The story of the mysterious disappearance of

Air France Flight AF 447

over the Atlantic ocean on June 1, 2009

Based on France's BEA's Final Report of this accident,
with my personal observations and comments.

OLLI Course T 802

October 3, 2012

Ludwig Benner

The Aircraft...

- Airbus A-330-200, operated by Air France
- Built in 2005 , Toulouse, France
- 18,870 hours flying time (block to block)
- cost (list price) =~ € 195 million

This is the aircraft involved

The Flight…

- Rio de Janeiro Brazil to Paris France
- Sunday, May 30, 2009, departed 22:29
- 216 passengers, 3 pilots, 9 cabin attendants (228)
- t/o weight 233 tonnes
- 5708 mile trip, 11 hr 24 min est flight time

This is the flight involved

Flight AF 447 was under radar control from departure from Rio de Janeiro airport to the INTOL waypoint, and under radar coverage up to the SALPU waypoint (RECIFE FIR, located between INTOL and ORARO). After this point, AF 447 was under en-route control (via a flight progress strip) based on information in the flight plan updated by the crew or by exchanges between control centres.

Air Traffic control route for flight and ATC control sectors

447 left Brazil coastline at NATAL waypoint about 01:00 under radar control. After that it was tracked by radar in the Recife Flight Information Region (FIR) until SALPU waypoint. Then flight was out of radar range, with position updates dependent on radio communications between 447 and ATC center in Senegal Africa

A330 cockpit at night

Aircraft was being operated from cockpit by two Pilots (PF and PNF)
Dark outside until accident. Flying on instruments – no visual cues
Note joystick– A330 is a “fly by wire” designed aircraft, highly computerized to achieve normal flights.

A330 cockpit at night

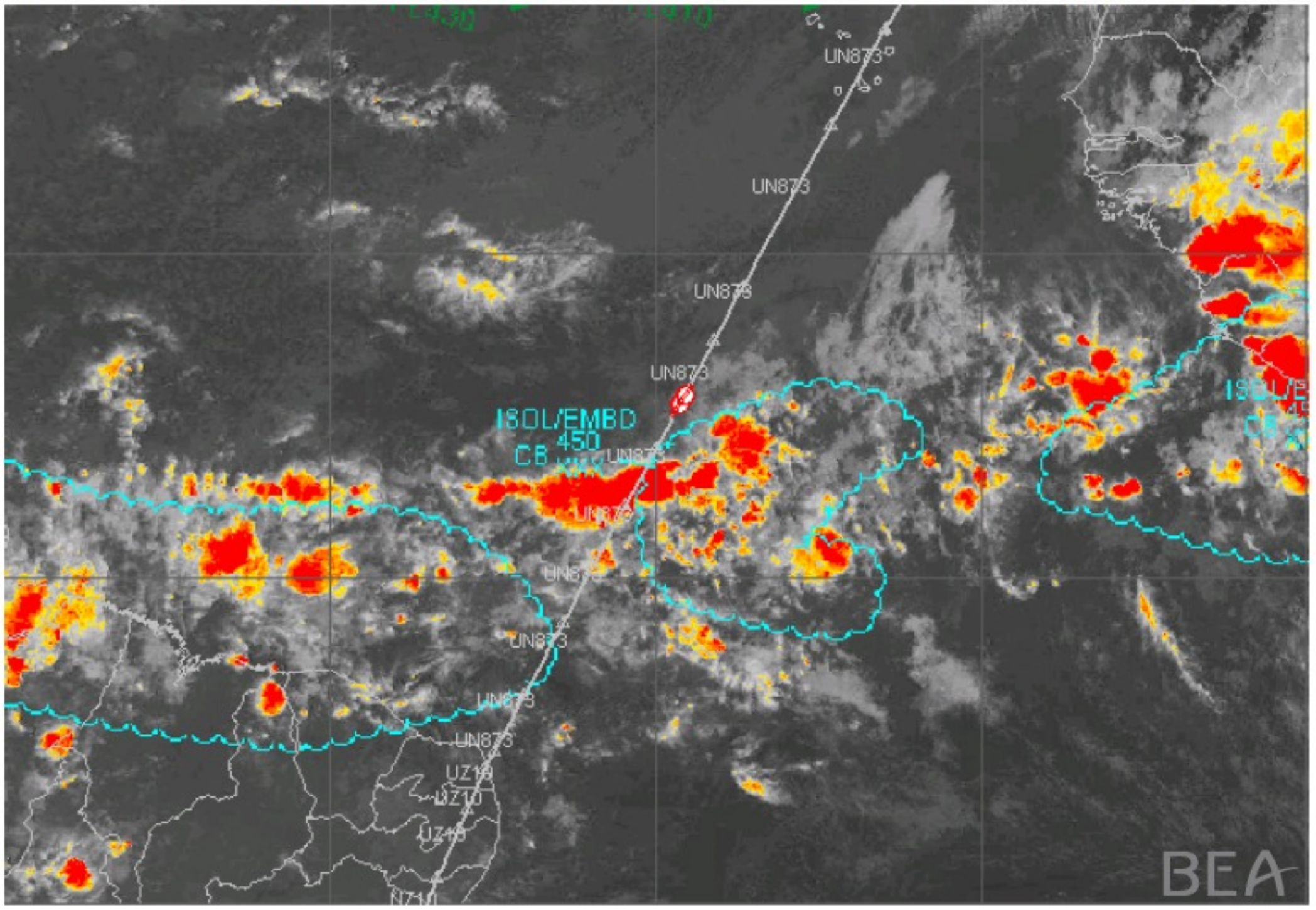
This shows displays in cockpit on which pilots relied for information about their flight.

Flight history…

- Uneventful flight at FL35 on autopilot to INTOL
- At INTOL, attempt to switch to Dakar Oceanic failed (1:35)
- Crew noted “thing ahead”on radar (1:35 +?)
- Flew into slightly turbulent zone at SALPU (1:45)
- Turbulence stopped (1:52)
- Approached ORARO at FL35, MACH .82, pitch ~2.5°, w&b=205 tonnes and 29º, couldn’t climb above cloud layer
- PF advised cabin crew to watch out in 2 min (2:08)

Note perturbation for 7 minutes between SALPU and ORARO waypoints.
Note also the slight pitch angle at which plane was stable at altitude. Probably unnoticeable in cabin.

IR -40° du 01 juin 00 h 00 + extrait TEMSI London 01 juin 00h 00



To give you context for what's coming, This shows you after the fact what they were flying into, expecting turbulence. Reconstructed weather map of Intertropical Convergence Zone (ITCZ) from satellite images, showing flight path. Around 00:30 OCC (Paris) informed crew about ITCZ. Note small cell before big cell

Red is storm cells potentially with icing, est to 50,000 ft high

Little cloud obscured big mass due to radar setting limits

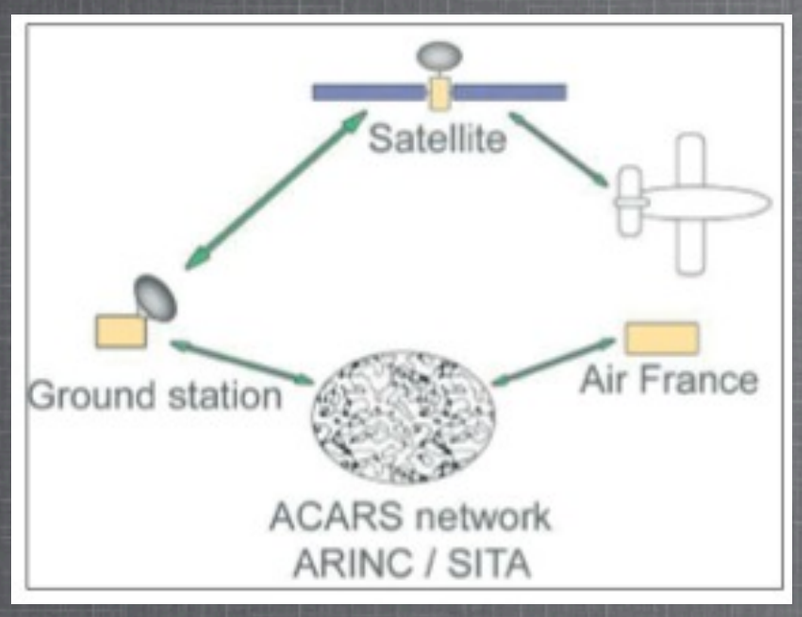
ATC Communications ceased

- no voice exchanges after 01:35
- third ADS-C connection failed (02:01)
- out of range out of ground radar

New communications from AF 447:

- Burst of ACARS Fault Messages sent automatically starting at 02:10:05
- That marked the start of cascading problems faced by pilots
- ACARS stopped at 02:14:26

ATC = Air traffic control (ground stations – separate aircraft)
ADS = automatic dependent surveillance – (contract or bilateral connection for tracking flight)
ACARS= Aircraft communication addressing and recording system, air to ground fault reporting system for maintenance crews



Flight computer sent Paris 24 ACARS fault messages in 4 min 16 secs

T_e= 2:10:05

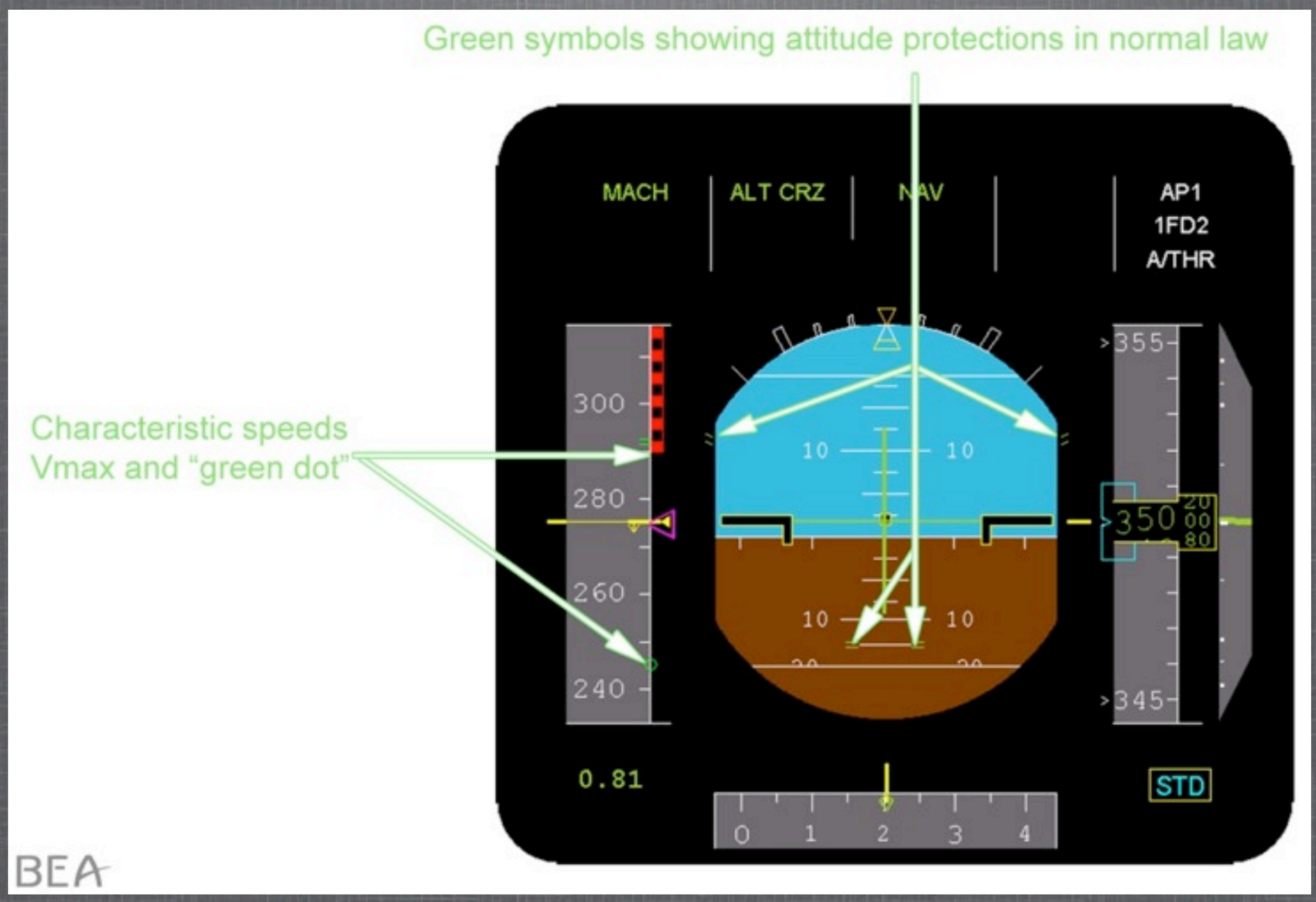
AP OFF -> ALT LAW

ECAM=Electronic Centralized Aircraft Monitoring
Read across left to right, times a top
AP OFF is first message T-emergency for pilots = 2:10:05
Autopilot off – control required manual pilot control

ACARS Messages sent from Flight computer to Paris are displayed here (2:10:05)

24 Messages were displayed as sent, to inform ops center and pilots of faults
Pilots have to observe, diagnose and respond to displayed messages, sounds and voiced stall warnings while managing aircraft flight at night in rough weather with no external visual navigation cues

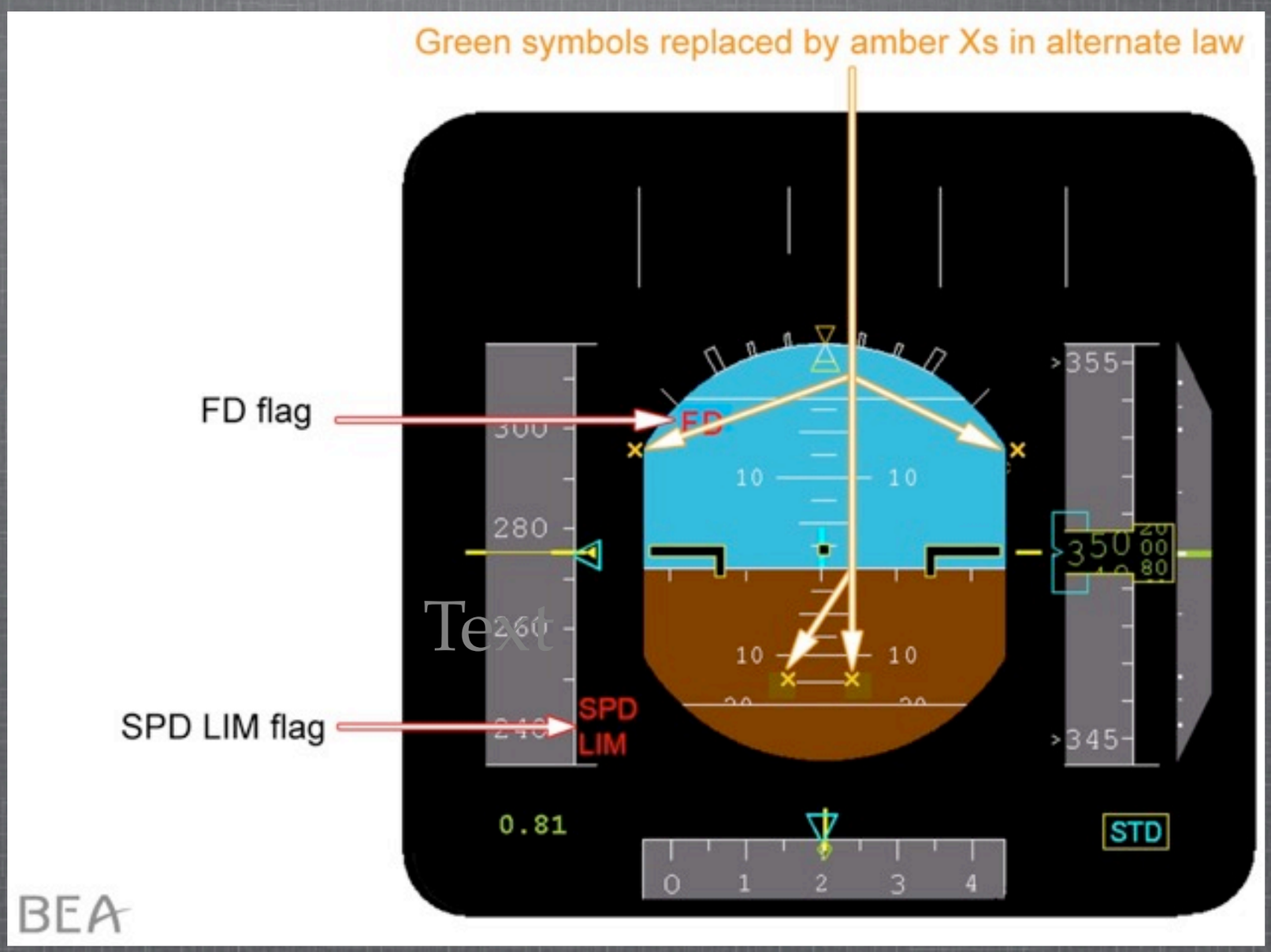
A330 Primary Flight Display (PFD)



Green turns to amber when AP disconnects (2:10:05)

Pilots primary dynamic information source during flight is PFD, other displays get frequent scans by PNF.

