [**LiDAR manufacturers**] Eye safety installation and operational requirements? In the operational and performance goals sections? To provide regulatory guidance.
- [**Action, Ven**] Committee chair to get with Mike and Lisa to gather LiDAR related regulatory document.

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Other considerations:

[**Action**] FAA/Ven to reach out to the necessary SMEs on CAT and Wake

[**Action, Jeff/Karan**] Inquire additional aircraft OEMs to participate in SC-230 WG-10 and WG11

Capture flight test experiences and difficulties experienced in the technology.

Overall architecture concept development between LiDAR and Radar

Section 5. LiDAR compliance with operational and performance goals

Atmospheric modeling of CAT

NASA can provide types of Turb events and meteorological data (Fred)

[**Action**] Lidar manufacturer to work with Fred/NASA to get/create/integrate atmospheric wind/particulate model. Lidar manufacturer to provide back scatter data.

Need a paragraph to list assumptions that converts vertical loads into velocity parameters produced by Lidar.

Validate: use NASA model as test cases similar to what's currently being used on turbulence testing today.

Section 7. Displays

If LiDAR detected CAT is operationally similar to the current WXR detected Turb, it's potentially good to keep display symbology the same as WXR Turb.

Additional section: Additional uses for LIDAR

Writing assignment:

1. Introduction [Ven to go around and gather information]:
    a. FAA can provide lots of valuable supporting information/POC on the work and studies done on CAT and Wake
2. Jeff
3. Jeff

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4. Airbus/Boeing
5. Lidar Manufacturer [Shumpei to coordinate]
6. V&V: Ven with the help from NASA

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Action item recap [Nov 07, 2018]

[**Action**] Gather LIDAR contacts recommendations from NASA (Ivan) and invite to WG-11

[Action]: Shumpei to upload presentation material to workspace

[**Action**] **OEMs/Avionics manufacturers** to investigate on feed forward studies using LiDAR Turb detection (current activities/operational needs/feasibility)

[**Action**] **OEMs/Avionics manufacturers** to brainstorm operational concepts on the LiDAR technologies discussed given the current TRL on the various technologies. Especially Wake/Wave vs traditional turb

[**Action**] study on the sources/phenomenon which need to be included in CAT [**Ven**]

[**Action**] **OEMs** to Study the operational needs for Wake detection in addition to FAA suggested separation criteria based on aircraft weight/speed/altitude etc info.

[**Action, Jeff/Karan**] Send out call for participation to airlines

[**Action, Jeff/Karan**] RTCA and Chair to send out official letter of invite to airlines to participate in WG-10/11 activities. Include some operational benefits in the invite to draw some interest.

[**Action, OEMs**] include in the notes: aircraft level threshold of CAT, to hopefully make the threshold similar to WXR Turb.

[**Action**] [**LiDAR manufacturers**] Eye safety installation and operational requirements? In the operational and performance goals sections? To provide regulatory guidance.

[**Action, Ven**] Committee chair to get with Mike and Lisa to gather LiDAR related regulatory document.

[**Action**] FAA/Ven to reach out to the necessary SMEs on CAT and Wake

[**Action, Jeff/Karan**] Inquire additional aircraft OEMs to participate in SC-230 WG-10 and WG11