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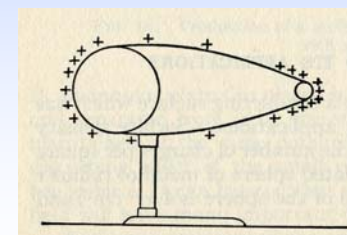


High-Voltage: P-static Test and Evaluation Facility at the FAA Technical Center

Robert Lilley, Aviation Management Associates, Inc.
Robert Erikson, W. J.; Hughes FAA Technical Center

FAA Cooperative Agreement 04-G-040, Task 3

October 24, 2006



October 24, 2006 - 1



P-static, the cause



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- ✈ **All aircraft charge in flight.**

- ✈ Impact – snow, rain, dust

 - ✈ “Wetted frontal area”

- ✈ Engine ion production

 - ✈ Impact, again, really





P-static, the culprits



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➤ Discharge Mechanisms

- Arcs
 - Equalizing potential among airframe elements
 - Maintenance – bonding, loose rivets, bad antenna mount, corrosion
- Streamers
 - Draining stored charge from dielectric surfaces
 - Maintenance – resistive coatings, windscreen glue bypass
- Corona
 - Equalizing airframe and atmosphere
 - Maintenance – dischargers burnt, broken; antenna coatings pinholed, sharp points uncoated.





P-static, reduction

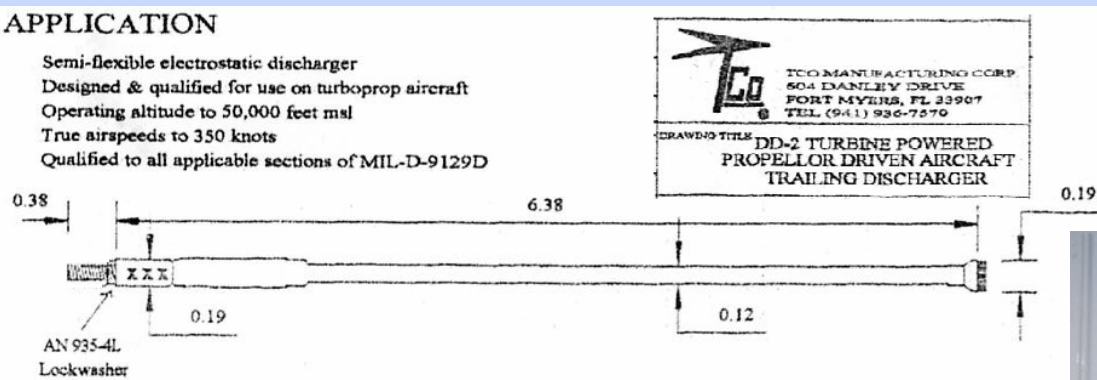
Size matters



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APPLICATION

Semi-flexible electrostatic discharger
Designed & qualified for use on turboprop aircraft
Operating altitude to 50,000 feet msl
True airspeeds to 350 knots
Qualified to all applicable sections of MIL-D-9129D



TCO DD-2 discharger

- -Low noise, efficient discharge at low corona threshold.
- -Resistive; forms filter with a/c capacitance
- -4μ wires

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ASA-3 discharger

- Same goal,
- different design
- Resistive wicks



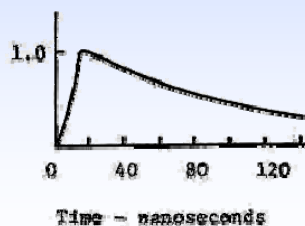


Motivation

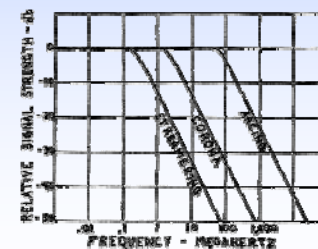


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- eLoran succeeds: new round of user equipment expected
 - Need to design tests for proponent receivers (RTCA docs)
 - Certification path must be sufficient, but also affordable
- Ground vs: flight tests for p-static effects
 - Can ground test be sufficiently representative of flight conditions?
 - Bob Truax's work says "yes", and our previous work suggests "yes"
 - Must we test every installation?
 - Define test sequence
 - – Can mfgr/DER combo succeed, or is a central "UL" Lab needed?



P-static threat to other systems?





