AIRBUS

MEMORANDUM

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A320 USA MSN 1044, Flight 1549 - Ditching simulation

1. CONTEXT

On the 15th of January 2009, the A320 MSN 1044 operated by USA suffered from a bird strike during climb short after take-off from NewYork LaGuardia airport.
Remaining thrust was low and it was impossible to maintain the level flight.
The crew elected for a ditching in the Hudson river.
In order to precisely analyses the last minutes of the event, Airbus performed flight mechanical simulations of the descent down to touch.
This memorandum provides information about the simulation of the last 300 ft and enables to draw useful and important information regarding alpha protection triggering during that phase.
The objective is to show the Airbus methodology and to provide the details that enable us to state that the aircraft was in alpha protection law from about 150 ft to the touch down.

2. HYPOTHESIS AND GENERALITIES OF THE SIMULATION

Airbus uses an A320 full (3 axis) flight mechanical model to simulate the aircraft movement.
The A320 models we work with are integrating, among others:

- A full aerodynamic/flight mechanical sub model, tuned using flight tests
- A sub model of flight control computers (flight control laws and flight control logics are simulated)

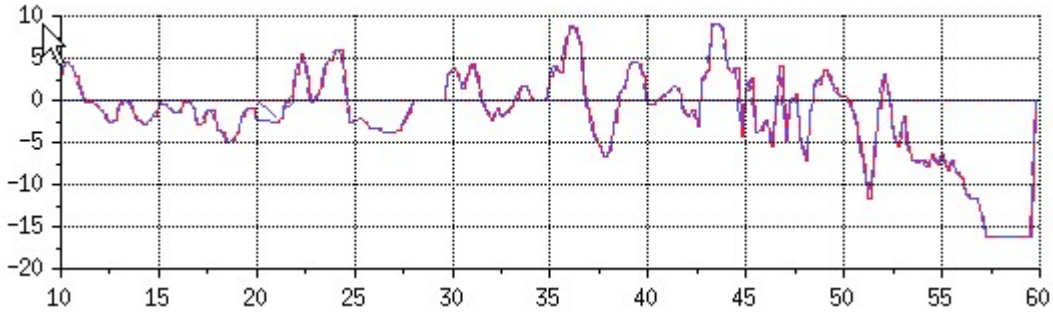
Then, using the orders coming from the DFDR, the model computes flight control surfaces deflection (through the flight control model) and then aircraft movement (through flight mechanics / aerodynamic model).
Those flight surfaces deflection are compared to DFDR recordings.
Typical flight mechanical parameters, outputs of the theoretical simulation are also compared to the DFDR recordings.

Note: T=0sec of Airbus simulation corresponds to GMT 20.29.42 of the DFDR (as used by Airbus).

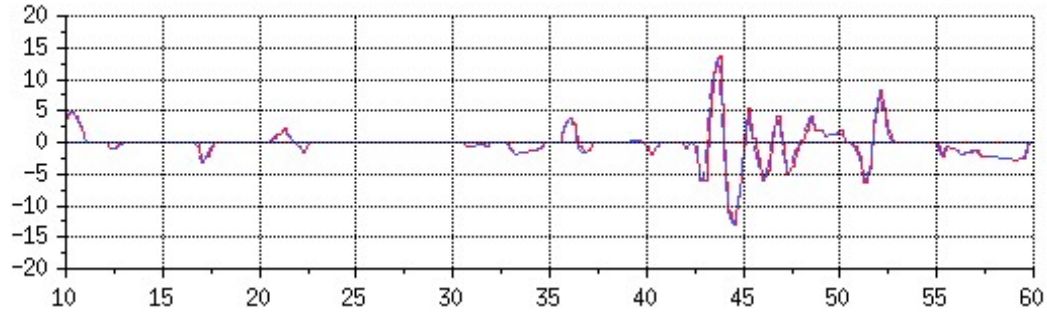
3. INPUTS OF THE SIMULATION

The crew inputs (longitudinal stick input, lateral stick input, rudder pedal stick inpus) are used as inputs of the simulation, as well as engine N1. The data that are used are coming from the DFDR.