2:10:05 Flight Director began changing displayed data



At 2:10:10, 5 seconds after autopilot quit,
First of several STALL WARNINGS also sounded

For the next four minutes the pilots grappled with sights and sounds greeting them, trying to make sense out of these dynamic inputs.

02:14:23 (Robert) Putain, on va taper... C'est pas vrai!
Damn it, we're going to crash... This can't be happening!

02:14:25 (Bonin) Mais qu'est-ce que se passe?
But what's happening?

C -3 sec

C-1 sec

- ACARS stopped at 02:14:26

AF 447 went silent

Meanwhile, in Paris,

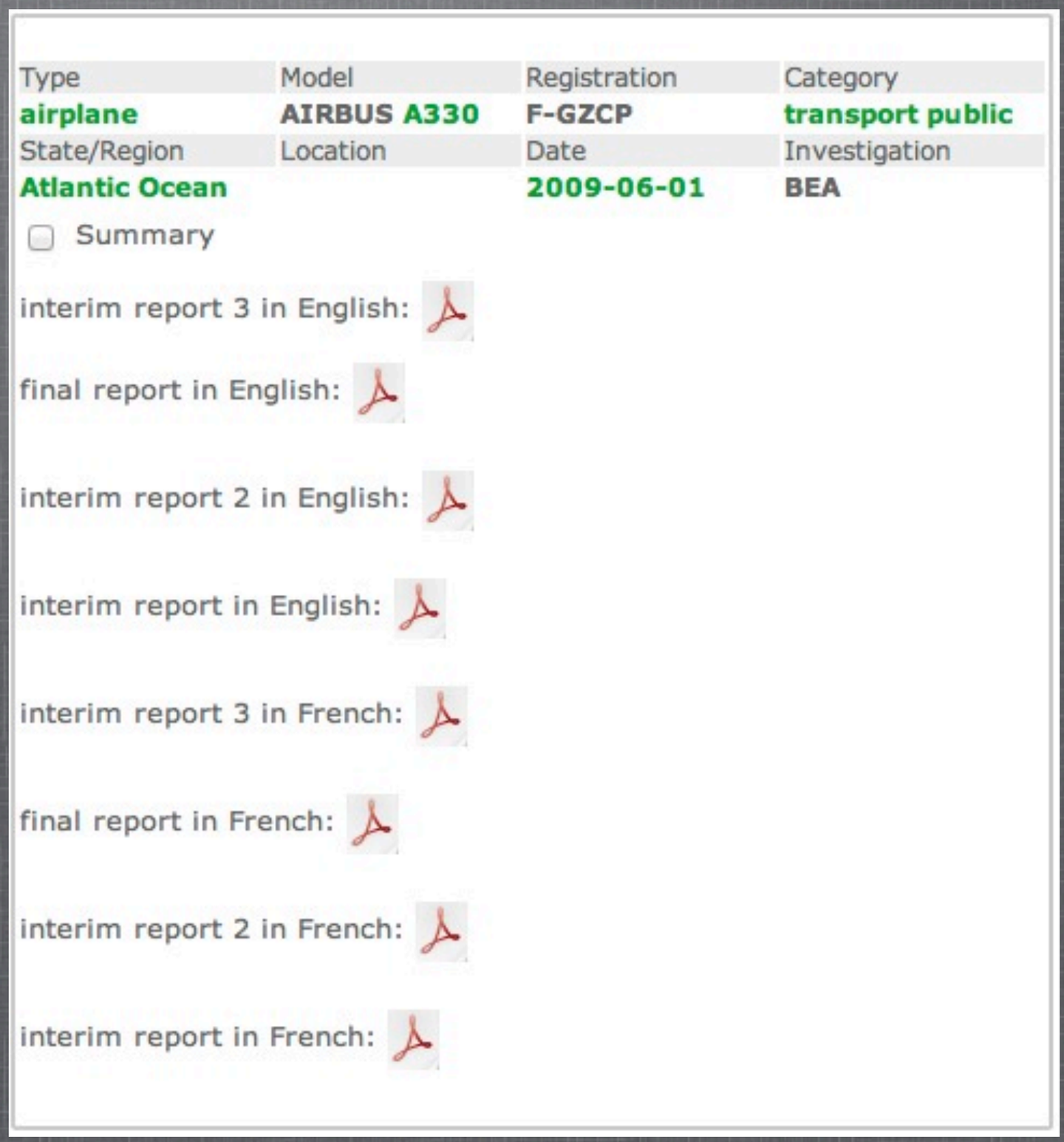
- Operations Control Center (OCC) monitored ACARS reports for AF systems
- OCC display indicated problem
- OCC alerted Crisis Center (CC.AF)
- BEA alerted

ACARS Reports flowed automatically to AirFrance OCC. When report flow anomaly occurs, systems are in place for the OCC to activate action within AF emergency actions

We now know flight ended and AF447 went silent when plane struck water.

BEA INVESTIGATION

Very complex investigation from June 2009 to July 2012, produced a number of reports over the next three years



Type	Model	Registration	Category
airplane	AIRBUS A330	F-GZCP	transport public
State/Region	Location	Date	Investigation
Atlantic Ocean		2009-06-01	BEA

Summary

interim report 3 in English:

final report in English:

interim report 2 in English:

interim report in English:

interim report 3 in French:

final report in French:

interim report 2 in French:

interim report in French:

Aircraft disappeared in mid-ocean with few clues about its disappearance. The investigation makes an interesting story. French BEA =Bureau of Investigations and Analyses for the Safety of Civil Aviation initiated an investigation of the presumed accident, spent €34 m. Issued 2 interim and one Final report - with reconstructed description of investigation and accident scenario, plus recommendations.

Published July 2012

Final Report

On the accident on **1st June 2009**
to the **Airbus A330-203**
registered **F-GZCP**
operated by **Air France**
flight AF 447 Rio de Janeiro - Paris

€ 34 million Investigation

BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile
Ministère de l'Écologie, du Développement durable, des Transports et du Logement

http://www.bea.aero/en/recherche_publi_result.php

Much of the presentation is from BEA's reports. They can be accessed at the web page shown.

The Investigation

BEA
Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile
Ministère de l'Écologie, du Développement durable, des Transports et du Logement

3 major phases...

Under ICAO Treaty SARPs

We'll briefly step through each

Phase 1 – Initial tasks

- Sea searches
- Maintenance group
- Operations group
- Systems and Equipment group

ACARS was only available accident data from the aircraft for 5 days

Sea searches = locate crash site debris collection, recorder recovery
Maintenance = F-GZCP history, 330 series history, ACARS, ADs, ACs
Operations = dispatch, ATC, pilot records, weather, black box analysis
Systems and Equipment= design, component histories, (pitot tubes, for example)
Investigated under ICAO treaty's SARPS for investigations ICAO = ….

The Investigation

Phase 2 - Wreckage search and recovery

1. Initial surface search
2. Undersea search
   - Phase 1 – acoustic search
   - Phase 2 – Side scan sonar
   - Phase 3 – AUV over 6300 km2
   - Phase 4 – WHOI terrain-following AUVs
     - site discovery
     - photo runs
     - photo fusion
   - Phase 5 – CVR/FDR and parts recovery and debris field mapping

AUVs are autonomous underwater vehicles, typically towed thru water
Woods Hole Oceanographic Institution, a US entity, played crucial role in wreckage recovery.

The Investigation

Phase 3 – after wreckage recovery,

- Black box CVR and FDR readouts
- Flight analysis
- Debris analysis
- Analyses integration into explanatory description of what happened
- Problem definition
- Recommendation development
- Report publication (ICAO format)

“Black boxes” or data recorders were keys to reconstructing what happened in this case because they were the only source of dynamic in-flight behaviors. Salvaged debris also provided surviving data for inferring some events. This is the process involved.

The Investigation

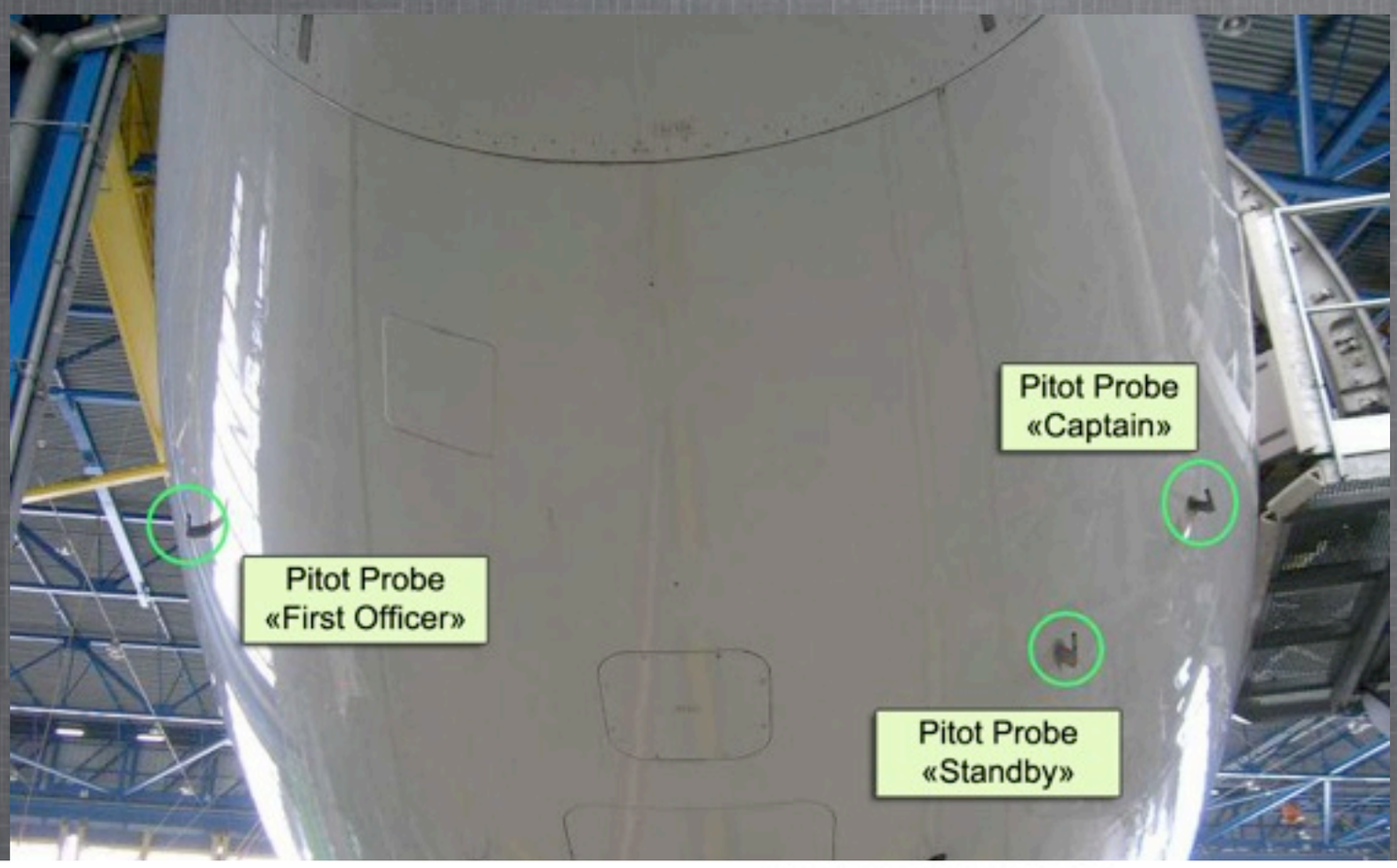
Phase 1: Initial surface search

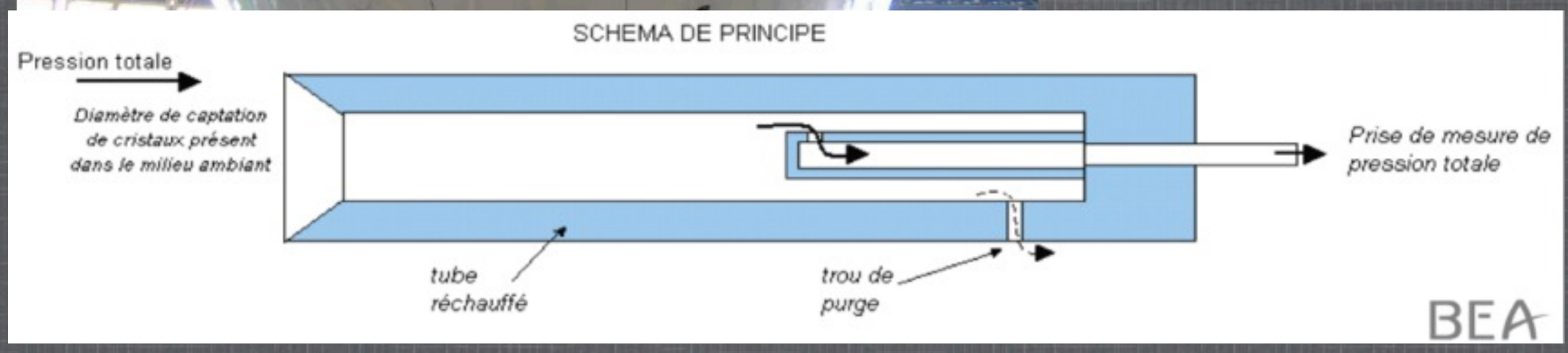
5 days later, the first bodies and aircraft parts were located and recovered.