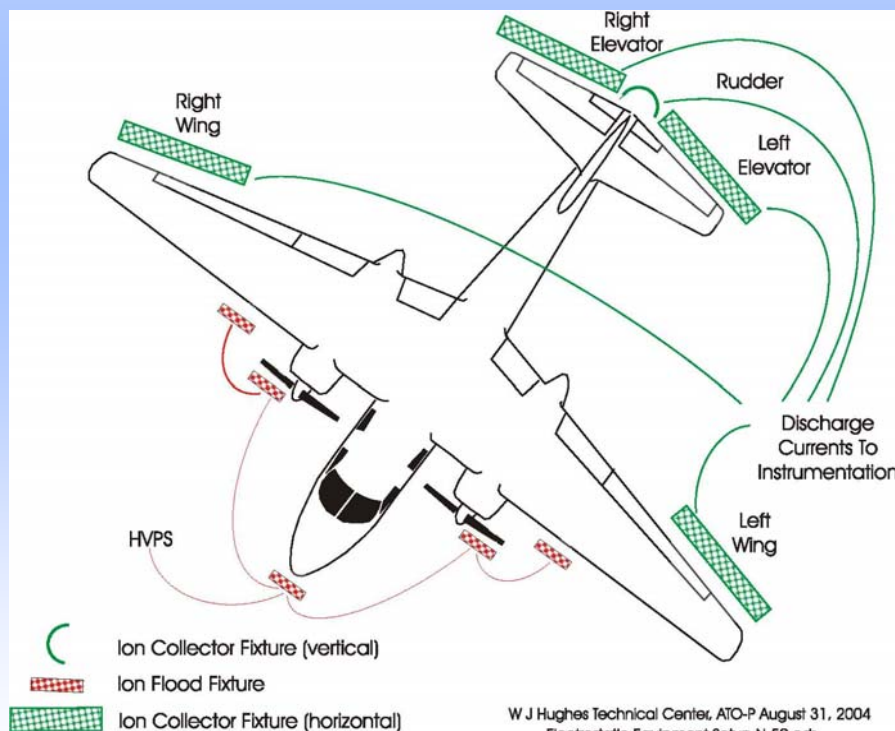
Backdrop – methods



→ Ground test method

→ (R. Truax, for 3 decades; now FAATC)

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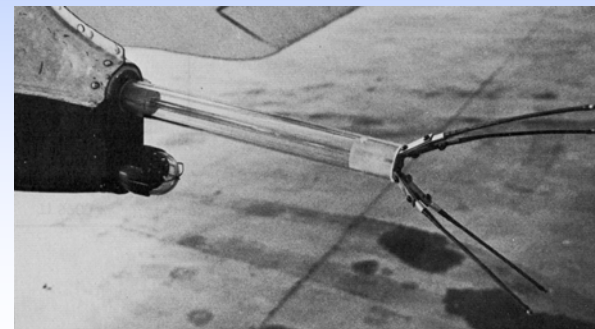


Backdrop: experiences



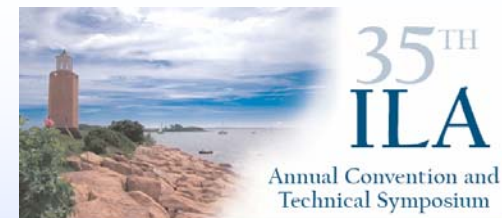
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- 1992 – Ohio's DC-3 – ground and flight
- 1998 - Ohio's Saratoga
 - As the FAA Loran evaluation program was getting underway
 - Modeling of coverage/availability using all-in-view
 - E/H field antenna comparisons
- 2004 – FAA's Aero Commander
 - Ground, flight
 - P-static on demand difficult
 - Active charging – DC-3 / Commander (FAATC approval difficult)
- Observations
 - Noise proportional to total current?
 - Invariant across aircraft types?
 - Ground tests representative of flight?





Airplanes



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Ohio University King-Air, DC-3 and Saratoga
FAA Technical Center Aero Commander



