

Black Swan Events

Safety Management Summit
SMS Brazil 2019
Sao Paulo

Santiago SALTOS

Regional Safety Director, Latin America & Caribbean

AIRBUS



What Defines a Black Swan Event?

Black swan events are characteristically

- extremely hard-to-predict, or rare
- beyond the realm of normal expectations

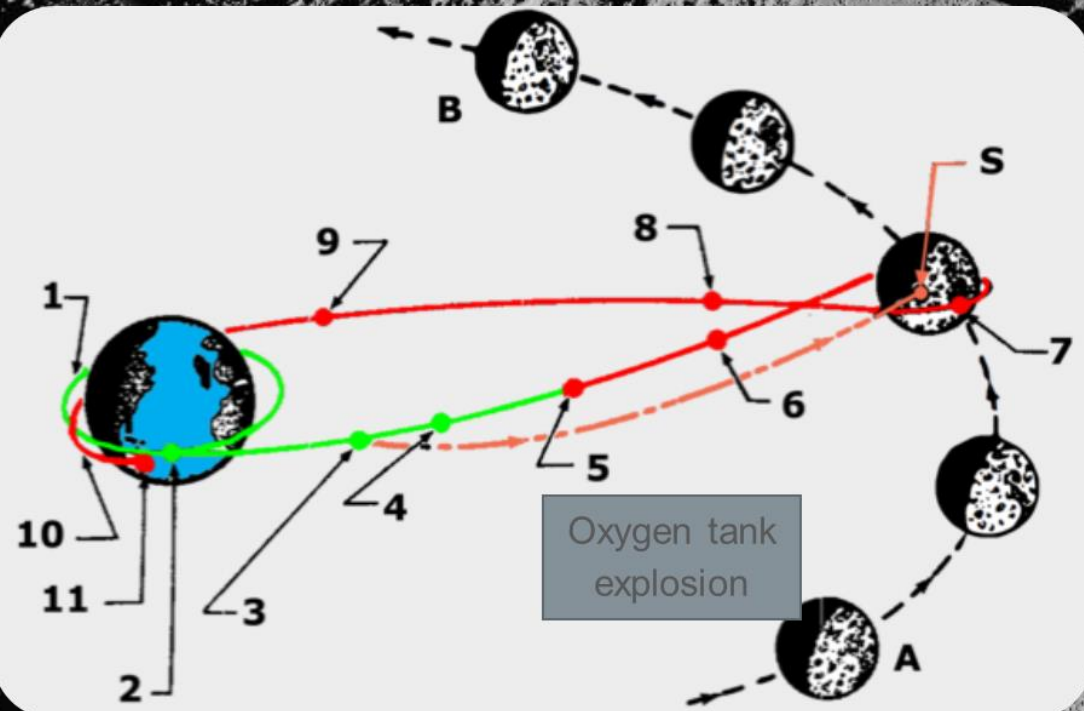
In ancient Greece, it was assumed a black swan could not exist ... until it was unexpectedly discovered in the wild much later.

“Houston, we've had a problem...”



Apollo 13 Status

- Loss of electrical power (2/3 fuels cells out)
- Loss of oxygen supply (2 tanks out)
- Loss of water generation



Mission reconfiguration

- Direct abort not possible
- Need to go-around the moon
- Use of Lunar Module as lifeboat

Black Swan events

... in the aerospace industry

Apollo 13
April 11, 1970



US

Mission Report Conclusions

The mission was aborted because of the **total loss of primary oxygen** in the service module [...]

The performance of lunar module systems demonstrated an **emergency operational capability**. Lunar module systems supported the crew for a period approximately twice their intended design lifetime [...]