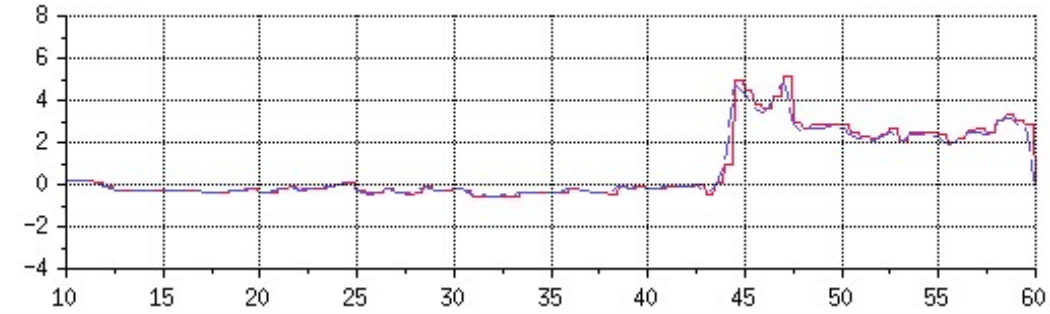
Captain longitudinal stick input = f(Time)



Captain lateral stick input = f(Time)



Rudder pedal orders = f(Time)



In red are the data coming from the DFDR.
In blue are the data in the Airbus theoretical simulation.

External perturbation (3 axis wind) has been estimated by integrating accelerations and by comparing ground speed vector v.s. airspeed vector.
This wind is also injected to the simulation. However note that amplitude is not significant (less than 3 m/s).

4. OUTPUTS OF THE SIMULATION

4.1 FLIGHT MECHANICS PARAMETERS

Typical flight mechanical parameters, outputs of the theoretical simulation are compared to the DFDR recordings.

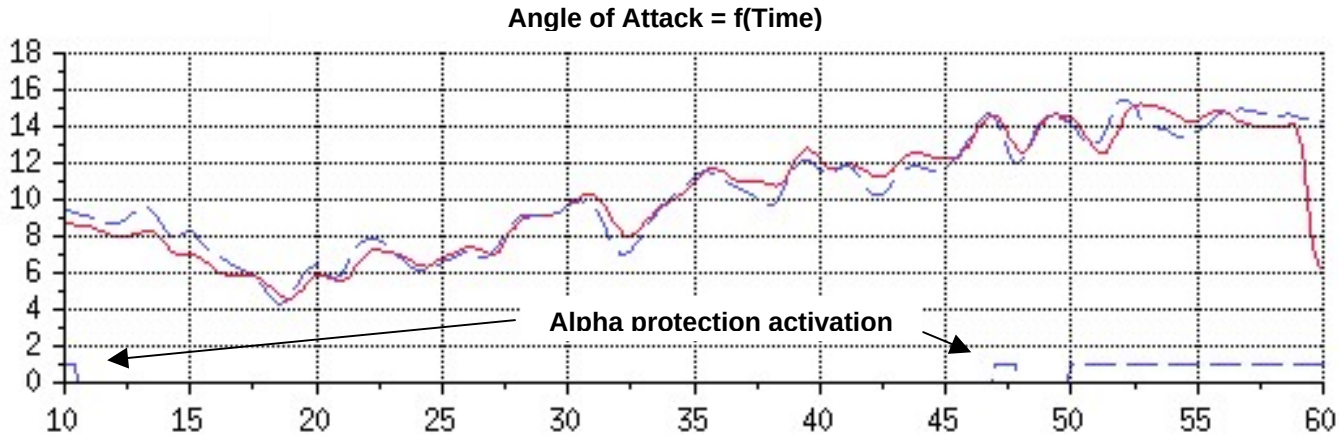
As we focused on the longitudinal axis, it is given on the next page the main longitudinal parameters.
In red are the parameters coming from DFDR.
In blue are the parameters coming from the Airbus theoretical simulation

The good matching we have between simulation outputs and DFDR recordings enable to have confidence on the quality of the simulation.
As we have a complete model of the flight control computer logics as well, is it then possible to get access to internal parameters that are not recorded in DFDR such as alpha protection activation.
This is detailed on the next paragraph.
Note: The “DFDR AoA” provided in the following plots is the average of AoA1 and AoA2.