October 24, 2006 - 8

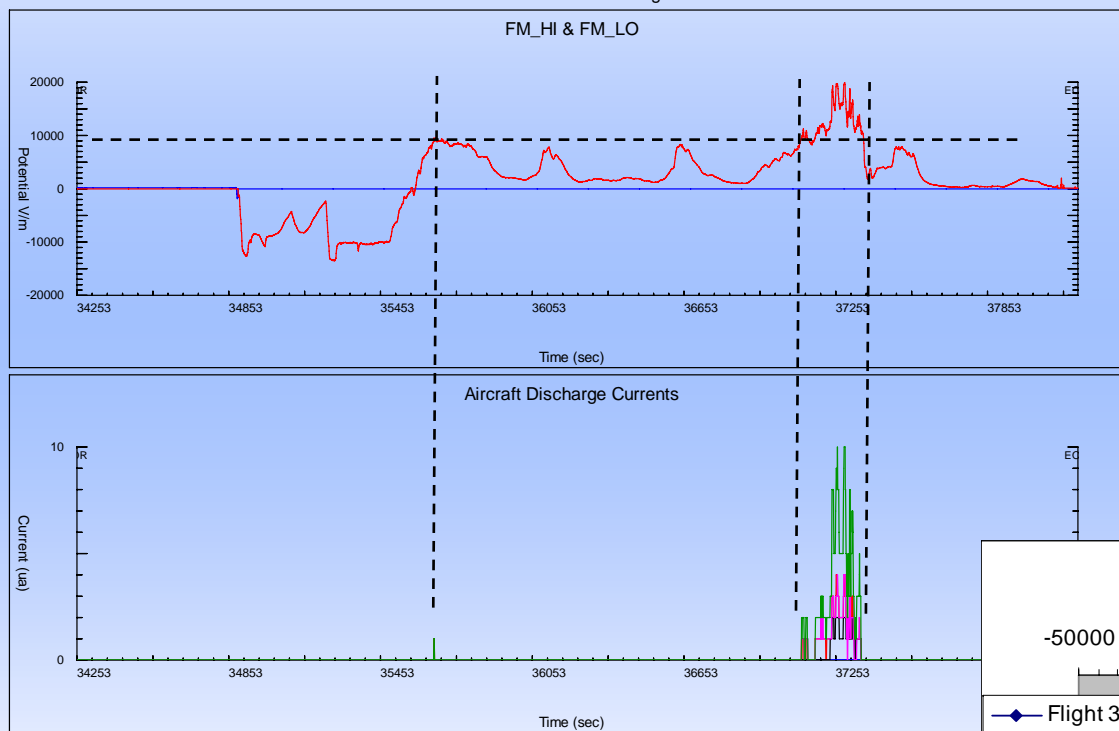


Air: Example

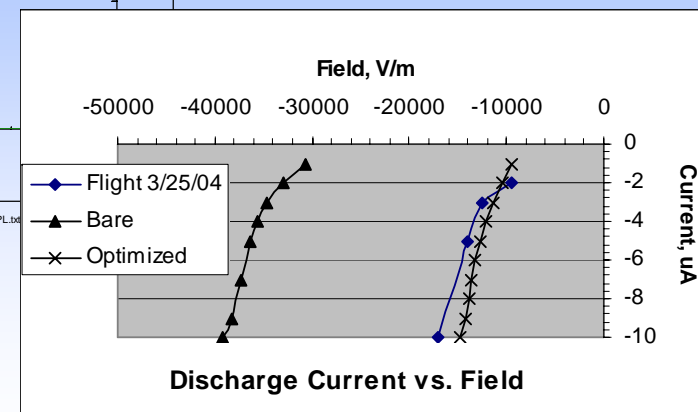


N-50 Flight 3/25/04, DD-2s Corona threshold; agreement with ground

Loran P-Static Testing



- 9.5 kV/m corona threshold observed
- Individual dischargers plus absolute-value sum shown
- Low currents; agree with ground “optimized” data; few dischargers conducting



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Legend: SME=Blue, SMH=Red, Apollo=Black, FM_H_Sen.=Blue, FM_L_Sen.=Red
RW=Red, RU=Black, LW=Magenta, Sum_I=Green

Files: ACY032504_Ext.txt, ACY032504_SME.txt, ACY032504_SMH.txt, ACY032504_APL.txt

Printed: 10/23/2006 7:25:37 PM FAA - W J Hughes Technical Center





Ground: Summary



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- ✈ Three different airplanes
 - ✈ Different times, different places; same type of discharger units
- ✈ P-static effects appear to be consistent
 - ✈ Noise comparison at -100 uA discharge current
 - ✈ Similar enough to suggest that total current is a predictor of noise increase
 - ✈ Could we move toward a general rule, not installation-specific?

Noise @ 100 μ A	DC-3	Saratoga	N50
Bare aircraft	33.9 dB	28.1 dB	24.0 dB
With dischargers	4.5 dB	2.6 dB	1.0 dB
Difference	29.4dB	25.5 dB	23.0 dB



- ✈ Antenna design, location, A/C maintenance are still factors



FAATC HV Facility

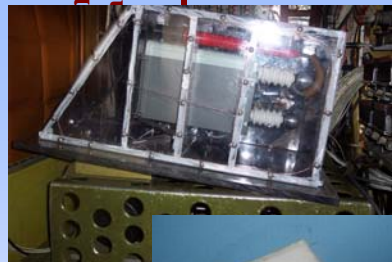


→ Purposes

- Provide data in response to RTCA SC questions
- Support for later proponent TSO testing, if needed

→ Controlled environment

- Screen room
- TCO test fixtures
- High voltage power supplies, accessories
- Field Mill – electric field measurement



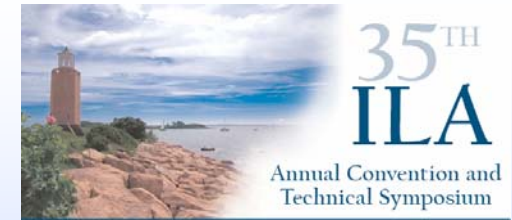
→ Calibration / Validation with flight data

