National Aeronautics and Space Administration

NASA

WG-2 Agenda

SC-229/WG-98 Plenary #4
Hamburg, Germany
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Agenda

- **Review WG-2 ToR, Scope & Schedule**
- **NASA ELTSAR Project Overview & Schedule**
  - Test Status
    - Crash Safety (Drop Tower)
    - Antenna Cable Strength & Fire/Flame Survivability
    - Vibration
    - GA Plane Crash Series
  - Summer WG Meeting Coordination
- **Additional WG-2 Discussion Items**
- **Draft MOPS Updates**
  - Crash Safety
  - Fire/Flame

Plenary #3 Follow-up
WG-2 ToR

- WG-2 “Crash Safety & Reliability” will provide WG-5 a set of *empirically-based* recommendations for adoption in DO-204B that will result in improved performance of 2nd generation ELT systems. The scope of these recommendations will address known failure modes of 1st generation ELT systems related to crash safety, automatic activation (when applicable), fire/flame survivability, vibration sensitivity, and overall system installation.

Plenary #3 Follow-up
WG-2 Scope

Item	DO-204A	Title
1	2.3.5	Vibration
2	2.3.7	Fire/Flame Survivability
3	2.6.3.1	Automatic Activation (including Fig. 1-1)
4	2.6.3.2	Crash Safety
5	3.1	System Installation
6	all above	Helicopter Specific Issues

WG-2 Meeting History

Meeting	Date	Activity
Plenary #1 Washington	**Mar 2014**	**SC-229 ToR and WG formulation**
WG-2 Telecom	Apr 2014	
WG-2 Telecom	May 2014	
WG-2 Telecom	Jun 2014	
WG-2 Telecom	Jul 2014	
WG-2 Telecom	Aug 2014	
Plenary #2 Toulouse	**Sep 2014**	**Preliminary test results and plan forward**
WG-2 Telecom	Oct 2014	Helicopter crash test complete
WG-2 Telecom	Nov 2014	
WG-2 Telecom	Dec 2014	
Plenary #3 Washington	**Jan 2015**	**Status, research findings, preliminary test results, scope of DO-204B recommendations**
WG-2 Telecom	Feb 2015	

WG-2 Forward Planning
Objectives for 2015 Meetings

Meeting	Date	Activity
WG-2 Telecom	Mar 2015	Crash safety testing complete
Plenary #4 Hamburg	**Apr 2015**	**Draft crash safety & fire recommendations**
WG-2 Telecom	May 2015	
WG-2 Telecom	Jun 2015	Vibration testing complete
WG-2 NASA LaRC	**Jul 2015**	**Meeting at NASA in parallel with crash test #2**
WG-2 Telecom	Aug 2015	Airplane crash testing complete
Plenary #5 Washington	**Sep 2015**	**(1) Deliver final crash safety & fire recommendations to WG-5** **(2) Draft vibration recommendations**
WG-2/-5 Telecom	Oct 2015	
WG-2/-5 Telecom	Nov 2015	Airplane crash analysis complete
Plenary #6 Paris	**Dec 2015**	**(1) Deliver final vibration recommendations to WG-5** **(2) Draft system installation & automatic activation recommendations**

WG-2 Forward Planning
Objectives for 2016 Meetings

Meeting	Date	Activity
WG-2/-5 Telecom	Jan 2016	
WG-2/-5 Telecom	Feb 2016	
WG-2/-5 Telecom	Mar 2016	
Plenary #7 Washington	**Apr 2016**	**Deliver final system installation and automatic activation recommendations to WG-5**
WG-2/-5 Telecom	May 2016	
WG-2/-5 Telecom	Jun 2016	
WG-2/-5 Telecom	Jul 2016	
Plenary #8 Europe	**Aug 2016**	**WG-5 delivers DO-204B to SC-229 to begin FRAC process**
WG-5 Telecom	Sep 2016	
WG-5 Telecom	Oct 2016	
WG-5 Telecom	Nov 2016	
Plenary #9 Washington	**Dec 2016**	**FRAC process**

Emergency Locator Survivability & Reliability (ELTSAR) Project Overview

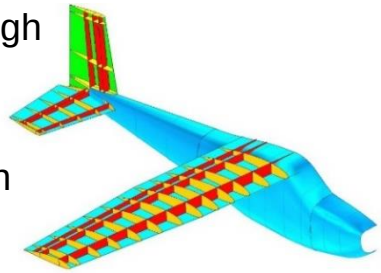
NASA is supporting SC-229's goal of making "*significant improvement to ELT performance*" through a multi-faceted research, analysis and test effort

Research:

