Airbus – NLR ILDAS 2 project related to BTP

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4 nov. Workshop at CWI, A'dam

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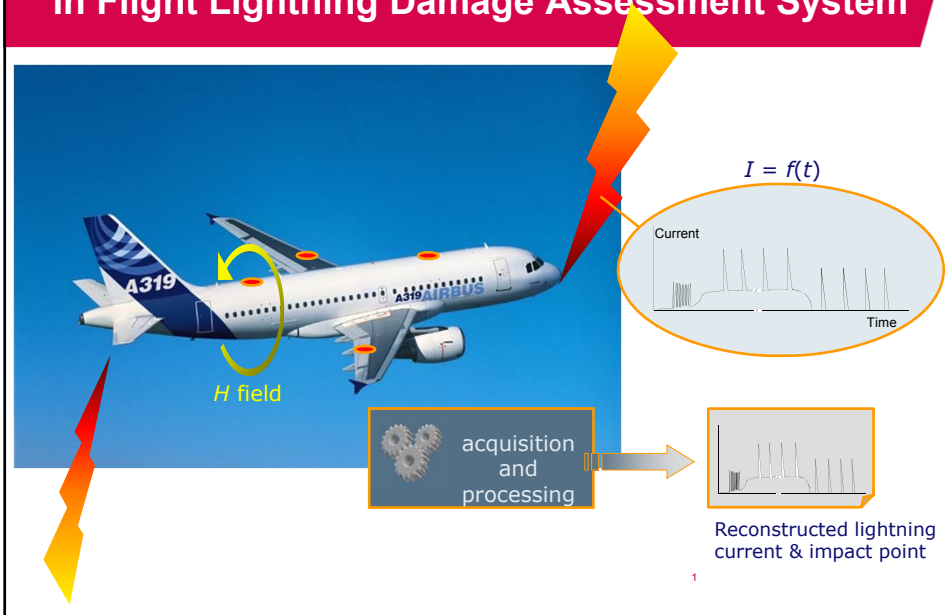
In Flight Lightning Damage Assessment System



Goal ILDAS

ILDAS-1 2006-2009,

ILDAS-2 2009-2014

- **Localize attachment**
- **Determine severity**
- **Decide on or speed up maintenance**
- **Build database**
- **Statistical analysis**

Partners:

Acra Control
Air France Industries
Airbus France
Culham Lightning Ltd.
Dassault Aviation
EADS Innovation Works
Eurocopter Deutschland GmbH
European Aviation Safety Agency (EASA)
Groupe Socius
LA Composite
Lufthansa
Lufthansa Technik
Marshall of Cambridge Aerospace
National Aerospace Laboratory NLR
ONERA
TU/e
USE2ACES
Vector Fields

Sensors and Ranges

Model calculations:

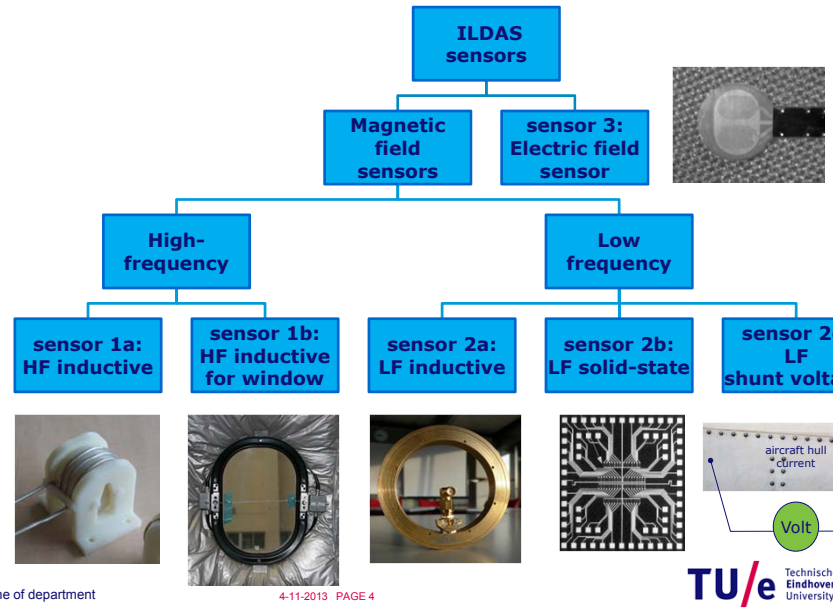
- **Amplitude: H-field 30 kA/m – 1 A/m**
- **Time: 0.2 μs – 1 s**

