雙供氣系統失效與空中失壓

行政院飛航安全委員會

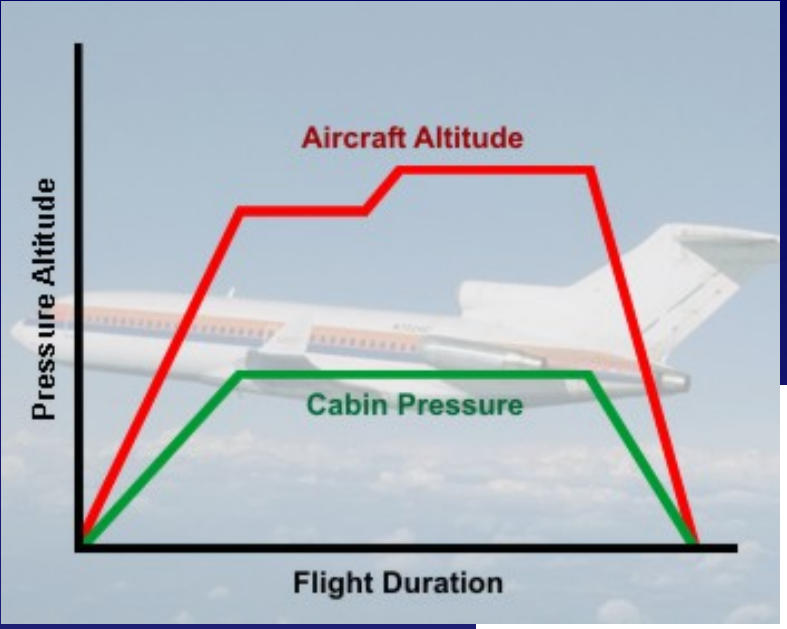
蘇水灶/ 飛安調查官

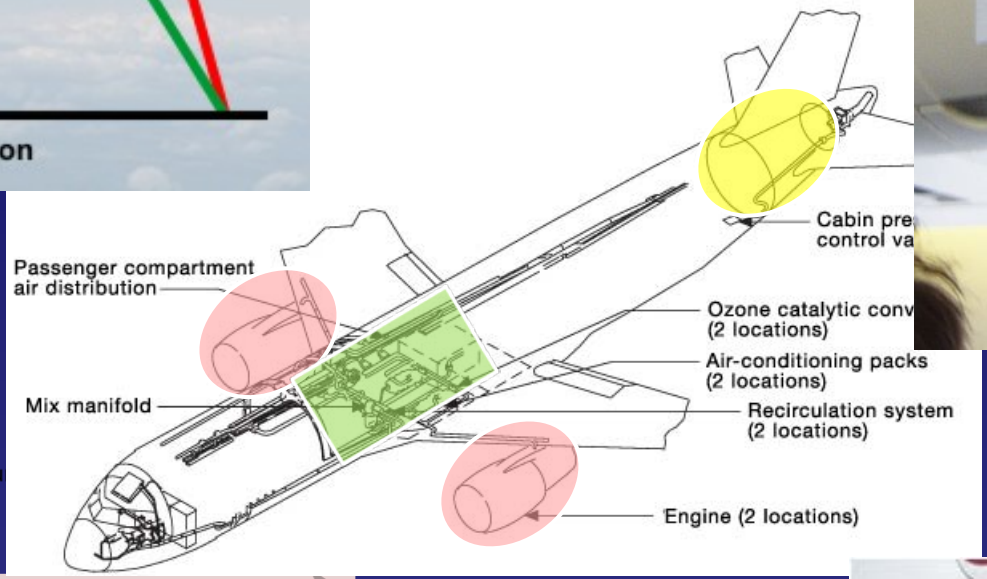
Outlines

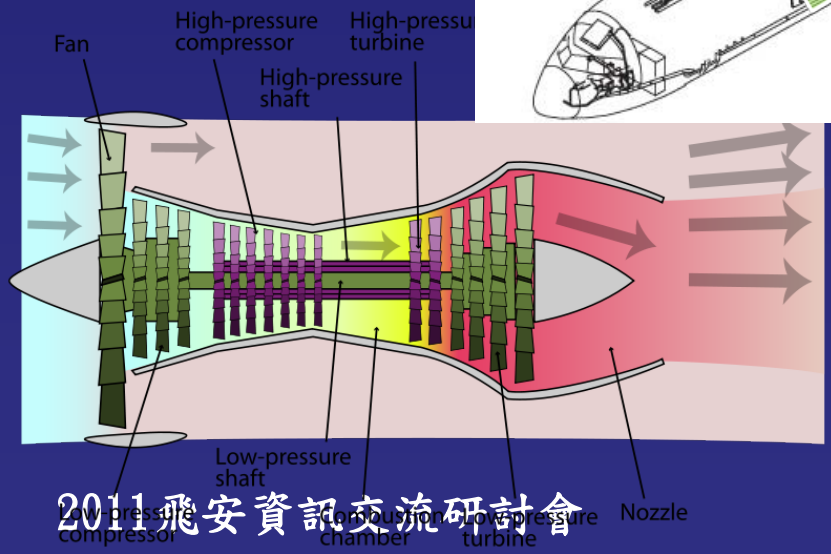
- Systems introduction
- Dual bleed loss case I study
- Dual bleed loss case II study
- Conclusion

Aircraft systems

- What aircraft systems could be involved in an occurrence of loss of cabin pressurization?
  - Pneumatic system
  - Air conditioning pack
  - Cabin pressurization system
  - Aircraft structure
  - Oxygen system

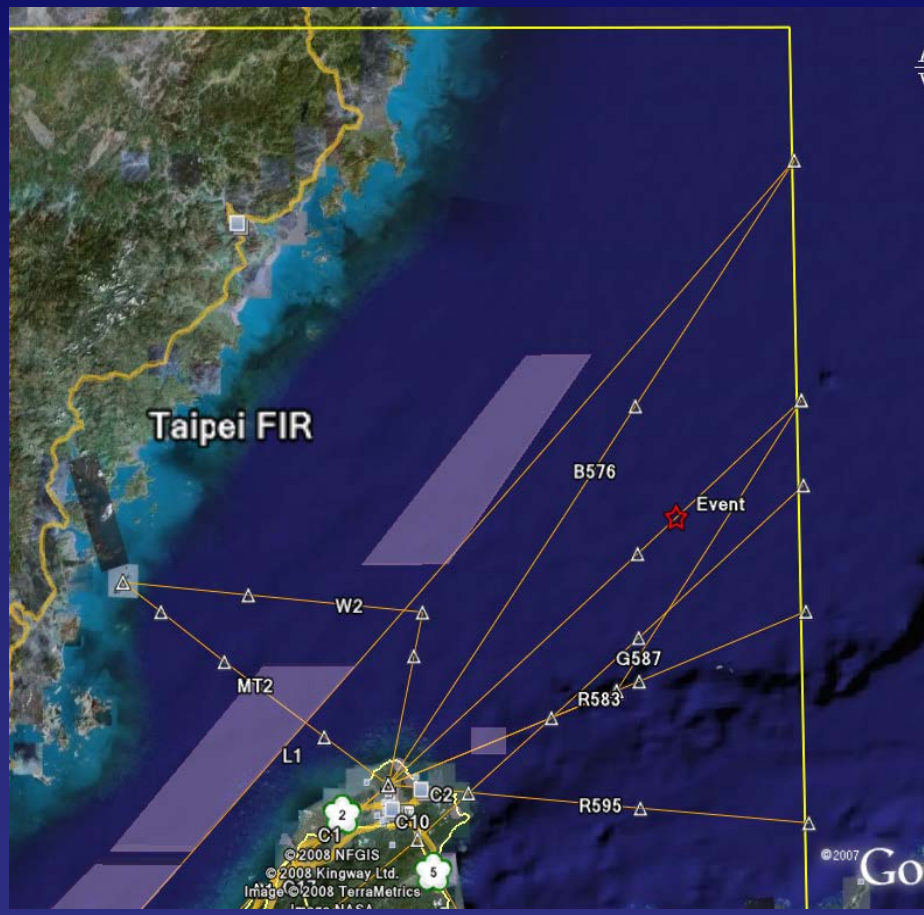

Aircraft Altitude
Pressure Altitude
Cabin Pressure
Flight Duration


Passenger compartment
air distribution
Cabin pre
control va
Ozone catalytic conv
(2 locations)
Air-conditioning packs
(2 locations)
Mix manifold
Recirculation system
(2 locations)
Engine (2 locations)


Fan
High-pressure
compressor
High-pressu
turbine
High-pressure
shaft
Low-pressure
shaft
Nozzle

DBL-I 事故經過

- 某航空公司一架A330-300原定由日本成田飛往香港，因颱風影響，改飛桃園國際機場。該機於成田機場執行飛行前檢查時，該機1號發動機逸氣閥(Bleed Valve)失效，依據該型機最低裝備需求表(MEL)36-11-02程序完成檢查放飛。於臺北時間1614時，該機由成田國際機場起飛，機載85人。