Surface debris indicated 447 was intact on impact

Tail section here was largest piece of floating debris. A handful of other floating parts were also recovered.

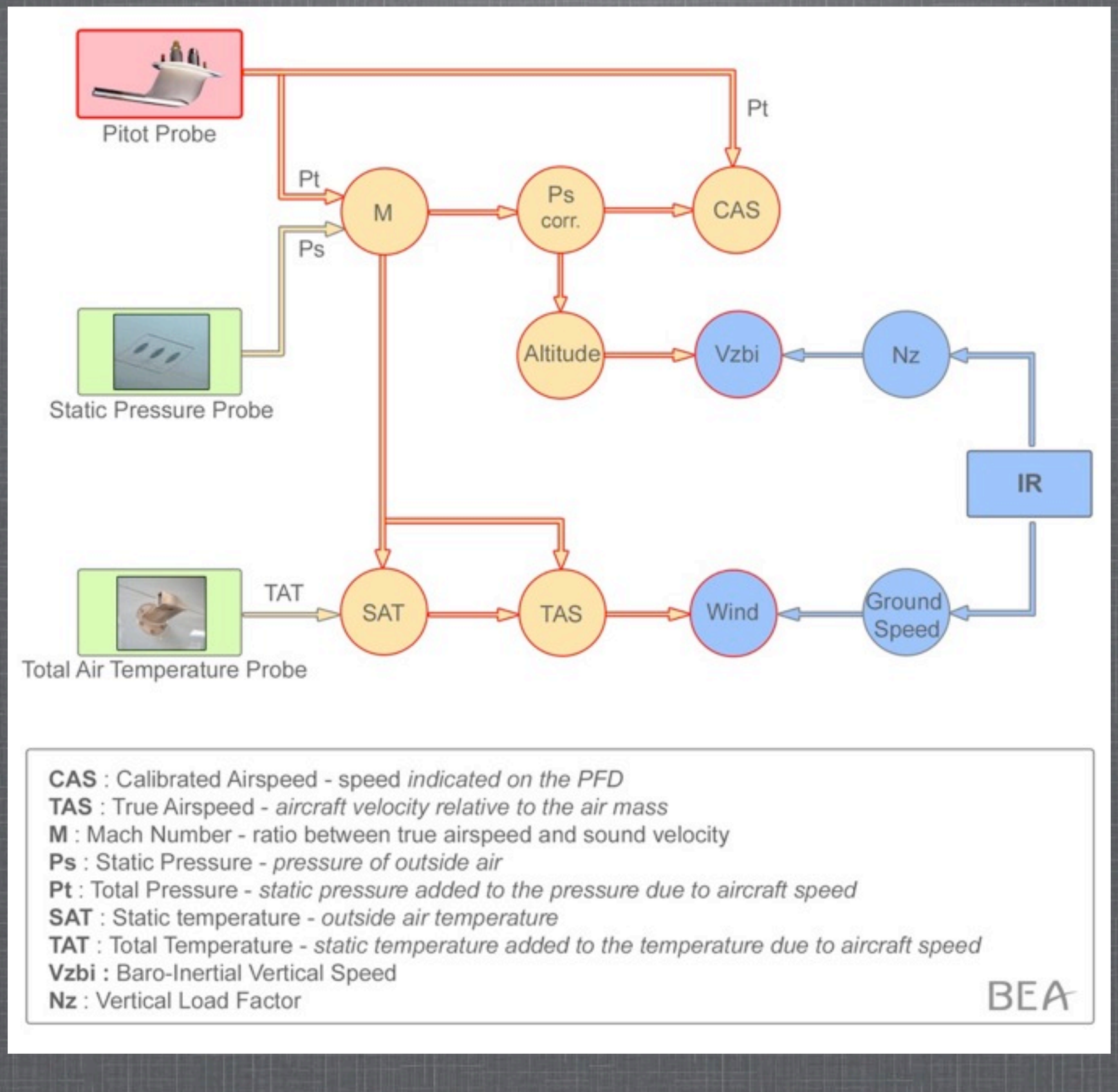
Investigation keyed on ACARS reports, suggesting pitot tube ice blockage





Computer programmed to reject odd inputs

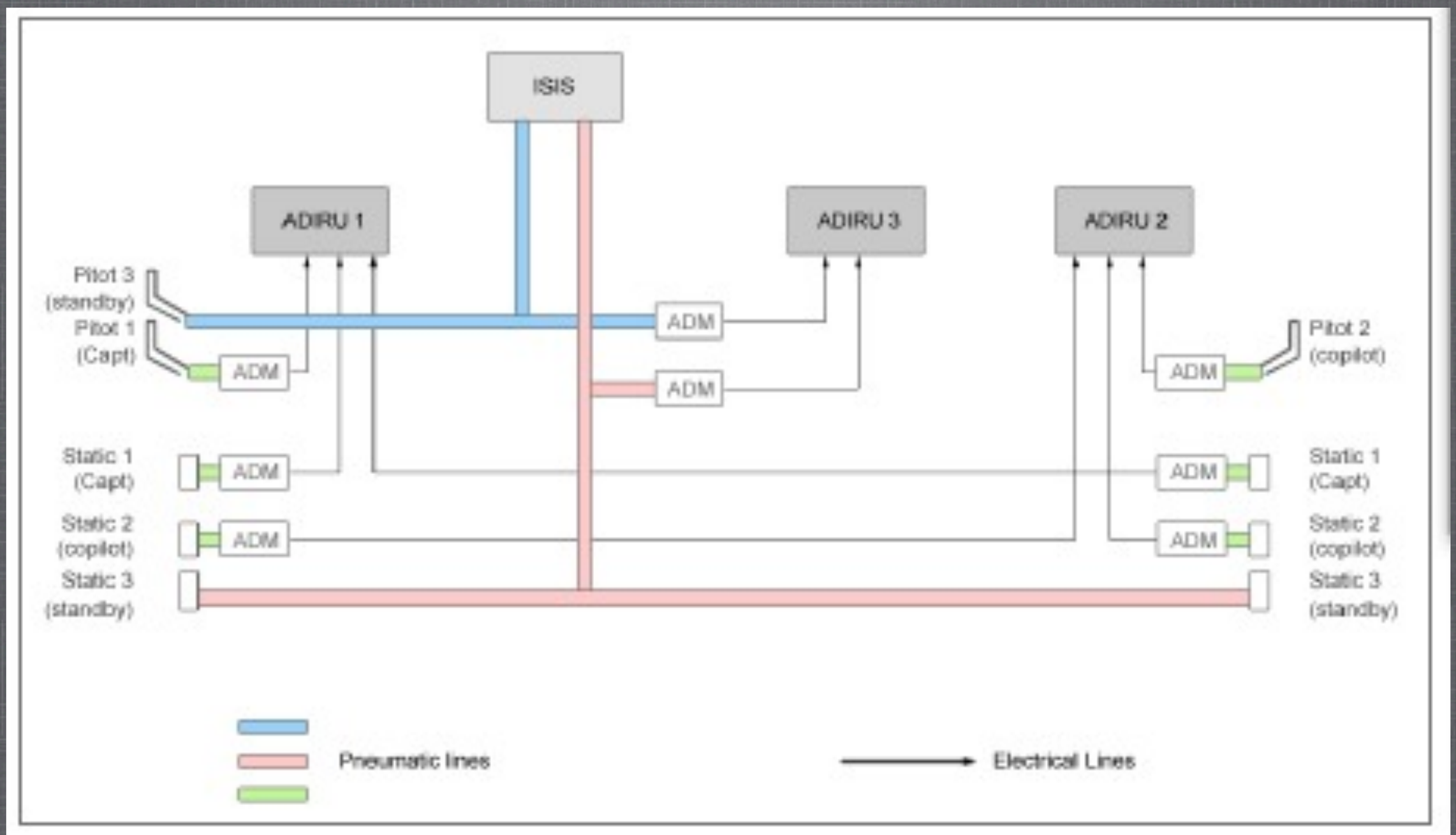
ACARS + weather + altitude pointed to pitot tube icing.
Pitot tube are intakes to provide speed measurement in flight.
AIRPLANE'S SPEED IS PRETTY IMPORTANT DATA.
Pitot tube locations – triple redundancy, sort of
Pitot heaters controlled by Pitot Heater Computer



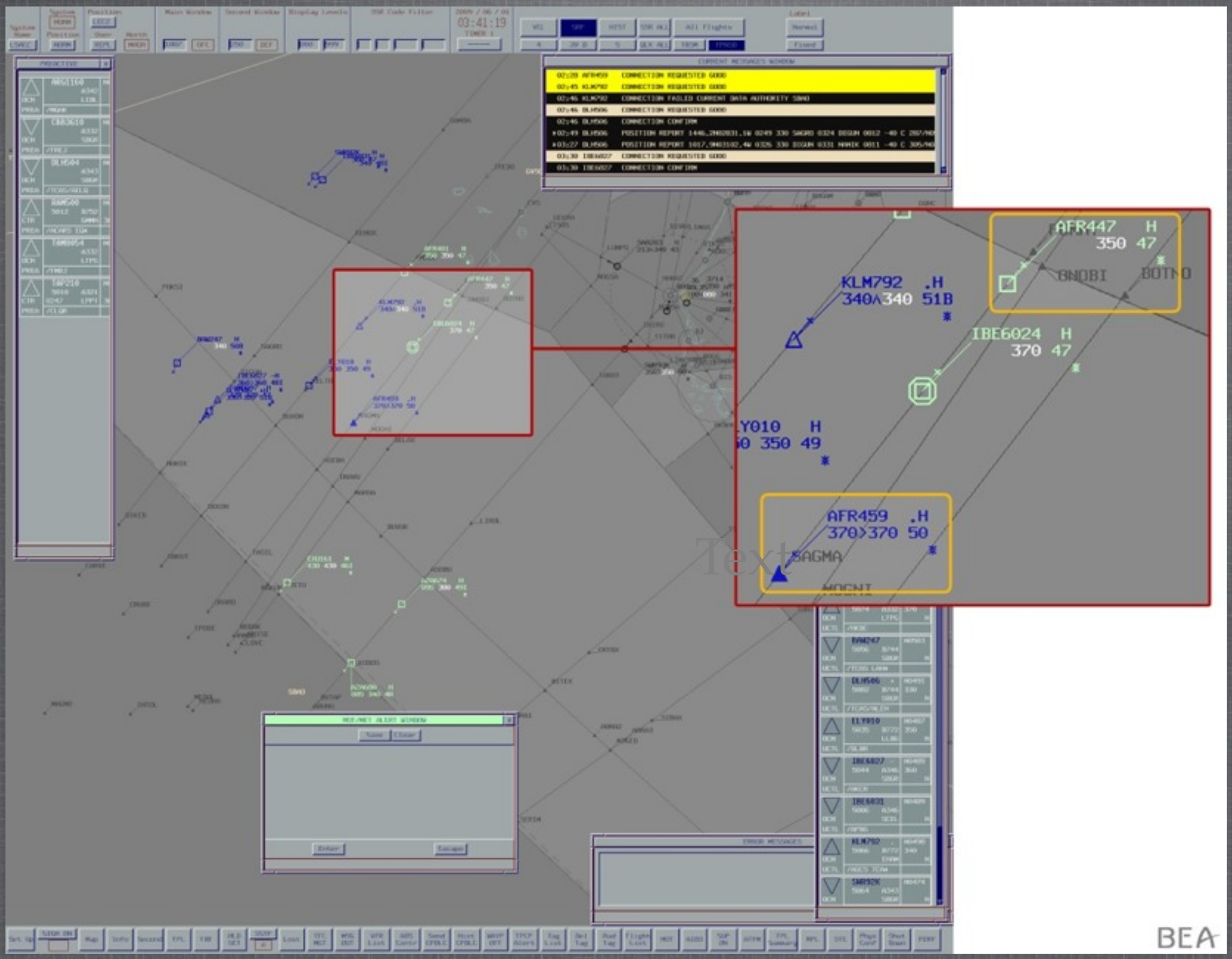
IR = inertial reference

Both horizontal and vertical speed outputs are calculated from three inputs.
If inputs are out of tolerance or conflict, computers turn command over to pilot

A330 speed measurement system architecture



all computerized except sensors, and even they have computerized controls
ADIRU = air data inertial reference unit
ADM = air data module
ISIS= Indicated standby instrument system



Used ATC data to estimate where 447 crashed

Skimpy surface data forced other approaches. Tried to pinpoint where a/c might have come down on the ocean to locate wreckage

lots of highways and sign posts in the sky. monitored by ATC to separate aircraft , also help estimate crash area.

The Investigation

Phase 2: Wreckage search and recovery

1. Initial surface search
2. Undersea search
   - Phase 1 – acoustic search

Underwater Locator Beacon

- emits 37.5 kH pulse every second for 30 days min. (usually 40 days)
- search covered 40 nautical mile circle from surface debris location
- ULB's damaged on impact, lost
- led to missing wreckage early.

After surface search yielded such poor data, focused on locating and recovery of ULBs (underwater locator beacons), recorders and debris. Missed FDRs and wreckage because CVR ULB found to be damaged, FDR ULB was never recovered.