Multiple band system:

- **Solid State**
- **Coil + integrator**
- **Resistive**

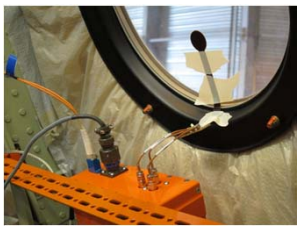
Trigger on electric field

Sensor types

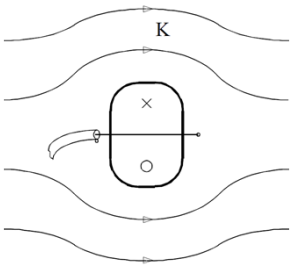


D/I measurements in aircraft

- Differentiating sensor
- Transport by cable
- Integrator
- Registration in EMC cabinet



E-field

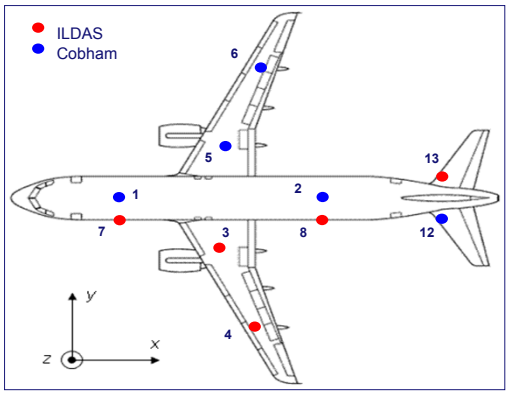


H-field window sensor
IE3 J. Sens. 11 (2011) 199

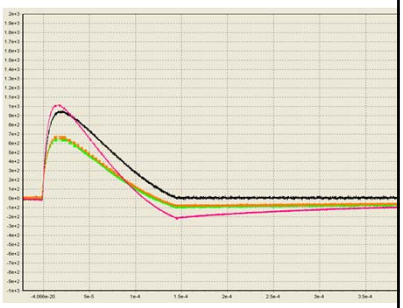
A320 tests at Airbus, Toulouse

Electrica… …versiteit …chnology

A320 tests at Airbus, Toulouse



VTP to Nose



— Injected current
Reconstructed from :
— H07 sensor
— H08 sensor
— H13 sensor

/ name of department

4-11-2013 PAGE 11

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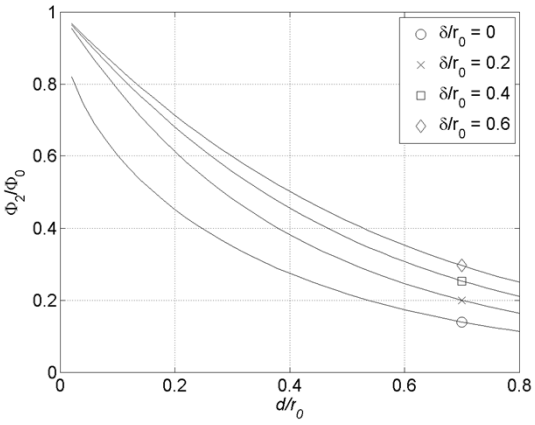
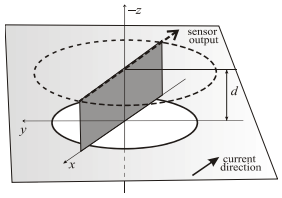
Window sensor calibration

Analytical approach for circular hole (Franz Ollendorff, 1932)