- **Historic and current failure rates and modes**
- Crash data from NTSB and other international sources
- Compare current to historic trends
- Identify previous improvements to avoid duplication of effort
- Identify primary failure modes

Analysis:

- **Nonlinear dynamics analysis of severe but survivable airplane crash scenarios**
- Validate models through test correlation
- Investigate various installations and crash scenarios



Test:

- **Ground-based unit testing and installed system crash testing**
- Helicopter crash test (TRACT 2)
- Crash safety testing
- Vibration testing
- Fire testing
- 3 GA airplane crash tests

Deliverables:

- Recommendations to RTCA SC-229/EUROCAE WG-98 regarding minimum performance standards for the next generation of ELT systems

RTCA
THE GOLD STANDARD FOR AVIATION SINCE 1935

EUROCAE

ELTSAR
High-Level Schedule

Phase	Activities	Status	ECD
1	Research & Planning		
	Literature Review	Complete	-
	NTSB Special Study	Complete	-
	Develop Project Plan	Complete	-
2	Laboratory Testing		
	Crash Safety (Vertical Drop Tower)	Complete	-
	Vibration	In-work	FY15 Q3
3	Helicopter Crash Test (TRACT 2)	Complete	-
4	GA Airplane Crash Testing	In-work	FY15 Q4
5	Analysis, Documentation & Closeout		
	Crash Analysis	In-work	FY16 Q2
	Final Recommendations to RTCA SC-229	In-work	FY16 Q2

Test Status
Crash Safety

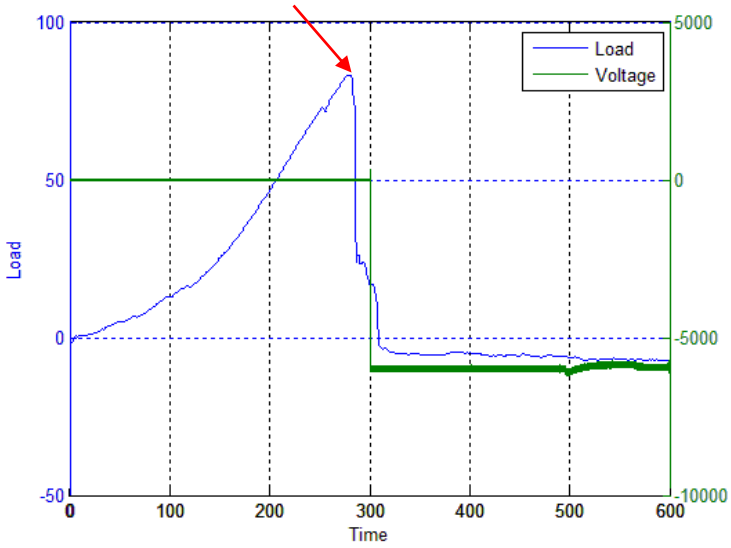
- **Completed testing an ELT with a 6-axis, solid-state, crash sensor**
  - Conduct: same parameters as prior crash safety tests at NASA
    - 15 total tests
    - 1, 2 & 3-axis loading
    - P200 (low g, long duration) & P600 (high g, short duration) crash pulses
    - Structural integrity and automatic activation monitored
  - Results
    - Structural: mounting system was directionally sensitive
    - Automatic Activation: 100% activation for all tests performed
    - This was the only ELT tested to automatically activate for each of these tests, including 6-axis ELTs with mechanical g-switches

See WG-2 summary from Plenary #3 for further test conduct details

Test Status
Antenna Cable Static Strength

- **Conduct:**
  - Samples from 4 ELT manufacturers and in-house avionics lab
  - Tensile pull rate of 0.1 in/min
  - Monitored load & voltage across cable
  - Time-lapse video @ 2 sec interval
- **Results:**
  - Strength range 20 to 100 lbf
  - Good repeatability
  - Failure always occurred at connector