The Investigation

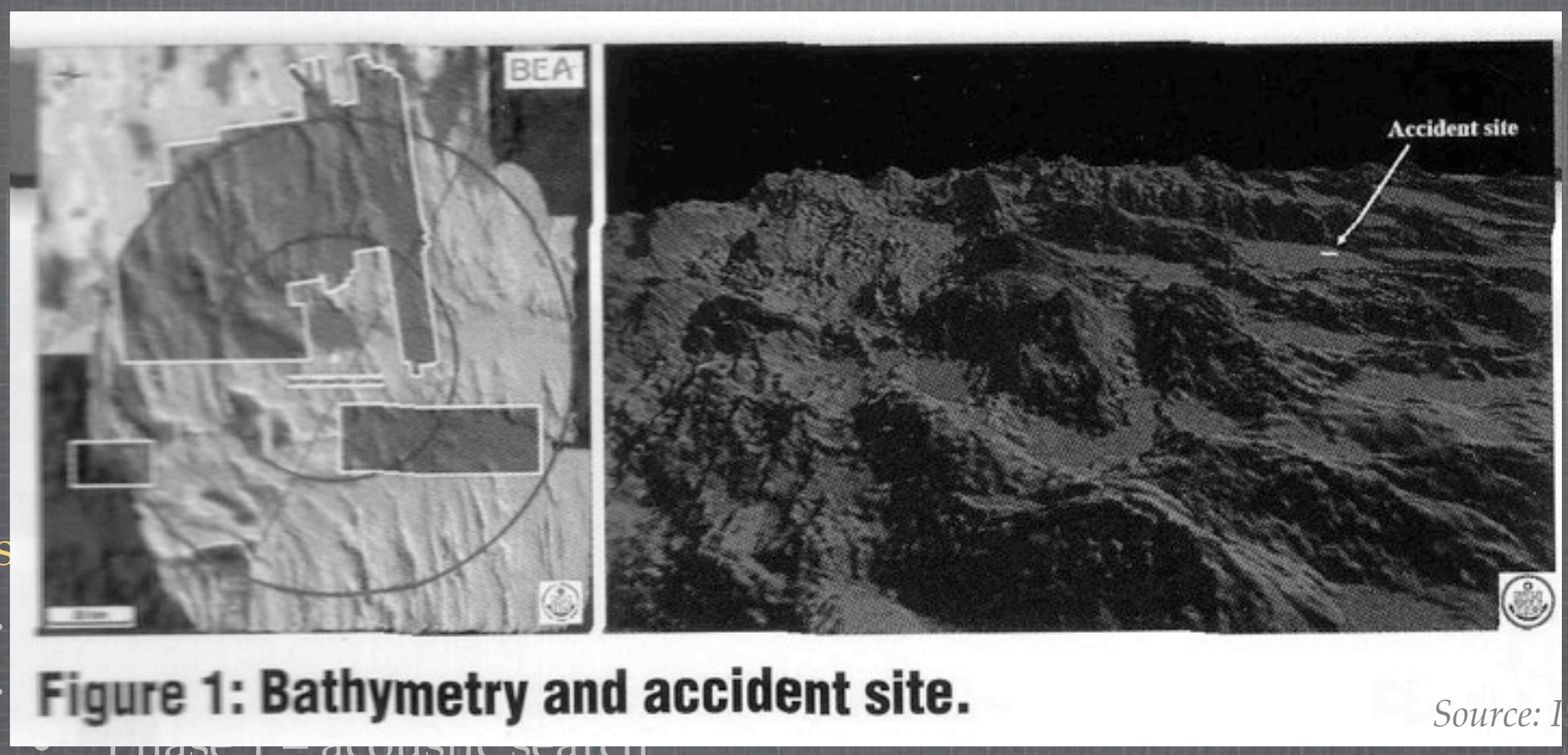


Figure 1: Bathymetry and accident site.

Source: ISASI forum

- Phase 1 – acoustic search
- Phase 2 – Side scan sonar
  - July 27-August 17 2009 over 1100 km circle
  - IFREMER deep towing vehicle
  - Produced bathymetric survey

IFREMER (French sea research institute) mapped ocean floor but didn't locate ULBs or wreckage site. Subsequently located site is overlaid on the survey. Pretty deep and rugged sea bed.

The Investigation

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ORION + 3 REMUS 600 AUVs
Unsuccessful
So French navy dropped 9 Drift Buoys
Metron updated probability distribution

Autonomous underwater vehicles failed to locate debris site again, so a new approach was tried, using drift buoys and statistical analysis techniques to define most likely place to find debris on ocean floor.
That led to next phase – bringing in even more sophisticated equipment.

The Investigation

d recovery

arch

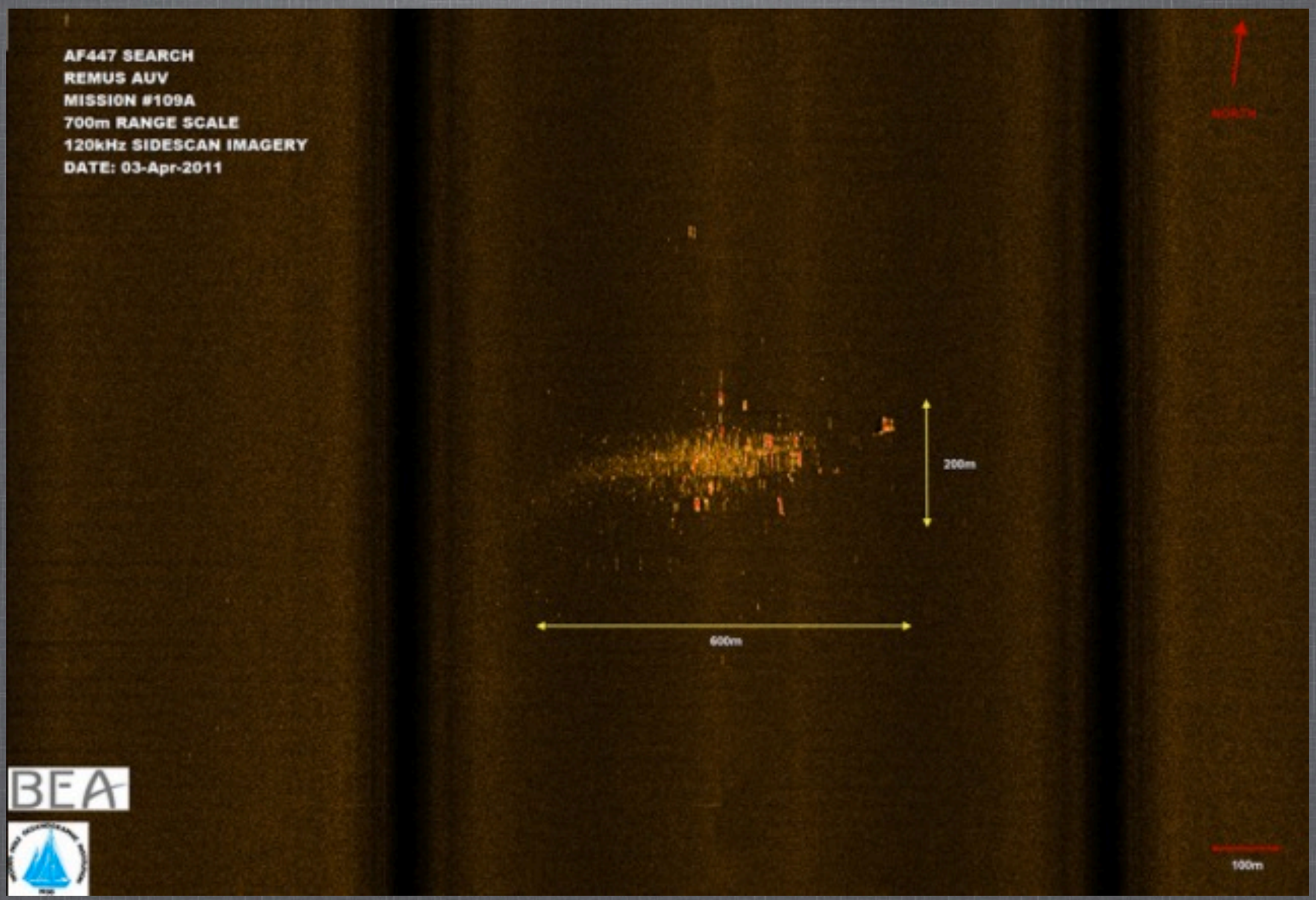
onar

6300 km2

- Phase 4 = WHOI operated terrain-following AUVs
  - site discovered at 3900 m depth, 6.5 nm NNE of last position transmitted by 447
  - photo runs
  - photo fusion

Woods Hole Ocean Institute vessel operating AUVs using sonar runs over the most likely location finally discovered the site 6.5 nm from last 447 position sent from the airplane. Lots of runs.

Sonar image of bottom feature that was confirmed to be the wreckage area (REMUS)



3 April 2011 sonar image of wreckage area. You can imaging how that lifted the investigators' spirits.
Now salvage operations could be undertaken.

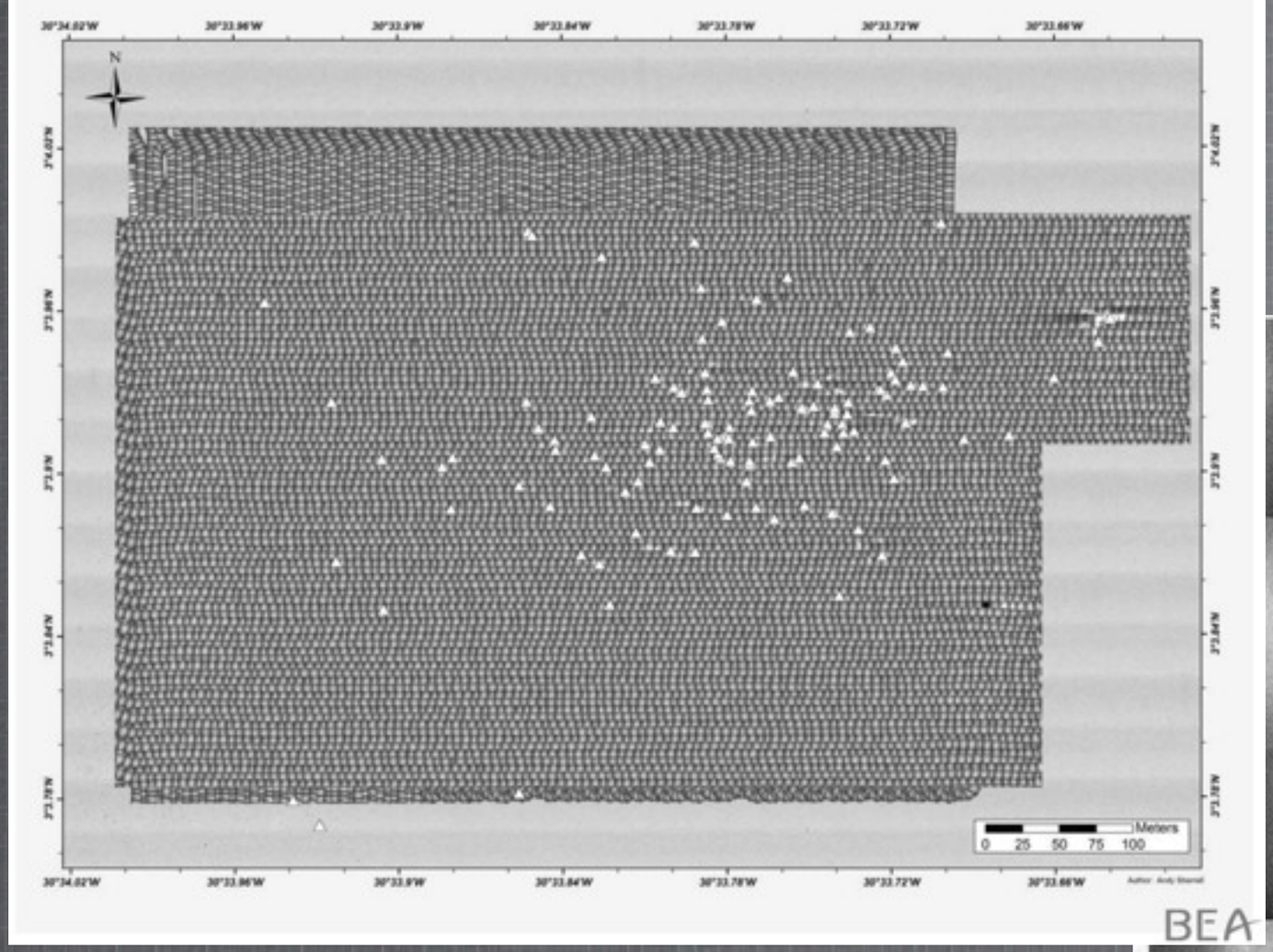


Figure 98: Visualisation of the photo mosaic obtained with REMUS AUV images and the aeroplane debris identified by using the REMORA ROV

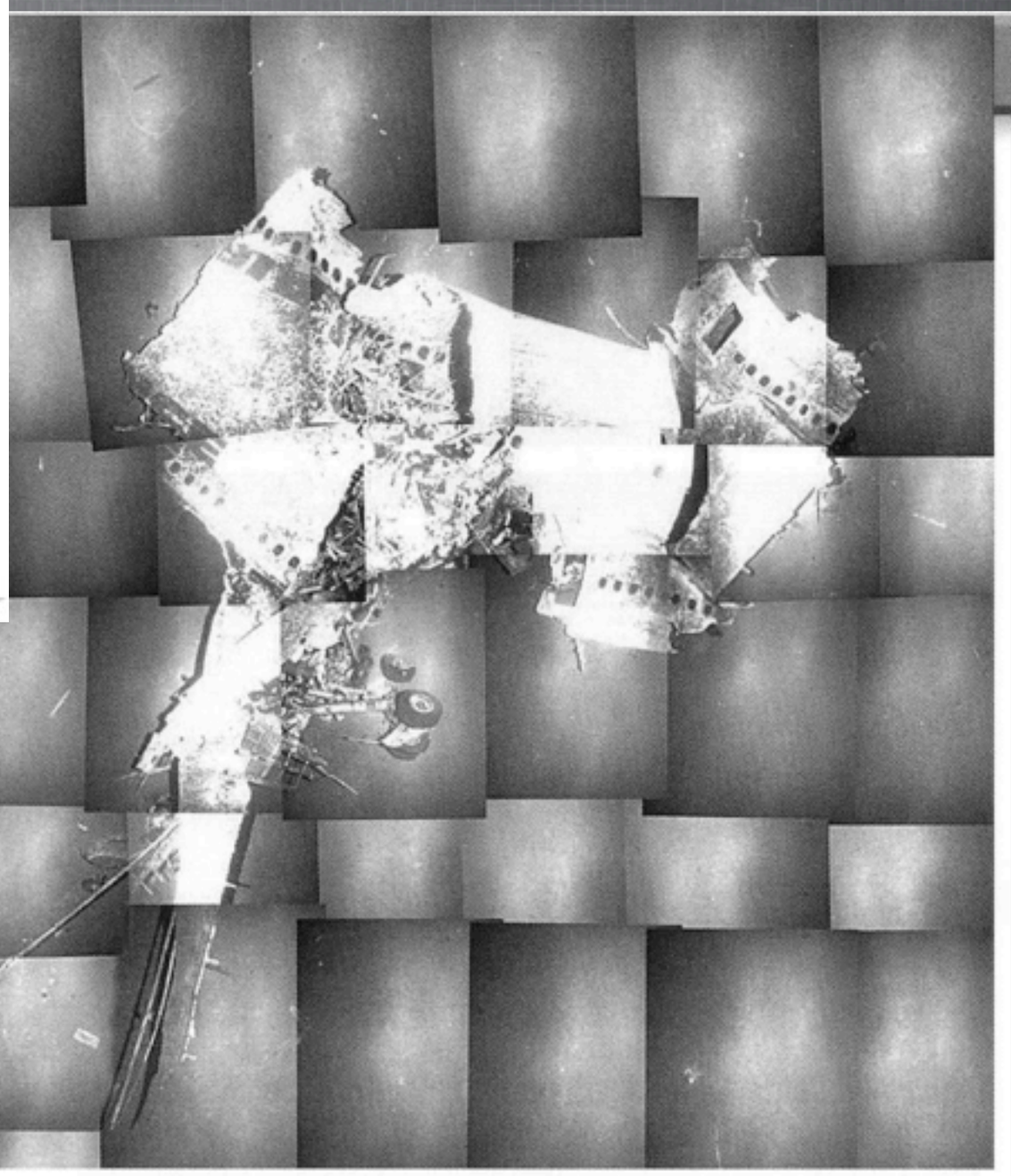


Figure 7: Example of the fusion process results.

AUVs took lots of images – and stitched them together, as shown here, to develop site debris diagram, and then got photos of actual debris.