- FAATC aircraft
- Other data -





P-static plans



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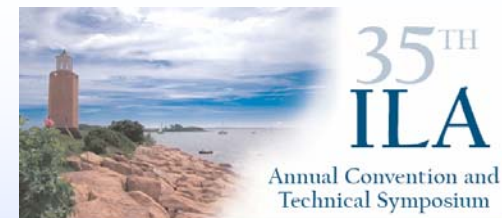
➤ Initial tests – research question briefs:

- Is screen room useful / required?
- A/C as capacitor – charge storage
 - Earlier ground tests indicate “yes”
 - Effect on test results
 - Wing section
 - Bench-top test configuration?
 - Is it “just noise” based on current and distance to antenna?
 - Direct-drive discharger or cluster as noise generator?
 - LDaC to measure spectrum and capture noise data
- Emulate corona streamer, arc sources





Will it fly?



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October 24, 2006 - 13



More plans



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- Effect of number and type of discharger units
 - Is a single discharger or a cluster with closely-spaced antenna sufficient to emulate an aircraft in flight generating corona?
 - Is the noise from multiple dischargers additive?





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Status: October, 2006



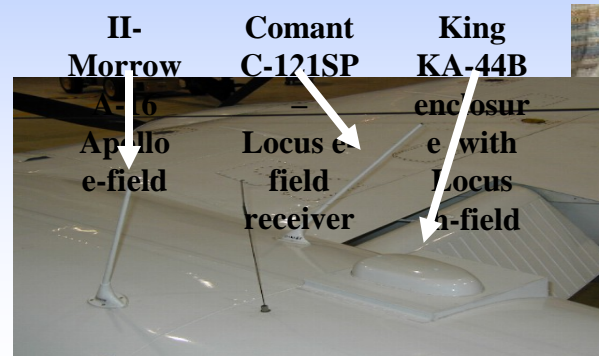
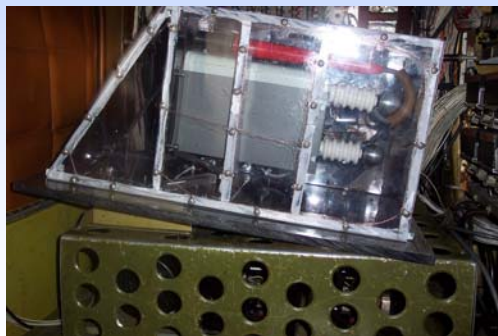
➤ RF Screen room available

➤ Early tests will determine need and effectiveness



➤ Aero commander A/C instrumented, tested and available

➤ Equipped for natural and artificial charging, instrumented dischargers, field mill, data collection gear. Natural charging is flight-proven. Approval is being sought for artificial charging.



October 24, 2006 - 15



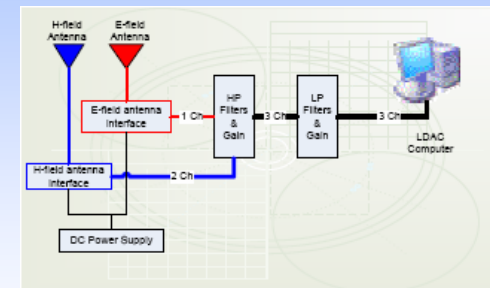
Status --



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- TCO special equipment housed at FAATC
 - Bob Truax phone-consulting
- New test fixtures
 - Wing section and instrumented supports
 - Charge storage and credibility
 - Benchtop fixture - corona and discharger noise
 - Truax simulator – arcs, streamers
 - Dielectric fixture - streamers
- LDaC completed and tested
 - High-speed “wide-band” data collection

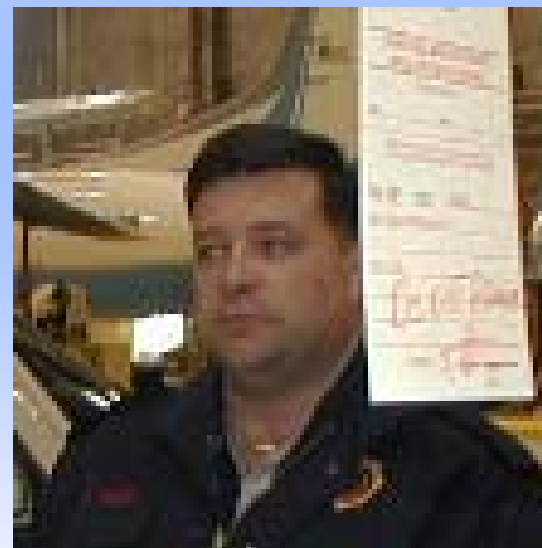




Status---



➔ FAATC fire/rescue teams are acclimated(?)
to Bob Erikson and his high-voltage tests...



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October 24, 2006 - 17