The **effectiveness of preflight crew training**, especially in conjunction with **ground personnel**, was reflected in the skill and precision with which the crew responded to the emergency

During the event

- Unexpected failure
- Need to adapt, think “out of box”, be inventive
- Importance of training
- Make full use of all available resources
 - *Human : crew+ground*
 - *Hardware*

After the event

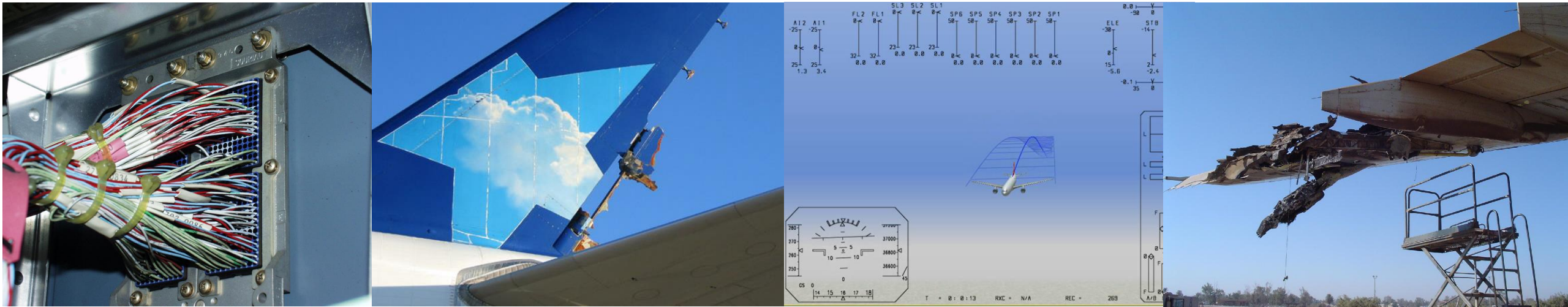
- Lessons learnt
- Safety enhancements

Black Swan events

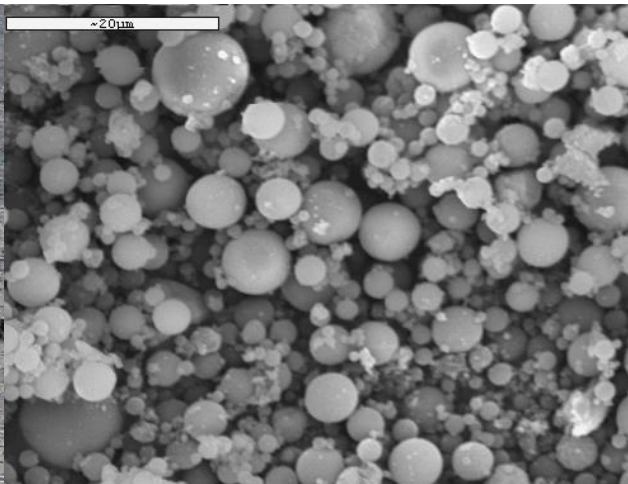
... in the aerospace industry

Apollo 13
April 11, 1970





Airbus Black Swan events - some examples



Crossed Roll Controls (Capt'n)

Event summary :

- Maintenance on EFCS before the flight
- At take-off the Captain (PF) applied a lateral sidestick input to the right but the aircraft banked to the left
- The F/O took over aircraft control promptly, without the captain's demand to transfer controls

Root cause : Inverted ELAC input wires during maintenance

Product enhancements :

- AMM improvements regarding EFCS maintenance
- Flight Control Check procedure modified

Airbus Black Swan events

A320 (2001)

Lessons Learnt

CRM : F/O
empowerment

Flat cockpit
hierarchy

Total loss of hydraulics

Event summary :

- LH wing hit by missile during initial climb (8000ft)
 - *Loss of the 3 hydraulics in 20s → F/CTL lost, Slats&Flaps frozen*
 - *Left wing in fire and associated fuel tank emptying*
 - *A significant amount of the left wing surface missing*
 - *Both engines still running*
- Crew managed to learn how to control the pitch & roll using thrust only

Root cause : terrorist act (missile)