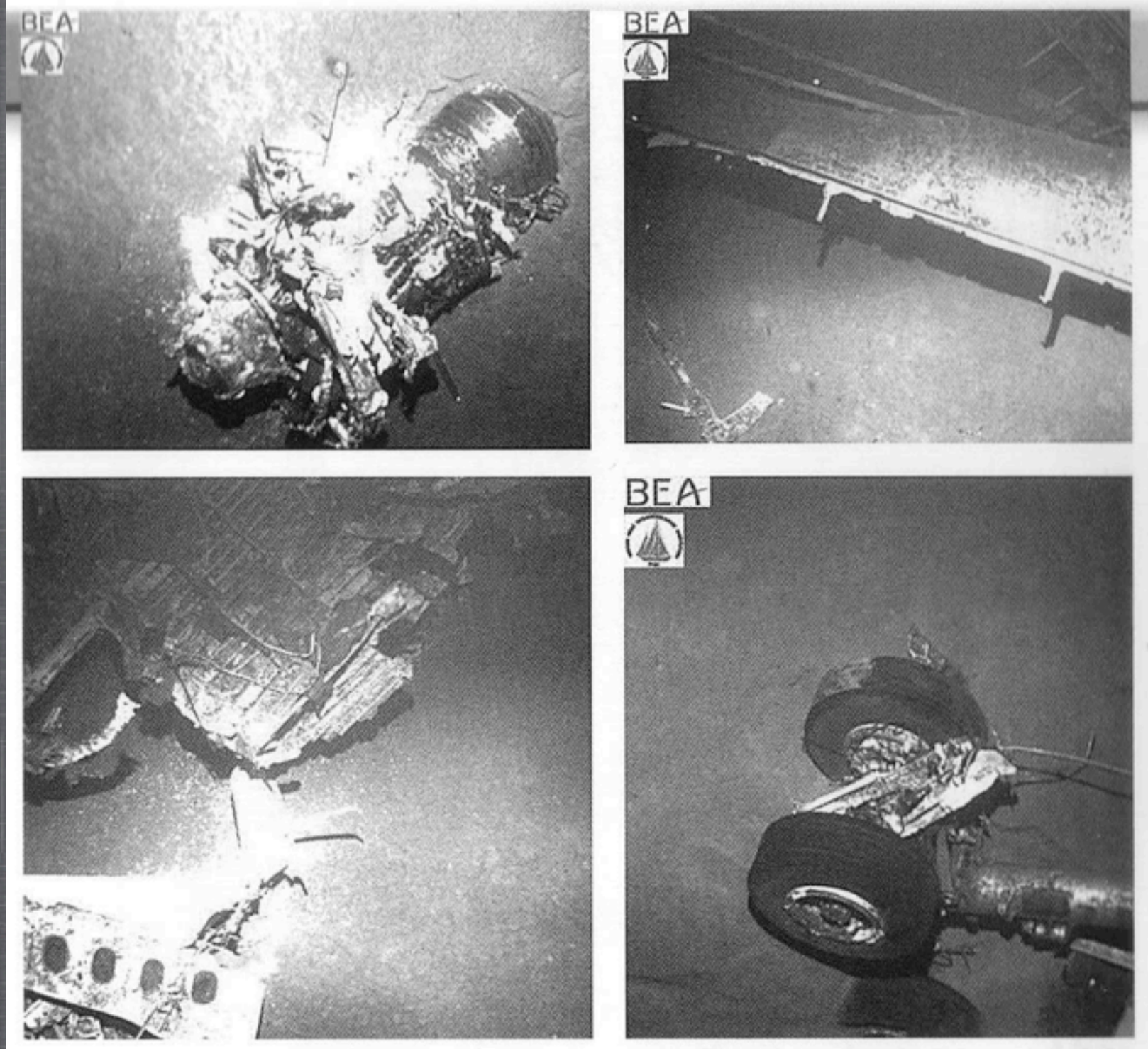


Figure 4: Selection of pictures taken by the REMUS on April 3, 2011. Clockwise from top left: engine, wing, fuselage panel, and landing gear.

Amazing images under almost 10,000 feet of water!

The Investigation

Phase 2 Wreckage search and recovery

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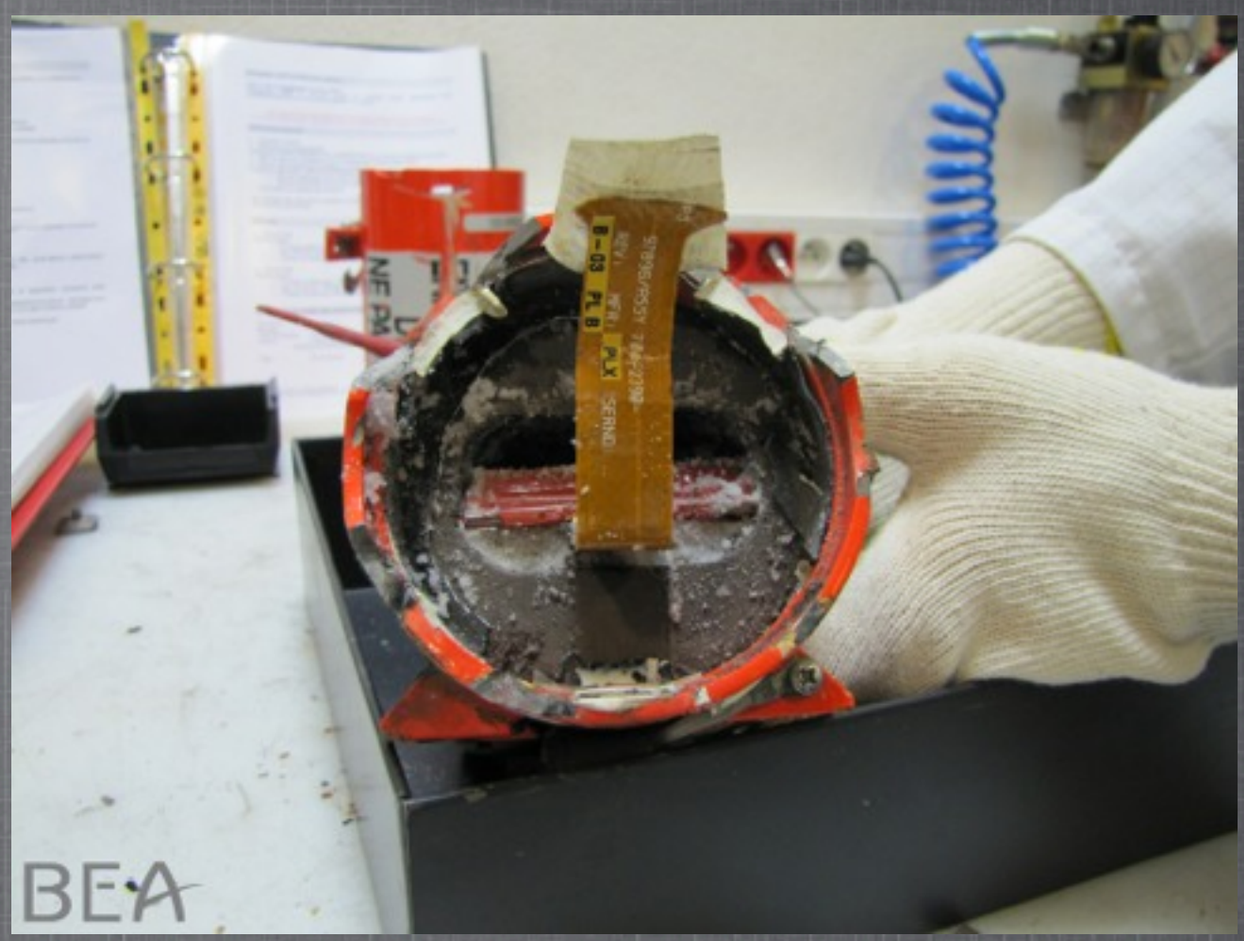
     - photo fusion
- Phase 5 –
- debris field mapping
- CVR/FDR and parts recovery

Figure 41: Passenger oxygen container recovered open: the three pins are in place

The oxygen masks were not released: there was no depressurisation in flight.



CVR

FDR

CLEANED MEMORY MODULES

Opened CVR and FDR modules after recovery after almost 2 years underwater.
Handling them produces some VERY ANXIOUS MOMENTS!!

Solid State Digital Flight Data Recorder

- 1300 parameters
- 25 hours recording capacity

FDR Recorder readouts

- Baked to dry them out
- Downloaded 5 tracks
- Track Synchronization showed some data missing
- Ultimately recovered all saved data
- Completed readout May 15 2011
- Synchronized with CFR using alarm sounds

Track 1: radio communications and the signal from the microphones for the pilot seated on the left;
Track 2: radio communications and the signal from the microphones for the pilot seated on the right;
Track 3: radio communications, the signal from the second copilot's microphone (rear seat), and the FSK signal;
A track made up from the first 3 tracks mixed together;
CAM track: the signal from the cockpit area microphone.
Sync'd to 100 ms accuracy

Cockpit Voice Recorder readouts

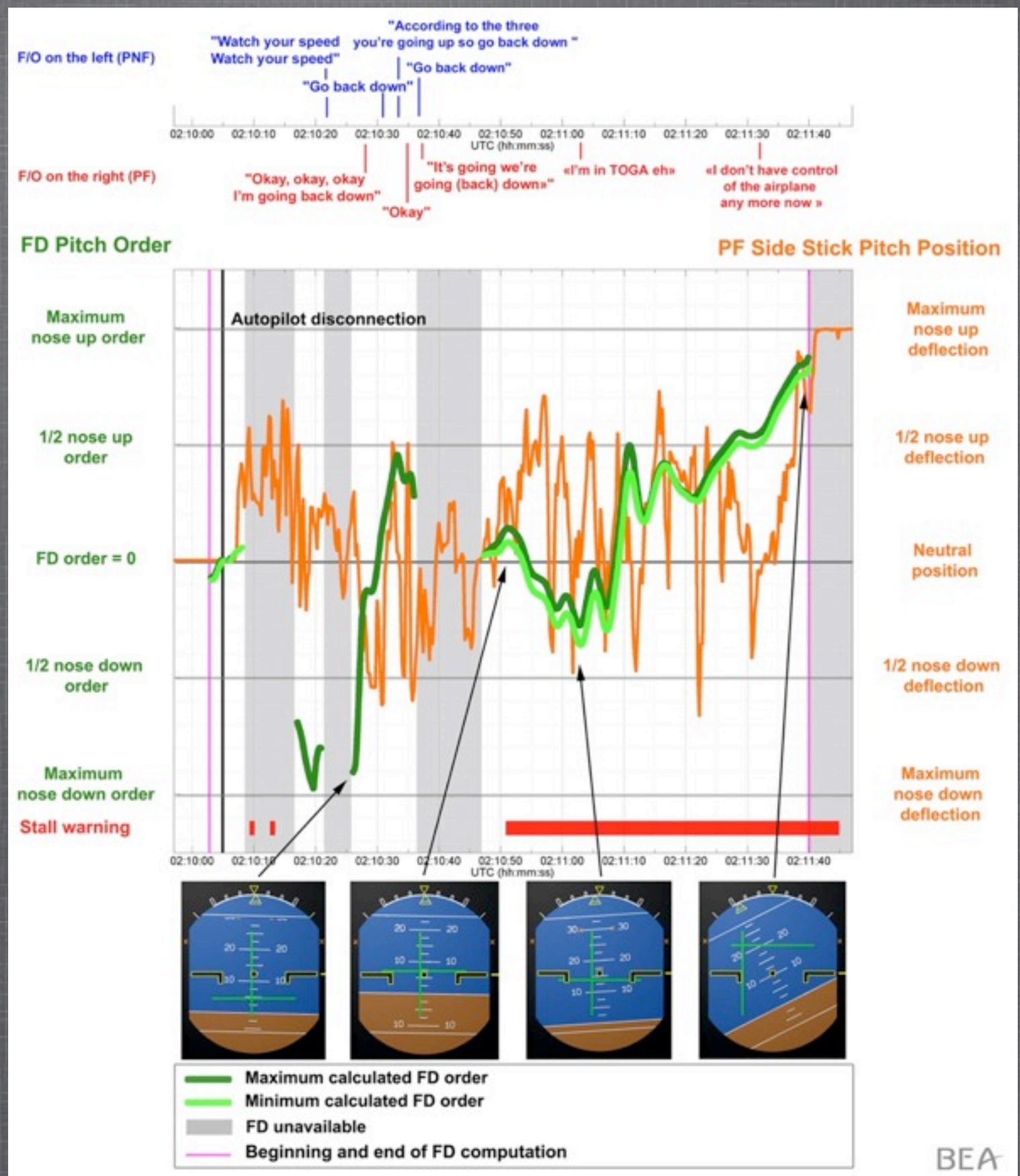
- Capture audio on tape/computer
- Listen to audio file
- Interpret what is said/heard (team)
- Transcribe what is heard
- Compare transcript with audio
- Synchronize times with other sources

Set up new Human Factors working group

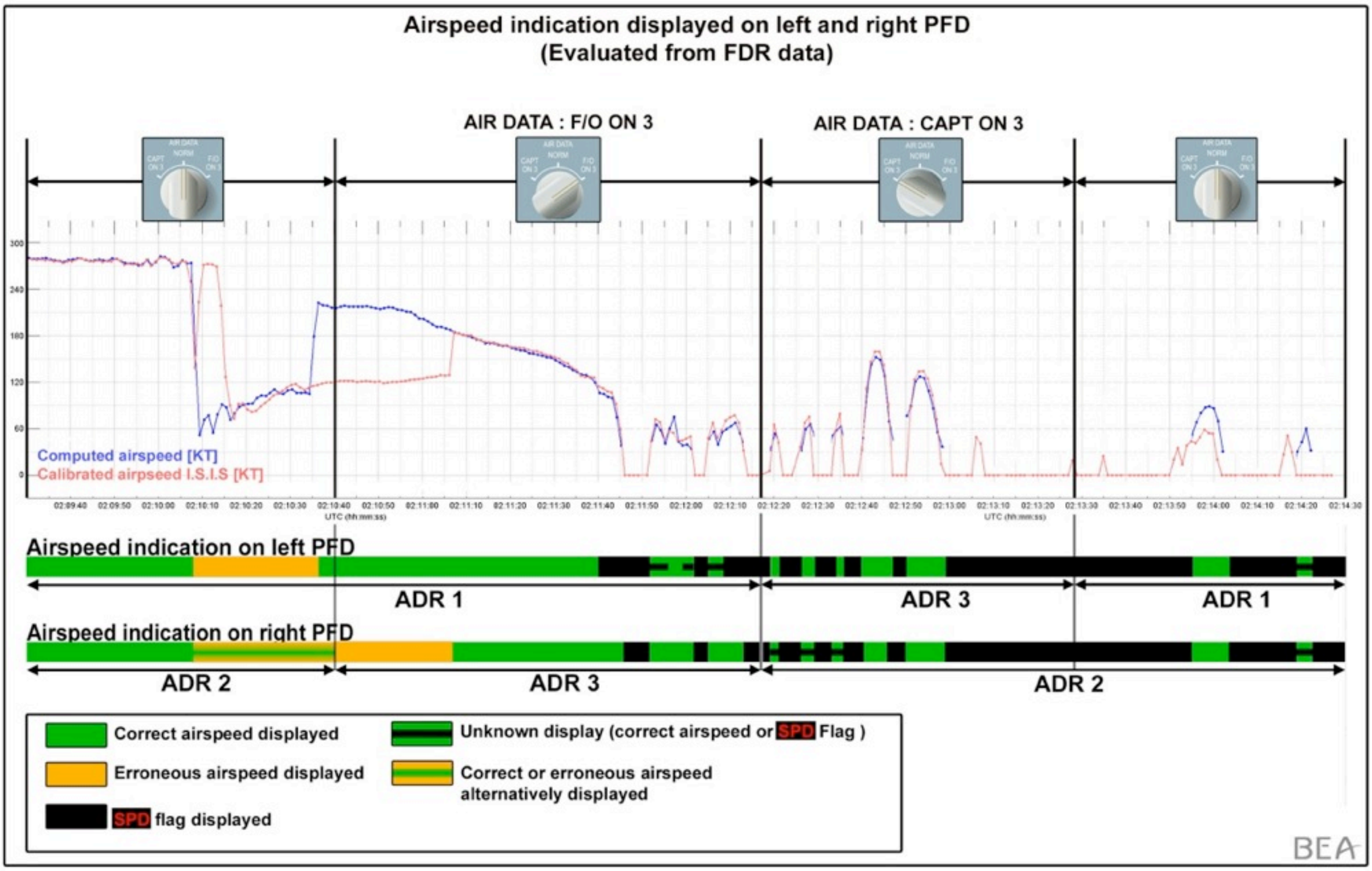
Integration and analyses of data disclosed what pilots and airplane did especially after the pitot tubes no longer functioned as designed because of the ice buildup. Interpretation of the data and its role in future risks was given to a new BEA working group.