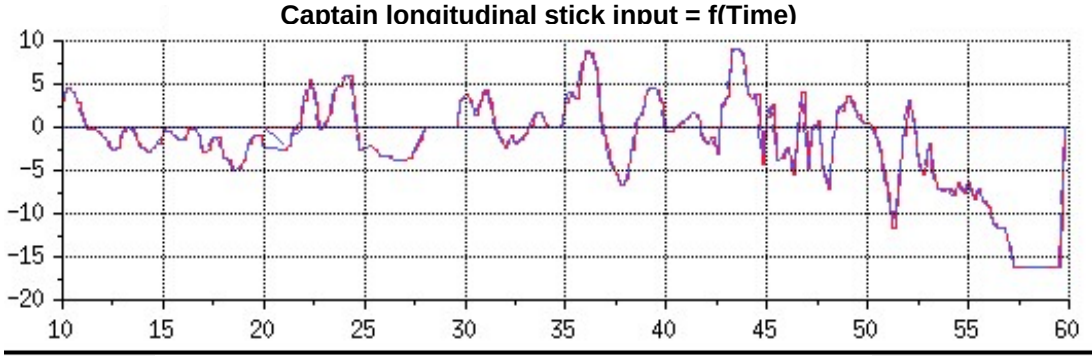
4.2 ZOOM ON ALPHA PROTECTION TRIGGERING

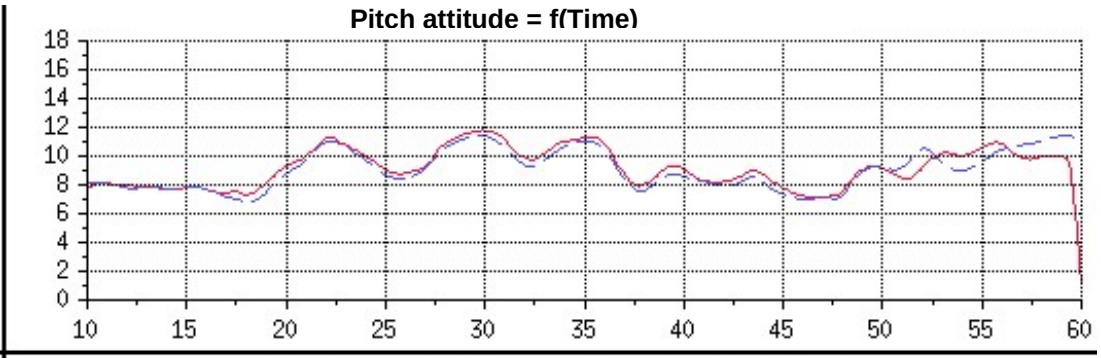
The flight control law modules used in this global aircraft model uses among all logics, the detailed and real activation / de-activation conditions of the alpha protection law.
It is possible to have access as output of the simulation to the Boolean (logical information, 1 or 0) identifying the activation of the alpha protection law.

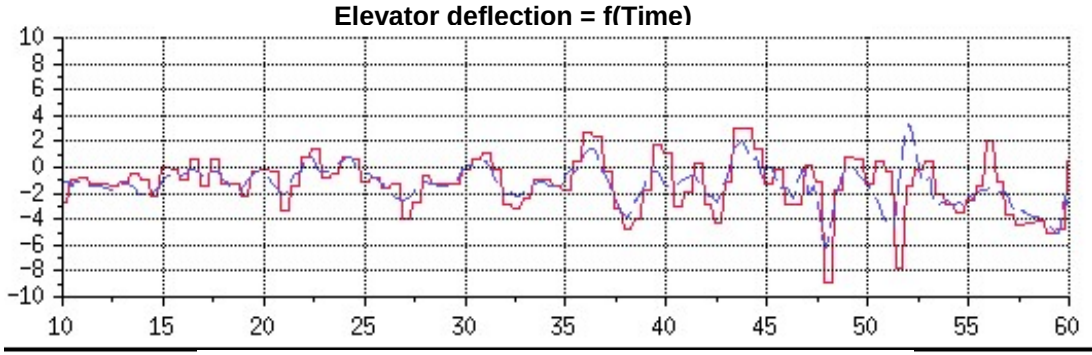
This Boolean is given below superimposed with the Angle of attack parameter.