Product enhancements :

- Not applicable to this event

Airbus Black Swan events

A300 (2003)

Lessons Learnt

Remarkable
airmanship &
team working

Flying with
engines only was
possible

Learn as you go

Rudder loss

Event summary :

- Normal flight until the cruise
- Sudden vibrations and loud noise
- Dutch roll experienced. Decreased and ceased when descending
- On ground, major part of the rudder was found missing from the aircraft

Root cause : rudder pre-flight damage (disbond)

Product enhancements :

- Reinforced sandwich rudders inspections
- Enhanced design of sandwich rudders
- Technology/design evolution on new programs

Airbus Black Swan events

A310 (2005)

Lessons Learnt

UPRT knowledge
*“slow down and
go down”*

Although damage
tolerant, rudder
needs a health
check inspection
program

Emergency water landing

Event summary :

- Significant loss of thrust on both engines due to the bird strikes
- APU ON by the crew → *retaining NORMAL Law, thus all protections*
- Landing strategy to be determined with limited or no time to prepare
- Crew focused on essential task of flying the aircraft given the emergency
- Aircraft flown occasionally within the Alpha protection range
- Emergency water landing

Root cause : multiple bird strikes impacting both engines

Product enhancements :

- New QRH procedure : EMER LANDING - ALL ENG FAILURE
- New engine certification requirements vs birdstrike
- APU auto-start function introduced on A350

Airbus Black Swan events

A320 (2009)

Lessons Learnt

Time-critical
decision making

Task-sharing & CRM

Systems knowledge
(Use of APU)

Fuel Contamination

Event summary :

- During descent, approach and landing the aircraft encountered a loss of thrust control event affecting both engines
 - *Both Fuel Metering Valves contaminated → blockage*
 - *Engine 1 remained at 70% N1, Engine 2 in sub-idle*
 - *Contaminants composed of salt, water and Super Absorbent Polymer (SAP)*
- An emergency landing was made (GS~240 kts, Flaps 1).

Root cause : Fuel contamination traced to refuel dispenser

Product enhancements :