BAE Human Factors working group analyses

Data integration example



Need for data recorders and their value is demonstrated here
Data integration into multilinear event sequencing display
Shows stall warning because a/c reached computed Rec MAX ceiling, not because of slow speed



Note orange and black parts of bars during the crucial 4 minutes pilots were trying to figure out what was happening...

Data Integration Example

Alarms

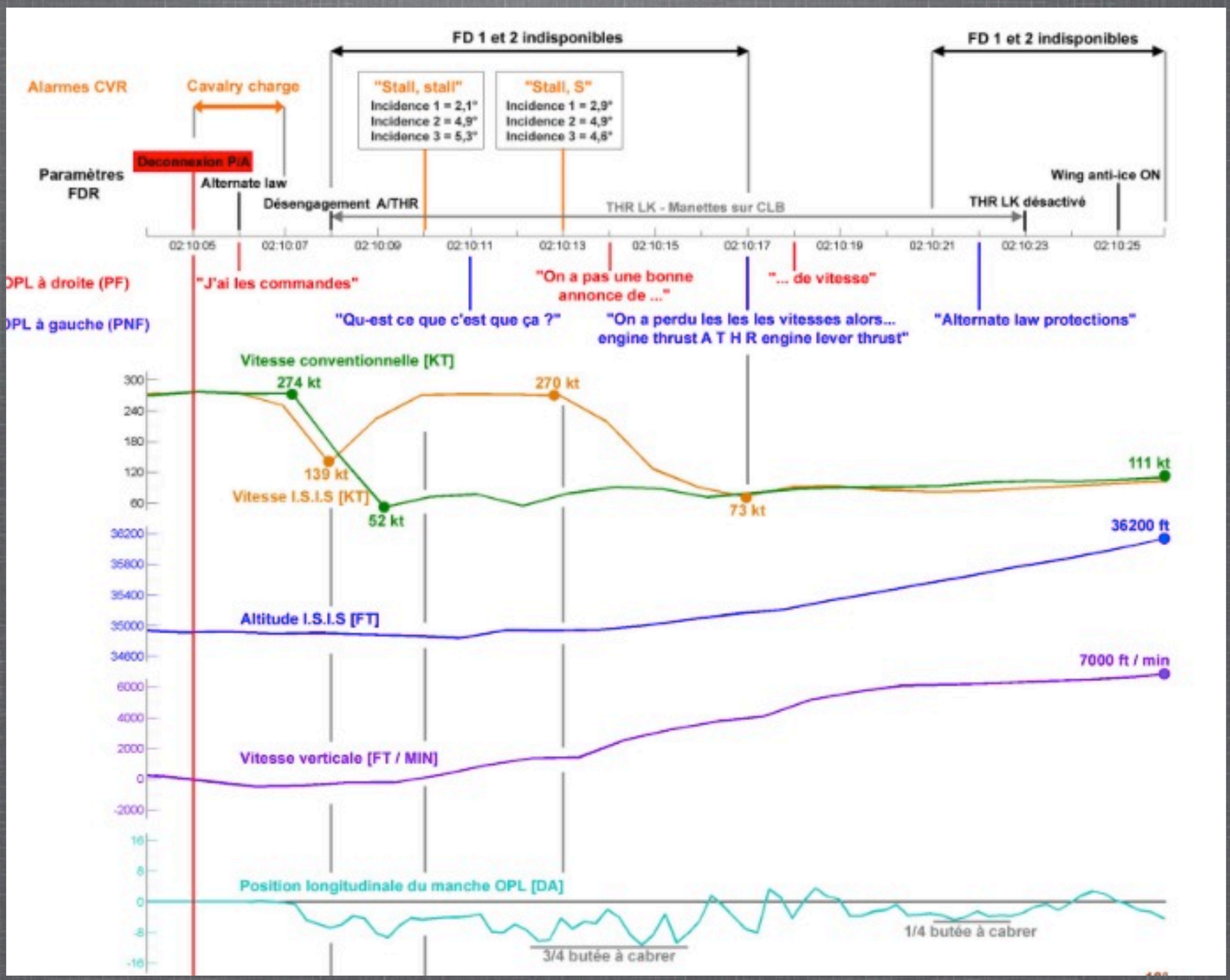
Computers

Time

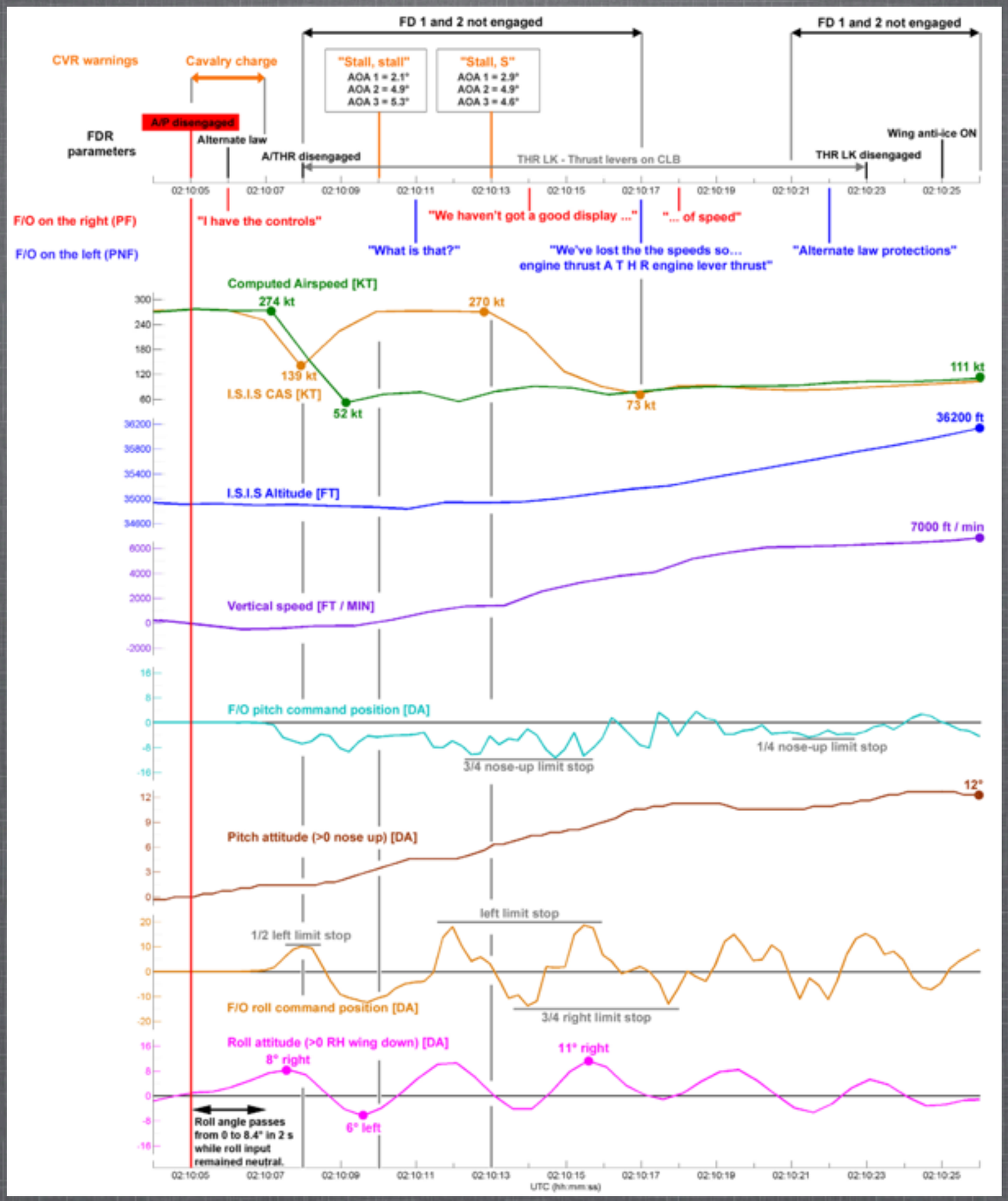
Pilot F

Pilot NF

FDR traces



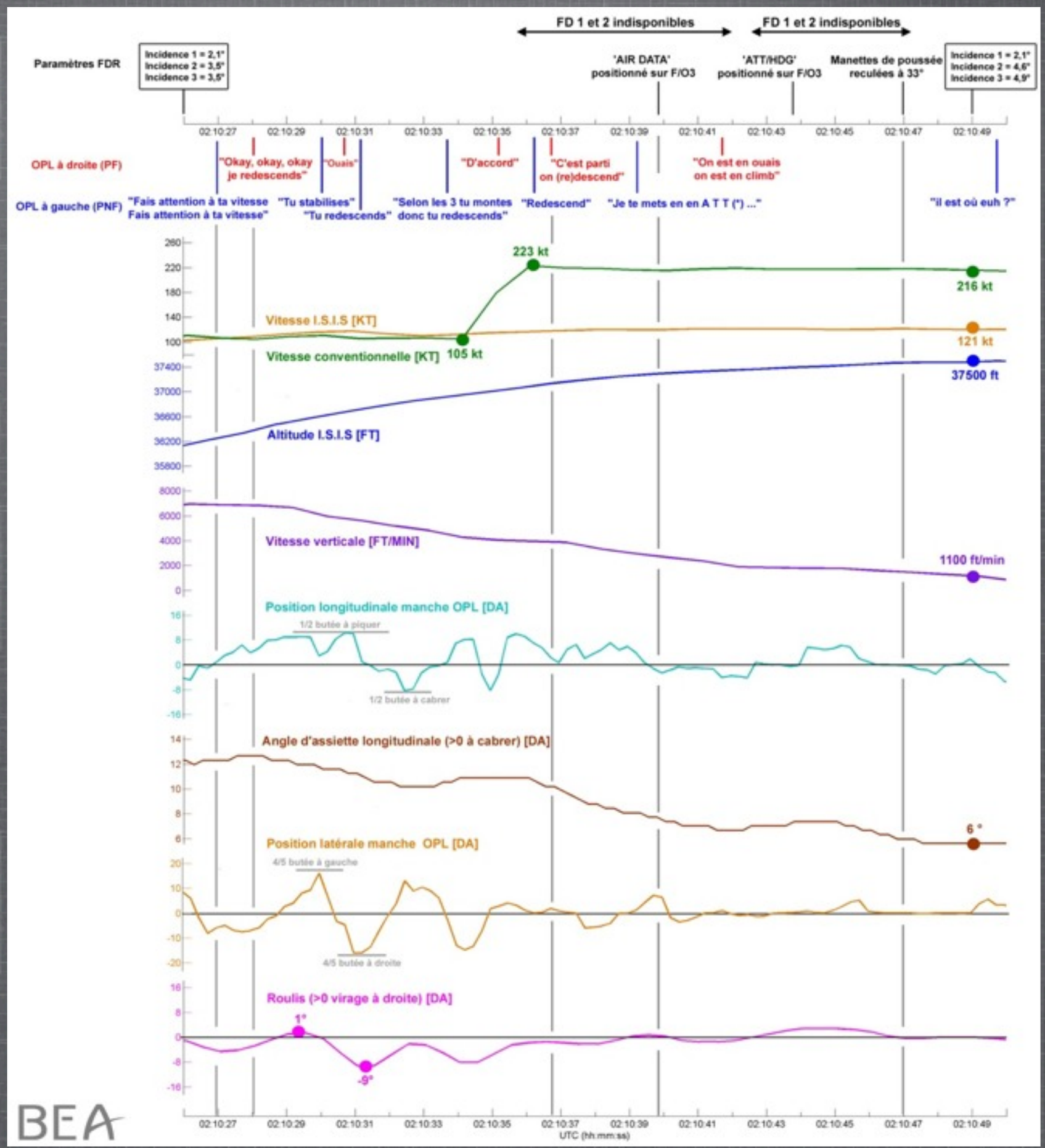
Note actions displayed on this illustration of the integrated data on a matrix display showing how crew and aircraft interacted during the crisis. Each row represents a different “actor”