Static failure load



Typical Failures

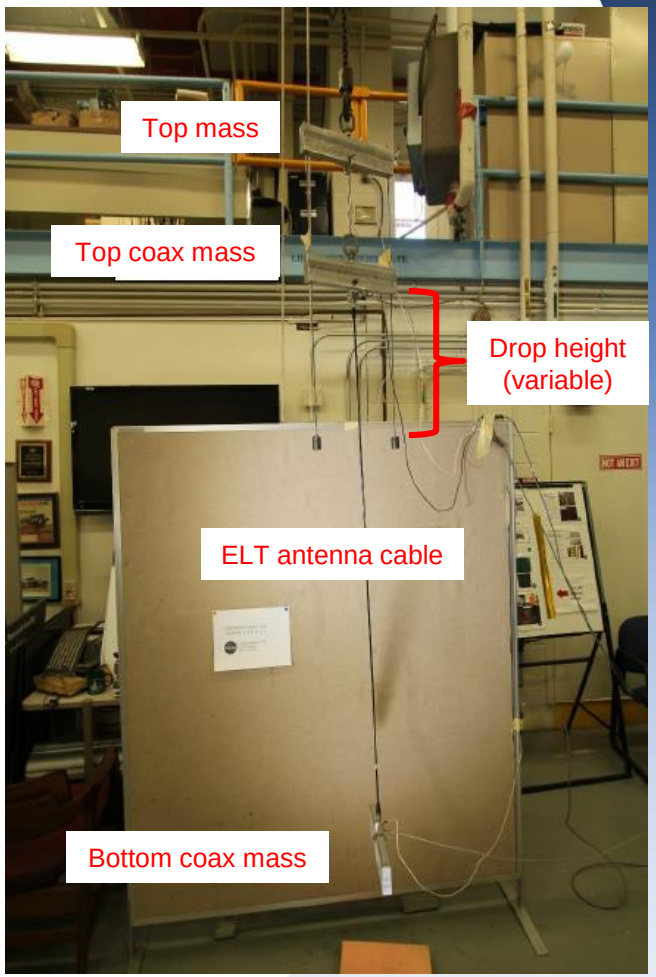
Test Status
Antenna Cable Dynamic Strength

Conduct:

- Samples from 4 ELT manufacturers and in-house avionics lab
- 2 release heights (10 fps, 5 fps)
- 3.7 lb falling mass
- Recorded acceleration of each mass and electrical continuity across cable
- High-speed video

Results:

- Peak force 200 to 500+ lbf for < 10 msec
- Good repeatability using brand new cables for each test
- Failure occurred at one or both connectors
- Some cables passed all tests



Dynamic Test Setup

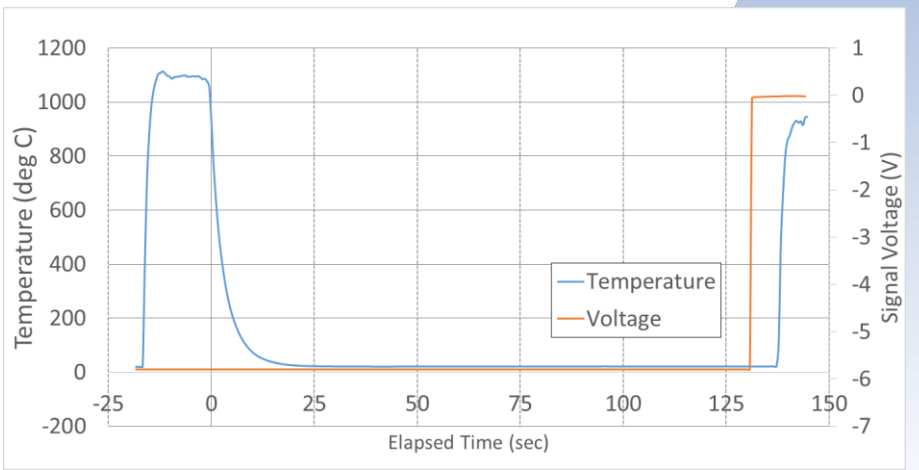
Test Status
Antenna Cable Fire/Flame Survivability

Conduct:

- Samples from 4 ELT manufacturers and in-house avionics lab
- Tested bare cables and COTS thermal protection
- 1100 deg C fire
- Recorded time to electrical failure

Results:

- Electrical continuity
  - Bare Cables: 1-2 mins ave
  - Protected Cables: TBD mins ave
  - Protection Cost: nominal



Test Status
Vibration

- **Test plan includes robust test environments from RTCA DO-160G**
- **Conduct:**
  - Variety of ELTs to be tested (1 & 6-axis mechanical g-switches)
  - Perform self- and g-switch tests before, during and after
  - G-switch test
    - Aligned with longitudinal sensing axis
    - Pulse below and above specified activation threshold (4.5 +/- 0.5 fps, 2 g min)
- **Objective:**
  - Assess the ability of current systems to withstand robust vibration testing and remain within performance specification for automatic activation
  - Install successfully tested ELTs with in-spec g-switches onboard crash tests
  - Apply lessons learned to DO-204B vibration specifications