- New operational guidance to assist flight crews

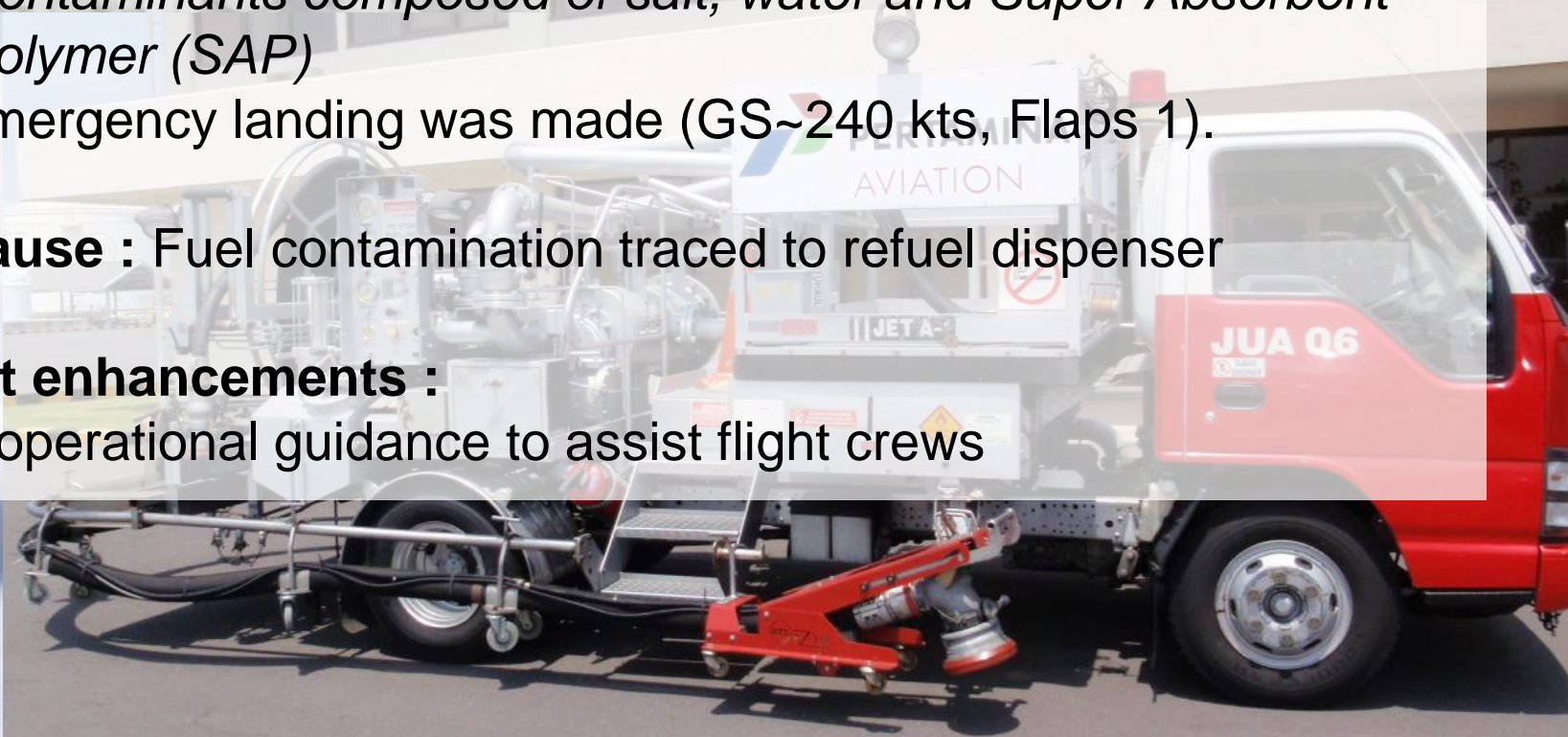
Airbus Black Swan events

A330 (2010)

Lessons Learnt

IATA Fuel Working
Groups formed

SAP filters are
being phased out
(Jan 2020)



Uncontained engine disc failure

Event summary :

- Intermediate Pressure Turbine (IPT) disc failure during climb
- Airframe impacted by disc debris → *damage to multiple systems*
- In-Flight Turn Back
- ECAM actions processed
- Safe landing and controlled disembarkation

Root cause : Uncontained engine disc failure

Product enhancements :

- IPTOS function : automatic engine shutdown in case of IPT overspeed
- Enhanced engine design and manufacture process
- ECAM scroller introduced on A350
- Fuel Shut Off Valves routing precautions on new programs
- OIS optimized landing distance calculation vs actual aircraft capability

Airbus Black Swan events

A380 (2010)

Lessons Learnt

A/C flown by the 2 crew members

Aircraft resilience due to redundancies (*AP, Flight Envelope protections*)

ECAM working beyond design envelope

AoA probes blockage

Event summary :

- The 3 AoA blocked during climb (~FL100)
- When reaching FL310 :
 - AP disconnected
 - High AoA protection unduly triggered → *pitch down commanded*
- Flight crew selected 3 ADR OFF and stabilized A/C at FL300
- Diversion performed with 3 ADR back ON

Root cause : AoA blockage (conic plates configuration)

Product enhancements :

- Removal of conic plate (*reversion to original AoA configuration*)
- Enhanced EFCS AoA monitoring
- New AoA probes under development

ANGLE OF ATTACK SENSOR

Airbus Black Swan events

A330 (2012)

Lessons Learnt

Continuous
system
monitoring

Aircraft
knowledge
(*use of AoA*)

Loss of RH windshield in flight

On-going Annex 13 investigation by CAAC

Event summary :