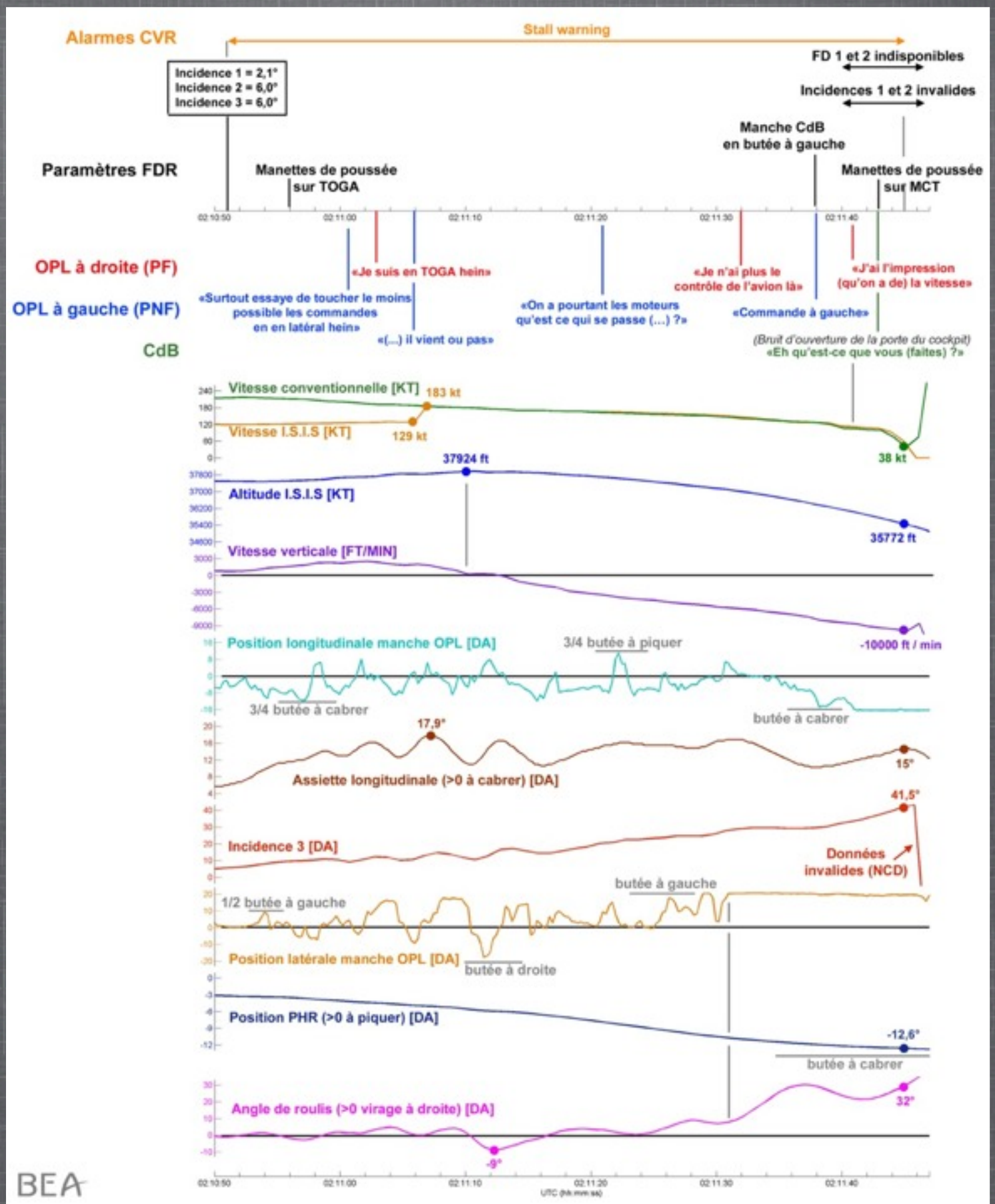
MES display – discuss

⑧Track 1: radio communications and the signal from the microphones for the pilot seated on the left;
⑧⑧Track 2: radio communications and the signal from the microphones for the pilot seated on the right;
⑧⑧Track 3: radio communications, the signal from the second copilot's microphone (rear seat), and the FSK signal;
⑧⑧A track made up from the first 3 tracks mixed together;
⑧⑧CAM track: the signal from the cockpit area microphone.

Sync'd to 100 ms accuracy



need to read report to understand meaning of the data….


Alarmes CVR
Stall warning
Incidence 1 = 2,1°
Incidence 2 = 6,0°
Incidence 3 = 6,0°
FD 1 et 2 indisponibles
Incidences 1 et 2 invalides
Manche CdB
en butée à gauche
Paramètres FDR
Manettes de poussée
sur TOGA
Manettes de poussée
sur MCT
02:10:50
02:11:00
02:11:10
02:11:20
02:11:30
02:11:40
OPL à droite (PF)
OPL à gauche (PNF)
CdB
«Je suis en TOGA hein»
«Surtout essaye de toucher le moins
possible les commandes
en en latéral hein»
«(...) il vient ou pas»
«On a pourtant les moteurs
qu'est ce qui se passe (...) ?»
«Je n'ai plus le
contrôle de l'avion là»
«Commande à gauche»
«J'ai l'impression
(qu'on a de) la vitesse»
(Bruit d'ouverture de la porte du cockpit)
«Eh qu'est-ce que vous (faites) ?»
Vitesse conventionnelle [KT]
183 kt
Vitesse I.S.I.S [KT]
129 kt
38 kt
37924 ft
Altitude I.S.I.S [KT]
35772 ft
Vitesse verticale [FT/MIN]
-10000 ft / min
Position longitudinale manche OPL [DA]
3/4 butée à piquer
3/4 butée à cabrer
butée à cabrer
17,9°
Assiette longitudinale (>0 à cabrer) [DA]
15°
41,5°
Incidence 3 [DA]
Données
invalides (NCD)
butée à gauche
1/2 butée à gauche
Position latérale manche OPL [DA]
butée à droite
Position PHR (>0 à piquer) [DA]
-12,6°
butée à cabrer
Angle de roulis (>0 virage à droite) [DA]
32°
-9°
02:10:50
02:11:00
02:11:10
02:11:20
02:11:30
02:11:40
UTC (hh:mm:ss)

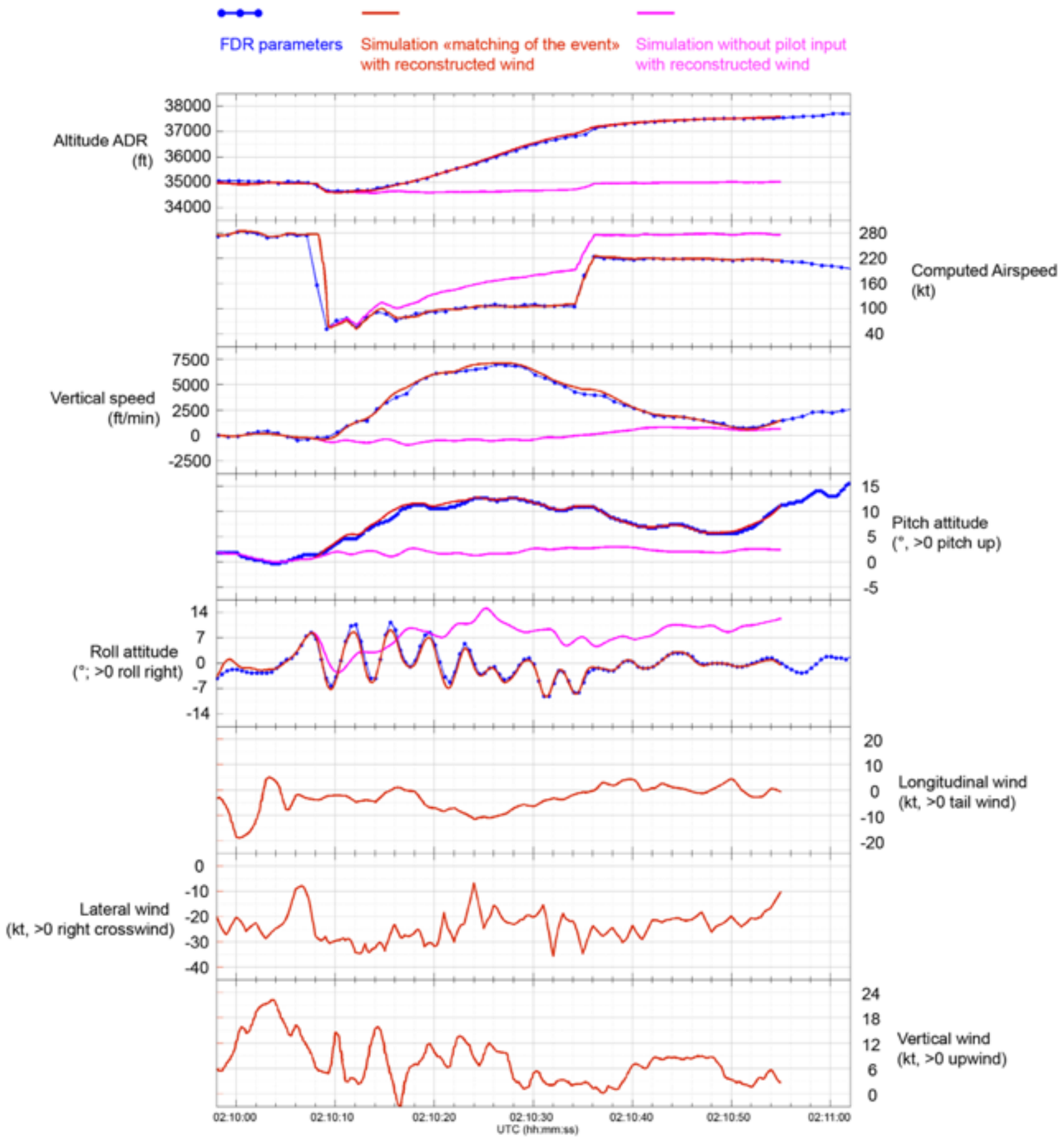
BEA

Tested replicability with simulator reconstruction

— =FDR parameters

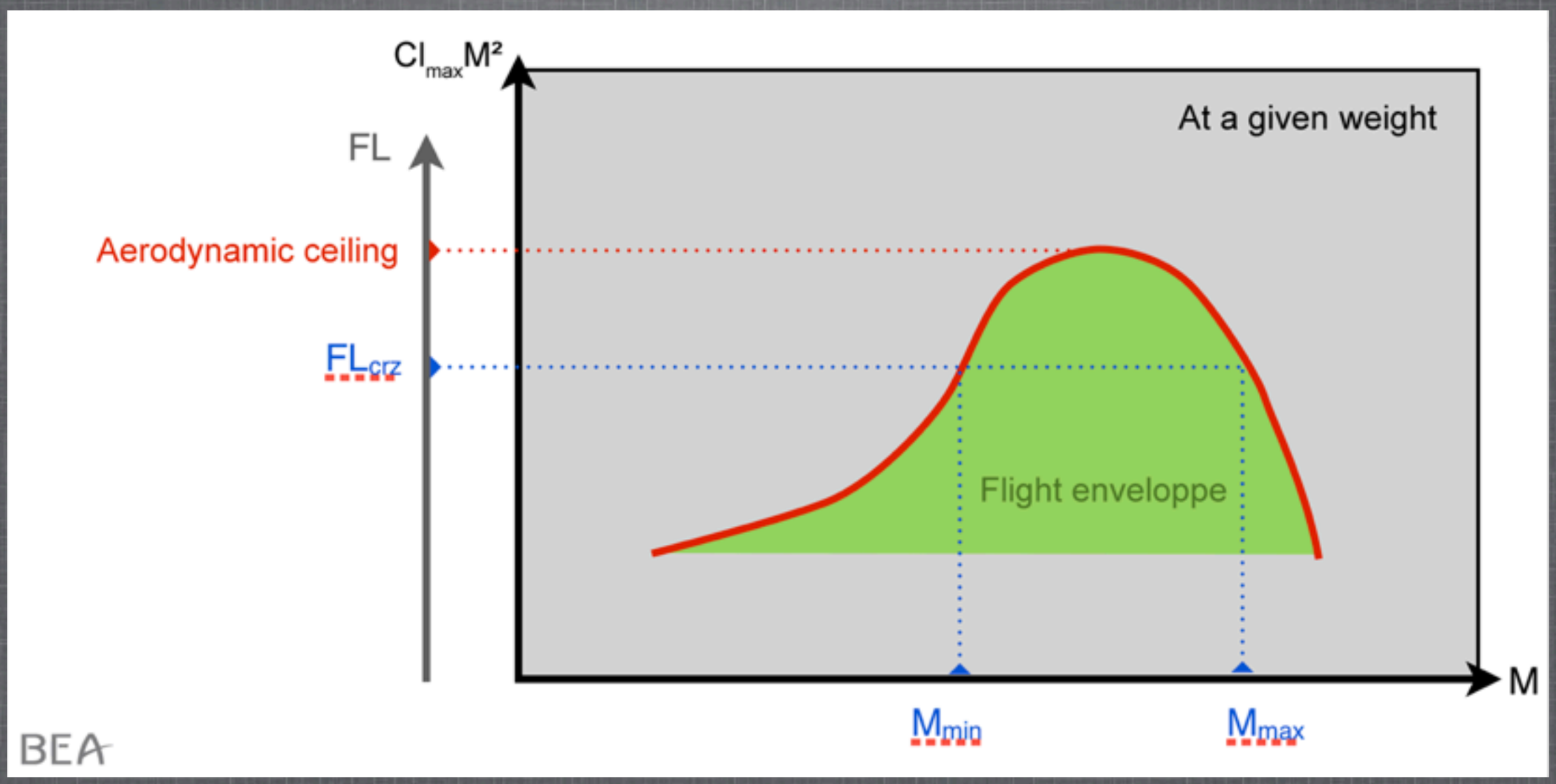
— = simulation w wind

— = simulation w/o PF input



These are some of the simulator generated vs. FDR parameter traces for the times shown at the bottom, constructed from the data samples recovered.
Note pitch (4th -blue line) and next roll attitude-from FDR parameters in this simulator vs FDR display (center wavy line)

Aerodynamic ceiling calculations



The stalls were not due to reduced speed but rather from the lift characteristics of the airplane at high altitudes, and how it is flown, especially the angle of attack near the aerodynamic ceiling for a given airplane design, weight and air density. That ceiling was slightly above 37,500 ft for AF447 at that point in the flight. It changes continually with declining weight as fuel is consumed.

What's changing since the accident?

A lot!