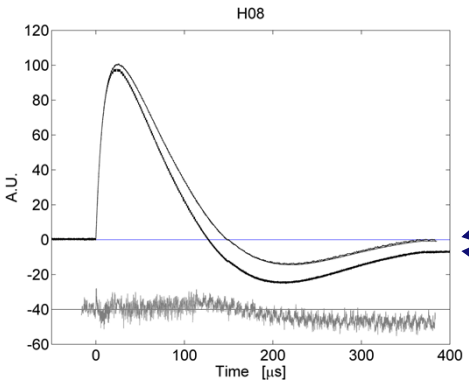
$$X = \frac{1}{2} H_0 \rho \left[1 + \frac{2}{\pi} \left(\arctan \xi + \frac{\xi}{1+\xi^2} \right) \right] \sin \varphi$$

$$H = \nabla X$$

$$\Phi_0 = r_0^2 H_0$$

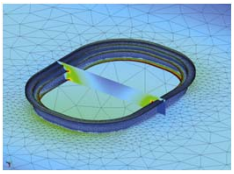
Window sensor calibration

Model to calculate sensitivity and redress waveform



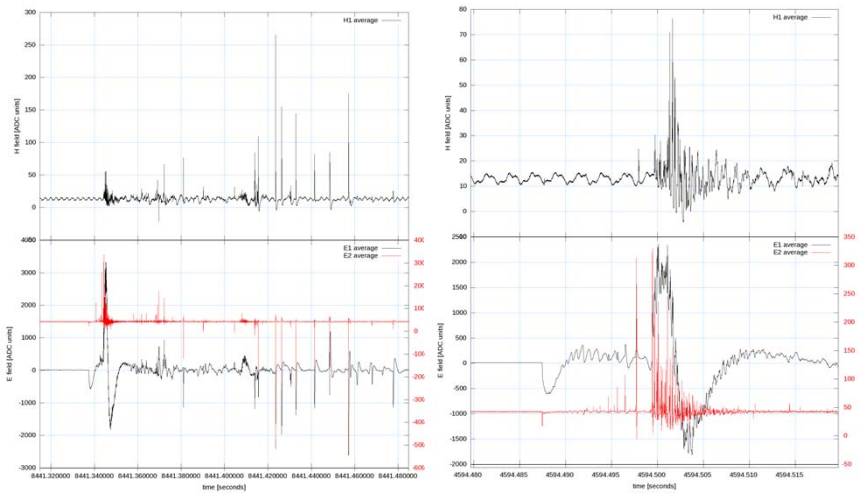
Waveform:
after correction
before

Difference × 10



	H07	H08
Rec. 10	148	158
Rec. 11	147	158
FDTD	141	--

A340 flight tests, begin 2011

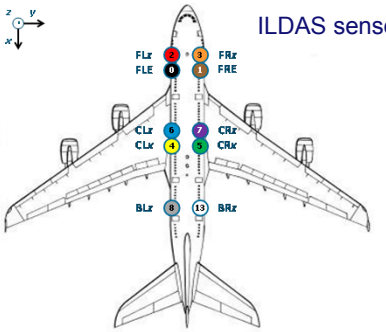


Alte de Boer et al.,
ICOLSE 2011, Oxford & SFTE 2012, Amsterdam

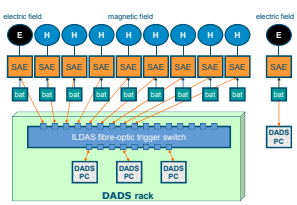
A380 Tests, spring 2013

ILDAS installed on the A380 flying test bed for the A350 XWB engine in the engine's icing certification flight tests