- 40 min after take-off, while in cruise (FL321), the RH windshield was lost
- Immediate descent towards a lower altitude (initial MSA = FL205)
- Diversion to the nearest airport (Chengdu, China)
- Transponder was set to 7700
- Uneventful landing
- The first officer and one cabin crew suffered minor injuries

Most probable root cause : windshield local high overheating due to electrical arcing

Product enhancements :

- FCOM & QRH improvements introduced in Dec 2018 revision
- Windshield design, manufacturing enhancements and potential additional mitigations are under review with the supplier

Airbus Black Swan events

A319 (2018)

Lessons Learnt

Golden rules – *Fly the A/C*

Risk of crew member ejection and hypoxia

Decision making (*descent & diversion*)

[QRH] COCKPIT WINDSHIELD / WINDOW CRACKED

Ident.: PRO-ABN-MISC-00012097.0001001 / 04 DEC 18

Applicable to: ALL

SHOULDER HARNESS.....

. FASTEN

TOUCH THE CRACK WITH A PEN (OR CAREFULLY WITH FINGERNAIL)

■ If no crack on cockpit side:

NO LIMITATION

The inner ply is not affected. Therefore, the window/windshield is still able to sustain the differential pressure up to the maximum flight level.

■ If cracks on cockpit side:

CREW OXY MASKS.....

. USE

MAX FL: 230 / MEA-MORA

The inner ply is affected. The flight crew is not able to easily determine if other plies are affected. Descend to FL 230/MEA and reduce differential pressure to 5 PSI .

**Crew member ejection
from the cockpit**

**fasten seat belts +
shoulder harnesses**

Hypoxia

**don the cockpit O2
masks**

Only if there is a risk of
dual ply failure

Flight Operations & Crew Aspects

Improvements introduced in
FCOM & QRH - Revision Dec 2018
(Major Event)

Communicated to Operators through FOT
(999.0100/18 Rev 00)

AIRBUS

Black Swan events are part of the aviation industry

Industry safety efforts have allowed minimizing the impacts of such exceptional events

Conclusion

When relevant, Airbus will develop Product Enhancements after such events

Main Lessons Learnt

Respect the golden rules

All trained pilot competencies will be needed

Make use of all available resources

Be ready to think outside of the box, taking the best of your procedures

© Airbus S.A.S. 2019 – All rights reserved. Proprietary documents.

By taking delivery of this Presentation (hereafter "Presentation" or "Presentations"), you accept on behalf of your company to comply with the following guidelines: No other intellectual property rights are granted by the delivery of this Presentation than the right to read it, for the sole purpose of information. This Presentation and its content shall not be modified and its illustrations and photos shall not be reproduced without prior written consent of Airbus. This Presentation and the materials it contains shall not, in whole or in part, be sold, rented, or licensed to any third party subject to payment. This Presentation contains sensitive information that is correct at the time of the 25th Flight Safety Conference. This information involves a number of factors that could change over time, effecting the true public representation. Airbus assumes no obligation to update any information contained in this document or with respect to the information described herein. Airbus S.A.S. shall assume no liability for any damage in connection with the use of this Presentation and of the materials it contains, even if Airbus S.A.S. has been advised of the likelihood of such damages. Material for publication is obtained from multiple sources and includes selected information from the Airbus Flight Safety Confidential Reporting System, incident and accident investigation reports, system tests and flight tests. Material is also obtained from sources within the airline industry, studies and reports from government agencies and other aviation sources. All Presentations are provided for information only and are not intended to replace ICAO guidelines, standards or recommended practices, operator-mandated requirements or technical orders. The contents do not supersede any requirements mandated by the State of Registry of the Operator's aircraft or supersede or amend any Airbus type-specific AFM, AMM, FCOM, MMEL documentation or any other approved documentation. Presentations may be reprinted without permission, except where copyright source is indicated, but with acknowledgement to Airbus.



AIRBUS