- existing aircraft
- air/ground communications
- pilot training
- simulators
- pilot trainers
- emergency response
- aviation knowledge base

Let's look at BEA's recommendations

Accident investigation findings shook up aviation industry -

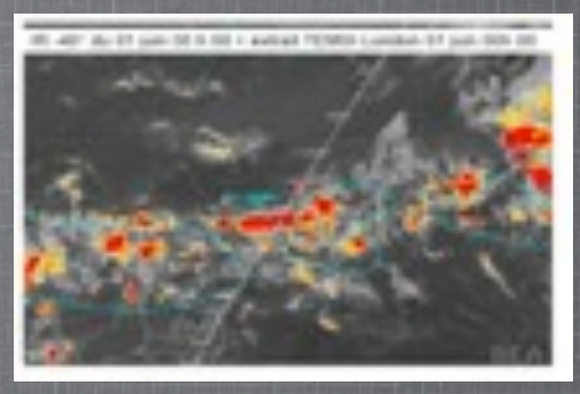
BEA Recommendations

Flight data recorder retrieval for maritime areas (for public transport aircraft)

1. Extend ULB life to 90 days for a/c flying over maritime areas
2. Add two UBL frequencies for same
3. Study ACARS type flight data transmissions for same
4. Develop proposals for use of deployable Eurocare ED-112 recorders

Reduce time required for investigators to find out what happened to speed up problem identification and fixes when crashes occur in remote or maritime areas

Recommendations



REC MAX stalls

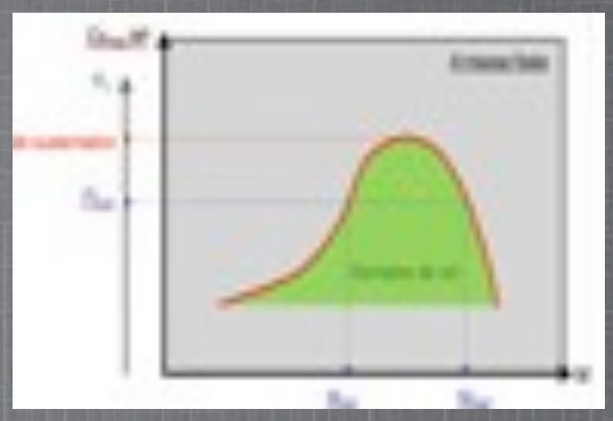
Aircraft certification (to EASA)

1. Do studies to determine composition of cloud masses at high altitudes

2. Coordinate regulatory agencies to modify certification based on results.

add to aviation knowledge base about weather, weather hazard prediction and weather's impact on flights

Recommendations



Pilot high altitude aircraft handling re stalls

To EASA

1. review content of check and training programmes to mandate manual aircraft handling of approach to stall and recovery at hight altitude

introduce training to cover gap in skill training disclosed by this accident especially re Stall warning threshold in Normal or alternate law

Recommendations

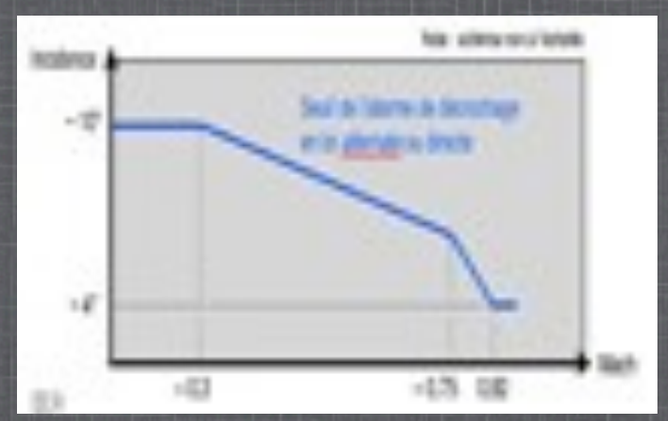
Pilot crew task sharing

To EASA

1. review content of check and training programmes to mandate manual aircraft handling of approach to stall and recovery at hight altitude

To DGAC (French Civil Aviation Authority)

1. provisionally define addition criteria for role of relief Captain



improve crew coordination to resolve in-flight surprises and challenges faster and effectively
“boredom interspersed with moments of stark terror” per Gearhart

Recommendations

Angle of Attack Measurement

To EASA and FAA

1. evaluate the relevance of requiring presence of an angle of attack indicator directly accessible to pilots onboard airplanes

rethink data surveillance work load on pilots to make their decision making faster and easier

Recommendations

Flight recorders

To ICAO

1. require that aircraft undertaking public transport flights with passengers be equipped with image recorder to observer entire instrument panel, and
2. establish very strict rules for readouts to guarantee the confidentiality of such recordings

To EASA and FAA

3. mandate the recording of the position of flight director cross bars, and conduct of flight display on right side, in addition to display on left side
4. evaluate making mandatory the recocrding of air data and inertial parameters of all sources used by the systems

very controversial – serves investigators but at what price to pilots – that's issue

Recommendations

Transmission of Flight Data

To EASA and ICAO

1. make mandatory, for px flights over maritime or remote areas, triggering of data transmission to facilitate localization as emergency is detected on board
2. study making mandatory for those a/c activation of emergency locator transmitter as emergency is detected on board.

mainly aimed at faster learning from accidents….

Recommendations

SAR coordination for remote areas

To ICAO

1. ensure implementation of SAR coordination plans or protocols for all maritime remote areas for which international coordination is required, including South Atlantic area

If crash had been survivable, took too long to find it. Longer is worse.

Recommendations

Training SAR operators

To DGAC (France)

1. develop homogeneous framework for training and approval of operators responsible for search and rescue activities in France

To ICAO

1. define the framework for training SAR operators in its SARPs

Tough to get mid-ocean SAR service rolling and effective
SAR= search and rescue
SARP = standards and recommended practices

Recommendations

Organization of SAR in France

To DGAC

1. designate point of contact at ICAO for ARCC that has adequate means to accomplish his/her mission

To ICAO

2. ensure each Member State has a national point of contact and makes his/her contact information available.

ARCC= aeronautical rescue coord ctr
for faster reactions to remote crashes, related to SARS

Recommendations

Air Traffic Control

To Brazilian and Senegalese authories

1. make mandatory the use by airplanes so equipped of ADS-C and PCDLC functions in the zones in question

To ICAO

1. request involved states to accelerate operational implementation of ATC and communication systems to allow permanent and reliable link between ground and airplane in all areas where HF remains only means of [that] communication

should help communications and tracking of flights in ITCZ

Recommendations

Pilot Training and Recurrent Training (1 of 6)

To EASA

1. ensure integration, in type rating and recurrent training, of exercises that take into account all [Airbus] reconfiguration Laws, to make its recognition easier [re] level of protection available and possible differences in handling characteristics, including limits of flight envelope

next six all aimed at making pilots smarter, better, faster at in flight problem definition and solving

Recommendations

Pilot Training and Recurrent Training (2 of 6)

To EASA

2. ensure that type rating and recurrent training programmes take into account the specificities of the aircraft for which they are designed

especially high altitude behaviors!

Recommendations

Pilot Training and Recurrent Training (2 of 6)

To EASA

2. ensure that type rating and recurrent training programmes take into account the specificities of the aircraft for which they are designed

Very controversial. This pits pilots against investigators – I'll explain if I have time

Recommendations

Pilot Training and Recurrent Training (3 of 6)

To EASA

3. define recurrent training requirements to make sure, through practical exercises, that the theoretical knowledge, particularly of flight mechanics, is well understood

New habit training, to squeeze out reversion to old habits

Recommendations

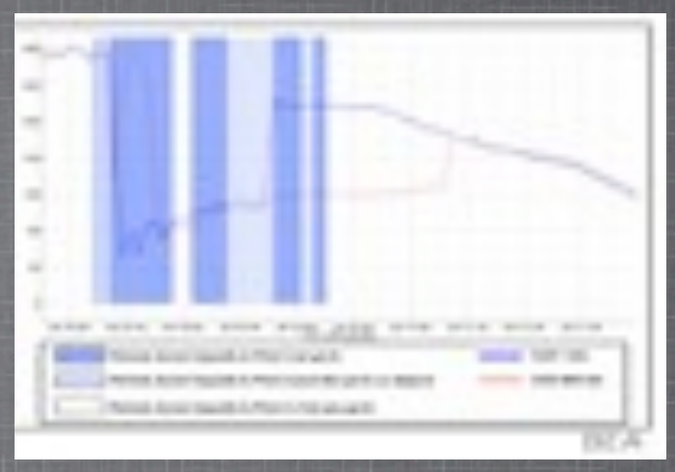
Pilot Training and Recurrent Training (4 of 6)

To EASA

4. review requirements for initial, recurrent and type rating training for pilots to develop and maintain a capacity to manage crew resources when faced with the surprise generated by unexpected situations

workload sharing training, been around a while.

Recommendations



Pilot Training and Recurrent Training (5 of 6)

To EASA

5. ensure that operators reinforce CRM training to enable acquisition and maintenance of adequate behavioral automatic responses in unexpected and unusual situations with highly charged emotional factor

CRM=cockpit resource management
same as 4

Recommendations

Pilot Training and Recurrent Training (6 of 6)

To EASA

6. define criteria for selection and recurrent training among instructors that would allow a high and standardized level of instruction to be reached

tries to get at consistently uniform and good pilot training by instructors

Recommendations

Improving Flight Simulators and Exercises

To EASA

1. modify the basis for regulations in order to ensure better fidelity for simulators in reproducing realistic scenarios of abnormal situations
2. ensure introduction into the training scenarios of the effects of surprise in order to train pilots to face these phenomena and work in situations with highly charged emotional factor

Simulators can’t simulate this kind of accident now, so fix simulators to handle

Recommendations

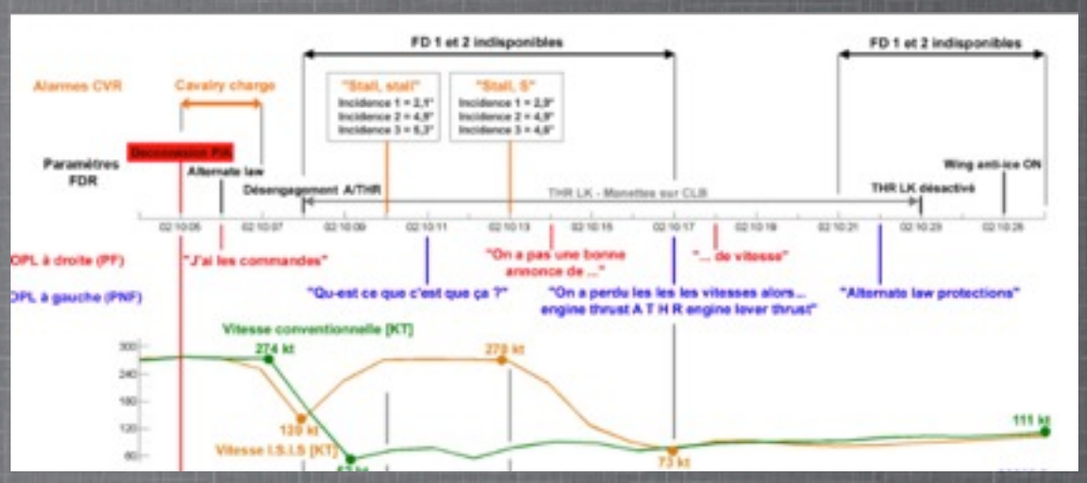
Ergonomics (2 of 5)

To EASA

1. require a review of the redisplay and reconnection logic of flight directors after their disappearance, in particular to review conditions in which action by crew would be necessary to re-engage them
2. require a review of the functional or display logic of the flight director so that it disappears or presents appropriate orders when stall warning is triggered.

this is aimed a data reliability and sourcing issues disclosed by this accident and investigaiton

Recommendations



Ergonomics (3 and 4 of 5)

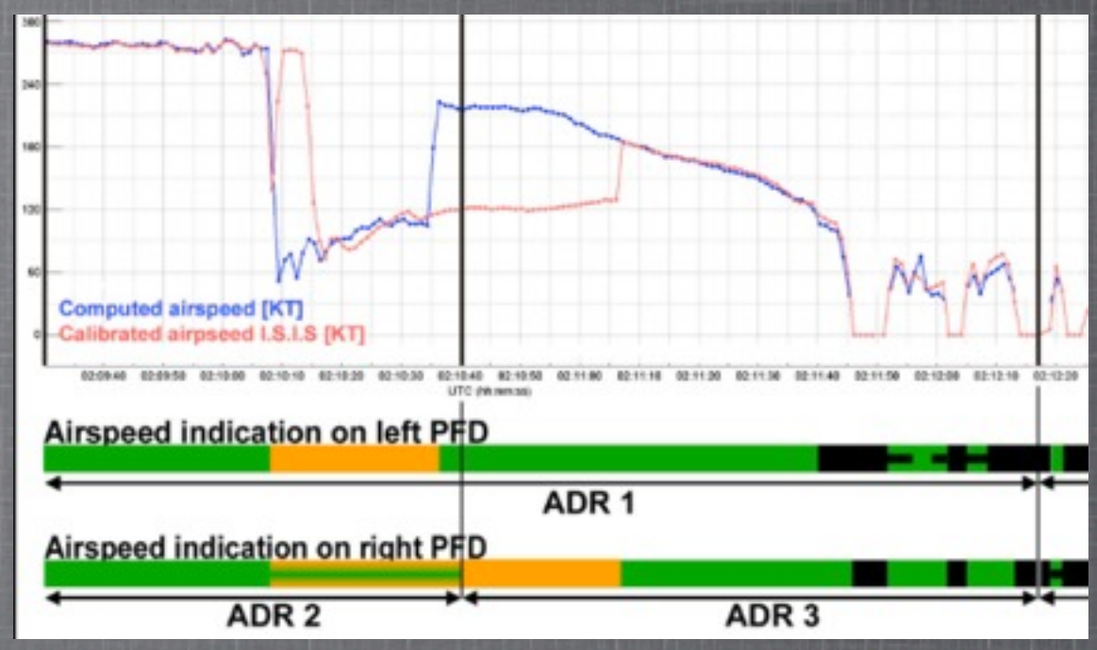
To EASA

3. study the relevance of having a dedicated warning provided to the crew when specific monitoring is triggered [to] facilitate comprehension of the situation
4. determine the conditions in which, on approach to stall, the presence of a dedicated visual indications, combined with an aural warning should be made mandatory.

this gets at pilot input data overload in crises like in this case, and fly by wire assumptions about pilot/airplane/data interactions.

Recommendations

Ergonomics (5 of 5)



To EASA

5. require a review of the conditions for the functioning of the stall warning in flight when speed measurements are very low

aims at improving stall warning interpretations

Recommendations

Oversight of the Operator

To DGAC

1. review the organization of its oversight [to] improve its cohesion and effectiveness
2. ensure the adequacy of the conditions of recruitment and training so all its inspectors have the skills required to exercise their functions

aimed at oversight organization's actions on "precursor" incidents that when not corrected allow accidents to occur.

Recommendations

Release of Drift Buoys

To ICAO

1. amend Annex 13 on search and rescue operations [to] encourage Contracting States to equip their search aircraft with buoys to measure drift and drop them, when those units are involved in the search for persons lost at sea.

Strictly an investigation improvement proposal to help locate debris in remote crash locations link ocean or jungle or desert crashes.

What changed
at Air France

- Replaced all pitot tubes
- Modified rules for relieving Captain
- Deploying new decision making method for pilots
- Changeover of mfgr's documents to English
- Added new simulator training re air speed anomalies and others
- Augmented crews and relief Captain rules and training (CRM)
- Implemented Line Ops safety audits
- Carrying out unreliable speed indication/ ADR CHECK PROC

Accident investigation findings shook up aviation industry -

What changed

EASA Certification Measures

- Pitot tube restrictions/changes
- Autopilot reconnection AD
- Changed Tech Specs for pitot tubes
- Proposed new standards for flight in icing conditions
- Supporting international study of high altitude icing conditions

- Increased events reporting from operators,
- Prohibits certain Thales pitot tubes on A330/340, and limits another to 1 probe , reduced maintenance intervals, participated in Increased events reporting from operators,
- Prohibits certain Thales pitot tubes on A330/340, and limits another to 1 probe , reduced maintenance intervals, participated in new tests, added special conditions on all new projects.

What changed

Aviation Industry Actions

- Manufacturers, operators, pilots associations and authorities formed working group to draft “Aeroplane upset recovery training aid” guide

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What changed

FAA Advisory circular

Issued Advisory Circular with

- good practice guidance that provides crews with appropriate methods and tools to prevent, recognize and recover from a stall
- theoretical training, simulator exercises, CRM, startle factor and upset recovery training aid

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Personal Observations

Fixing operators vs fixing equipment?

- *philosophy: pilot vs a/c performance reilability*
- *scope of task: no. of pilots vs no. of a/c*

Why previous incidents didn't promote action?

data requested -> disparate inputs

Monitoring training effectiveness?

- *metrics – what to measure and how*
- *feedback – for actionable data*
- *data integration – of disparate data*

SAR improvements?

what risks do they reduce

SAR = standards and recommended practices