DBL-I 事故經過

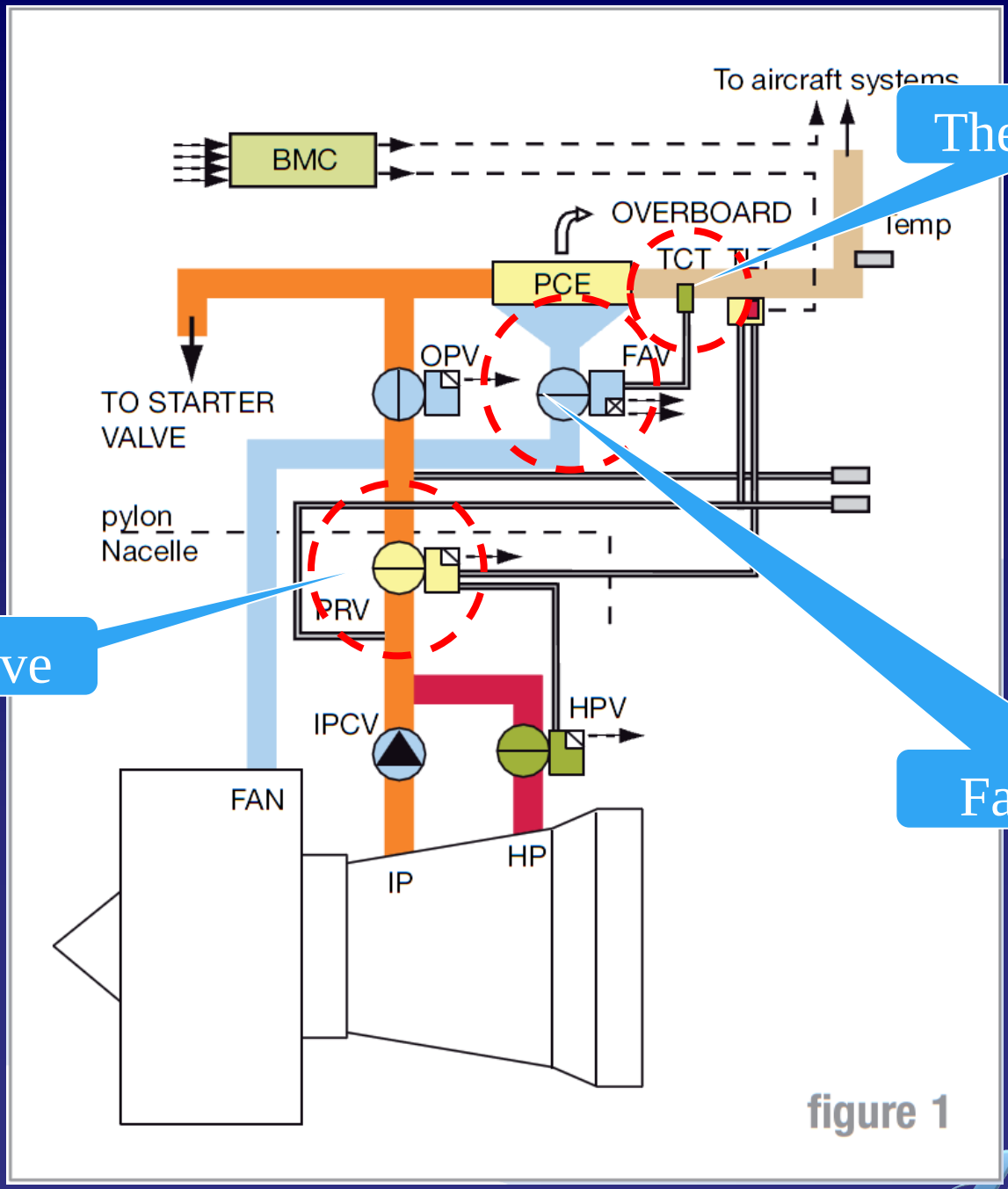
- 該機巡航高度40,000呎，於1852時，許可下降至FL140，於1855:46時通過 FL380，CM1發現ECAM“AIR ENG2 BLEED FAULT” 及 ” AIR ABNORM BLEED CONFIG” 訊息相繼出現。發動機供氣系統重置後仍失效，隨後發現艙壓高度開始上升，駕駛員決定放出減速板增加下降率。
- 1857:39時ECAM出現艙壓失效「EXCESS CAB ALT」主警告訊息，當時儀顯示艙壓高度為9,700呎。該機艙壓高度最高曾達13,424呎，飛航組員即依緊急下降程序下降並戴上氧氣面罩。於緊急下降過程中，飛航組員以手動方式放下客艙中氧氣面罩。

Recent maintenance records

- Intermittent fault of Eng 1 bleed valve not closed for 6 times during last month
- In this occurrence Eng 2 bleed fault at approx 36000 during descent, initial reset unsuccessful, 2nd attempt OK. It was the first time failure for this aircraft.