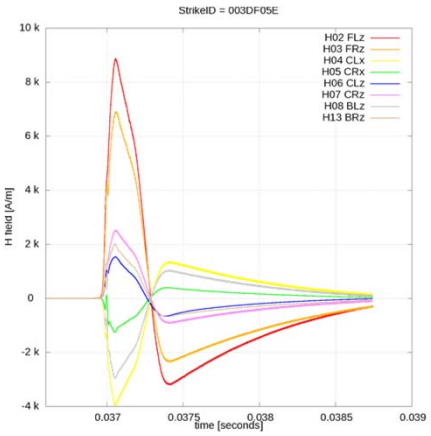
ILDAS sensor configuration

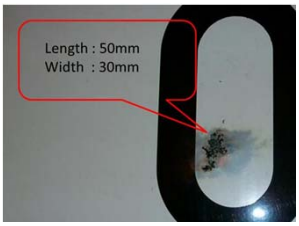


ILDAS configuration



An H-field record flight May 2013

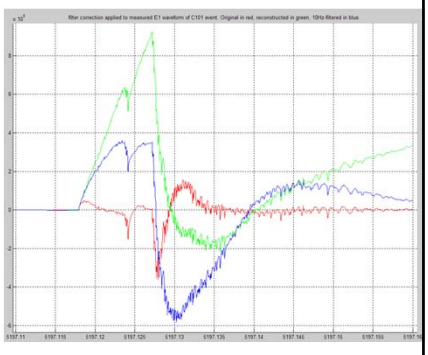




190 kA stroke

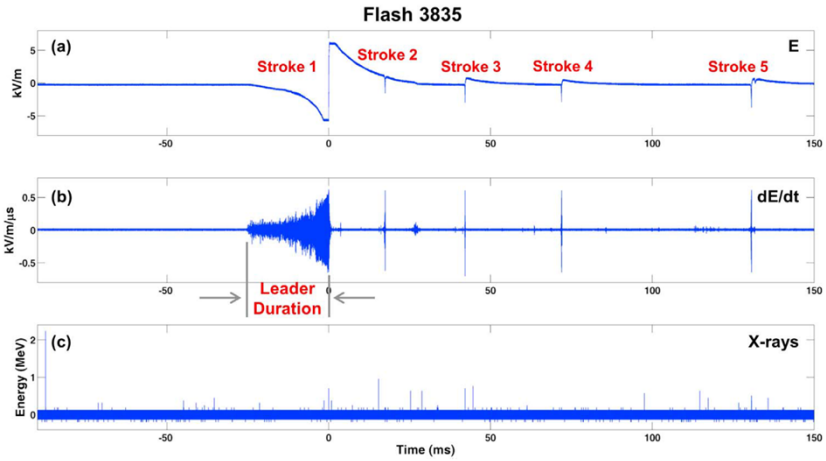
Outlook

- **A350 test flights, with many window sensors only**
  - **Composite material**
- **Interest from geophysicists / lightning specialists**
  - **Inception leader current, connected with E-field data**
  - **Lightning current f(t) behavior**
  - **X-rays during discharge development**



E field at leader initiation
A. de Boer et al., SFTE 2012

But:



A study of X-ray emissions from thunderstorms with emphasis on subsequent strokes in natural lightning, S. Mallick, V. A. Rakov, and J. R. Dwyer, (2012) J. Geophys. Res., vol. 117, D16107

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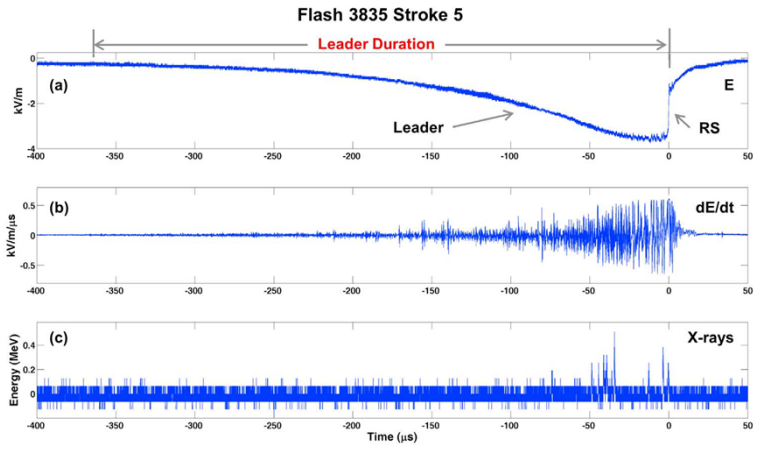

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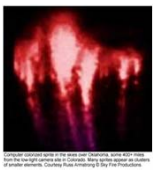
End 2013 flights

- At 0°C level with Airbus 350
- ILDAS with window sensors for lightning
- 2 X-ray detectors embedded in ILDAS
  - range of energies 30 keV – 15 or 20 MeV
  - 3 mm Al attenuates energy < 50 keV
  - CRFP unknown attenuation yet
- Hires data ± 0.5 s from trigger by lightning hit
- Continuous counting during flight in 18 ms interval of 2 level-crossings

Research questions

- X-rays ?
- If, during lightning attachment ?
  1 sec measurements
- Afterglow (D. Smith, ICSC)
  2 sec would have been better
- Background by cosmic radiation ?
  Continuous counting
- TLF X-ray contribution ?
  Extremely bright (David Smith)



Let's hope for the best


"That's all Folks!"