Test Status
GA Plane Crash Test Series

- **Full-field photogrammetry, high-speed video (external and onboard) & 64 onboard data channels recording:**
  - Airframe & ELT acceleration, pilot & co-pilot loads, antenna cable loads
- **4 live ELTs per plane (12 total)**
- **Installation Options:**
  - Beacon Location: Cabin or Tail
  - Beacon Orientation: Floor, Side, Ceiling, Ceiling 45°
  - Antenna Location: Cabin or Tail
  - Antenna Proximity to Beacon: Same frame or other frame

#	Date (tentative)	Velocity	Pitch	Surface
1	01 Jul 2015	72 fps	+8°	Concrete
2	29 Jul 2015	80 fps	0°	Soil
3	26 Aug 2015	80 fps	-15°	Soil

Summer 2015 WG-2 Meeting

- **SC-229/WG-98 members are invited to NASA Langley Research Center in Hampton, VA to observe GA plane crash test #2**
  - Tentative date is Wednesday, July 29th
  - Conference facilities will be arranged for a WG-2 meeting on July 30th (and July 31st if desired)
  - Similar arrangements can be made for other WG's
  - Notes:
    - If the test is postponed due to weather, the meeting will begin on July 29th
    - For facility access, the following information is needed:
      - Name
      - Company or Organization
      - Date of Birth
      - Social Security Number (US Citizens)
      - Copy of Passport (non-US Citizens)

Additional WG-2 Discussion Items

- **Topics to be provided by the group**

RTCA DO-204A Paragraph 2.6.3.2
Crash Safety

2.6.3.2 Crash Safety (§2.2.5)

The equipment **shall** be secured, in the non-operating mode, to the shock tester, utilizing its normal aircraft installation configuration.

Adjust the shock tester to deliver a shock pulse having a half-sine wave with a duration of 23.0 ±2.0 milliseconds and an amplitude as specified below for each test direction. The instrumentation to demonstrate compliance **shall** have a 3 dB response over the range of at least 5 to 250 Hz. With the equipment mounted in its normal aircraft configuration, apply one shock in each of the following directions:

b. Upward - 100 G

c. Downward - 100 G

d. Backward - 100 G

e. Forward - 100 G

f. Sideward - 100 G (2 directions)

Upon completion of this test, the ELT shall be turned ON. The ELT must meet the aliveness test of Subsection 2.3.

1. Include multiple pulses to represent bounds of environment

2. Include multi-axis orientations, which failed previously qualified designs in ELTSAR testing

3. Demonstrate automatic activation & transmission *during* the event

RTCA DO-204A Paragraph 2.3.7 Fire/Flame Test

2.3.7 Flame/Fire Test

The ELT Unit **shall** be activated in accordance with §2.3.1.1.c. (3) or manually switched ON if a crash acceleration sensor is not used. The ELT, antenna and antenna cabling **shall** be subjected to the following tests:

2.3.7.1 Flame Test (All ELTs)

At the start of the flame test the temperature of the ELT **shall** have been allowed to stabilize in an ambient temperature of +25° C.

a. The fire source **shall** be a tray, 1 m (3.28 ft) square and 100 mm (4 in) deep, containing water to a depth of five cm, (2 in) on which is floated 10 liters (2.64 U.S. gallons) of Avgas (100 LL). The Avgas is ignited and allowed to burn for 15 ±2 s, before carrying out the following flame test.

b. The equipment under test **shall** be placed in a position directly over the center of the fire tray at a height of 1 ±0.025 m (39 in ±1 in), above the tray.

c. The equipment under test **shall** remain in the flame for a minimum period of 15 seconds.

d. The test **shall** be conducted in still air if possible.

e. After removal from the flame, the equipment under test **shall** be allowed to cool naturally to ambient temperature before being tested. The ELT must meet the aliveness test of Subsection 2.3.

f. Ensure that all mechanical devices operate satisfactorily.

2.3.7.2 Fire Test (When Required)

The ELT(AF) **shall** be subjected to a fire of at least 1,100° C, producing a thermal flux of 20 W/cm^2 (63,400 BTU/ft^2 hr) minimum. The minimum diameter of the area of the fire **shall** be twice the maximum diagonal dimension of the ELT. The flames **shall** envelop the outside area of the ELT under test for a continuous and uninterrupted period *of at least* two minutes.

After removal from the flame, the equipment under test **shall** be allowed to cool naturally to ambient temperature before being tested. The ELT must meet the aliveness test of Subsection 2.3.

Note, per Table 2-2, the fire test is optional for AF & AP and Not Applicable for S & AD type ELTs

1. Duration should be performance-based, i.e. a desired multiple of satellite bursts

2. Confirm functionality *during* event, perhaps via remote activation and monitoring

3. Merge the fire/flame tests into a single, performance-based test that considers operational characteristics, such as satellite transmission delay times and functionality *during* event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