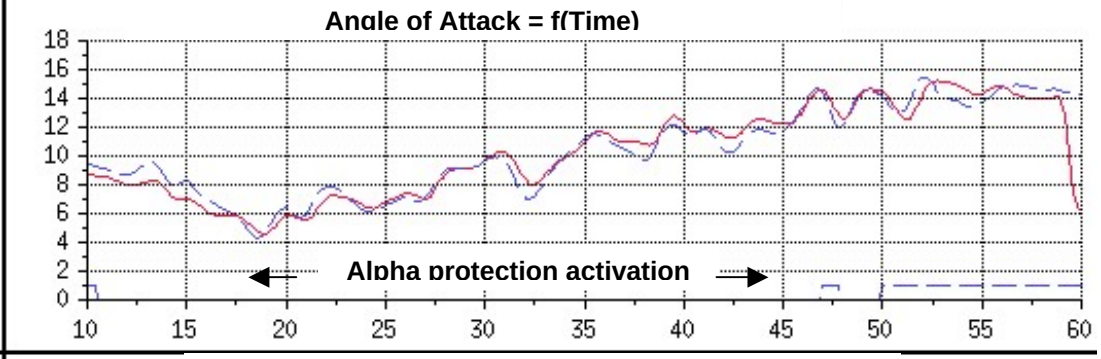


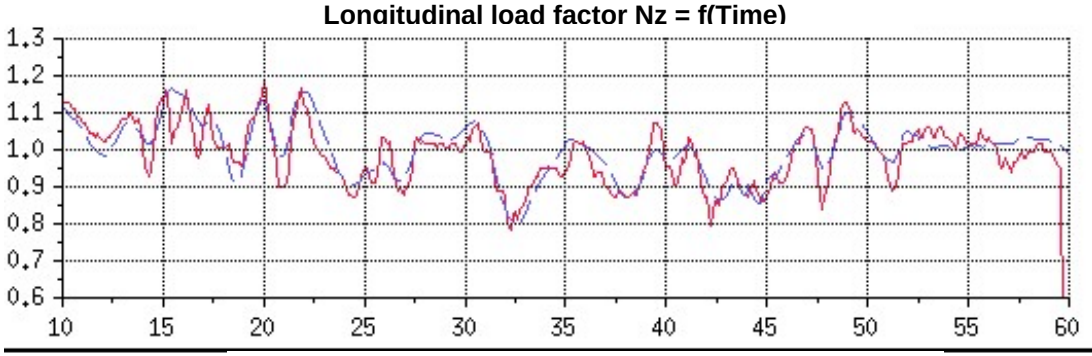
The boolean at the bottom of the chart in blue is the alpha protection activation.
There is a first AoA prot activation at 300 ft (aircraft was actually already in prot from about 1200 ft, in CONF Clean, information coming from another simulation).
Then a t=11 sec (corresponding to slat/flap extension), aircraft left the protection.
There is a transient activation at t=47sec = about 220 ft, during 2 sec).
The aircraft then entered the AoA protection (when in CONF 2) at t = 50 (about 150 ft) and stayed in protection up to the end.

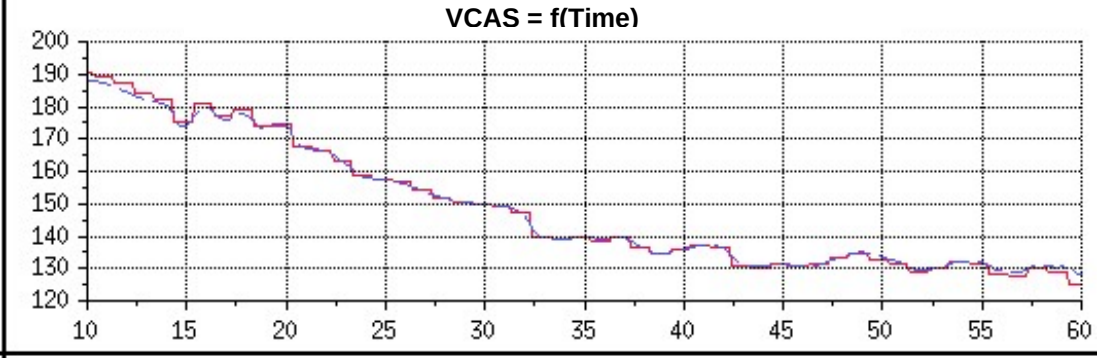

Captain longitudinal stick input = f(Time)

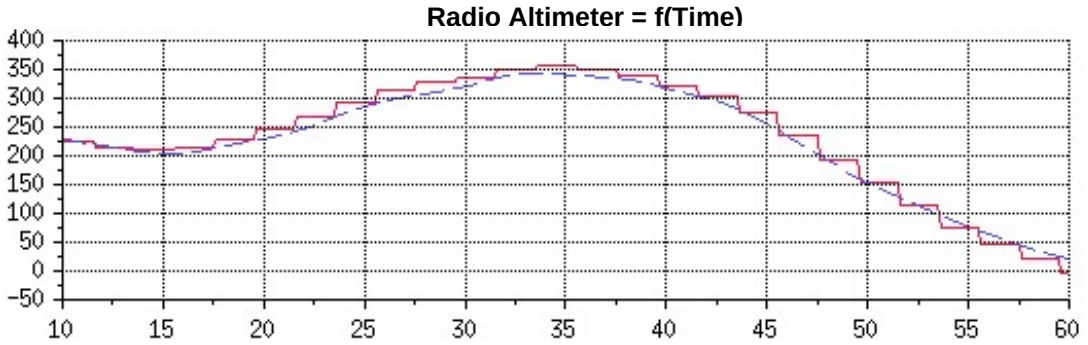

Pitch attitude = f(Time)

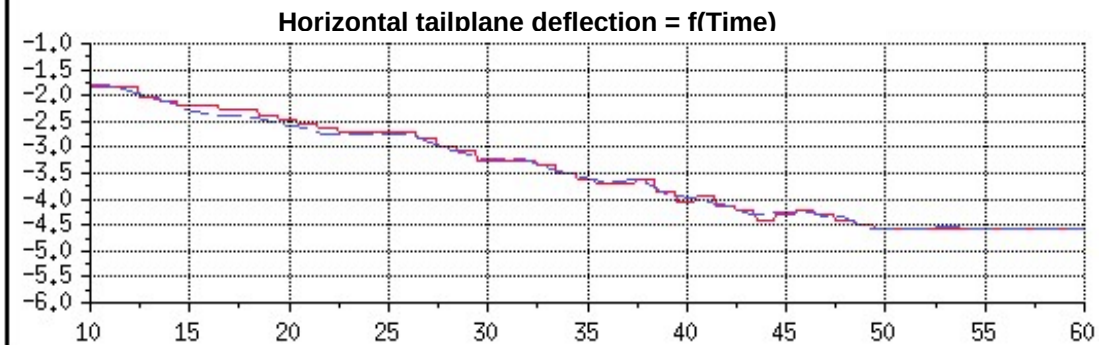

Elevator deflection = f(Time)


Angle of Attack = f(Time)
Alpha protection activation


Longitudinal load factor Nz = f(Time)


VCAS = f(Time)


Radio Altimeter = f(Time)


Horizontal tailplane deflection = f(Time)