Replaced components

- Fan Air valve
  - P/N 6733A030000,
- Bleed valve
  - P/N 6764B040000
- Thermostat
  - P/N 398E020000

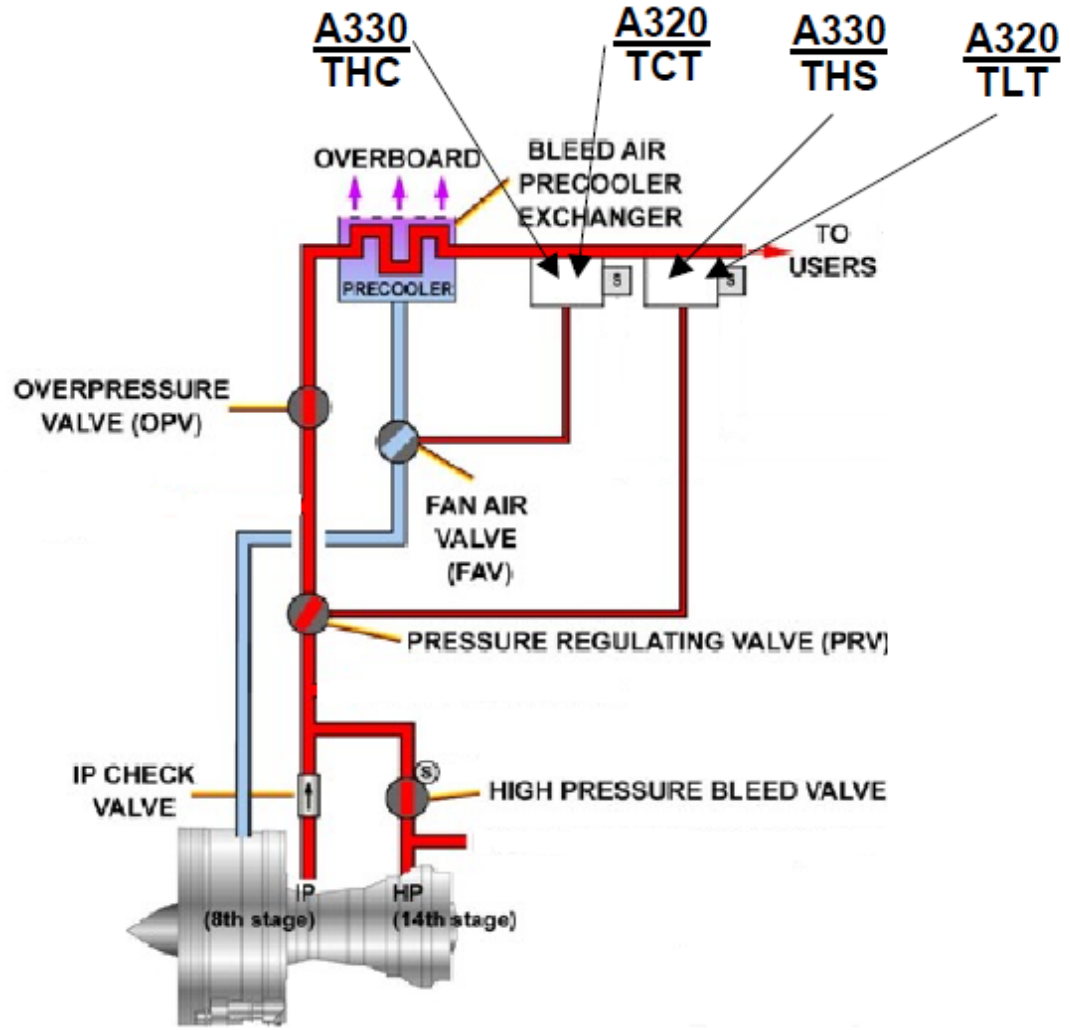


Thermostat

Bleed valve

Fan Air Valve

Temperature Regulation



Temperature Control Solenoid = THS / TLT (Thermal protection function backup)

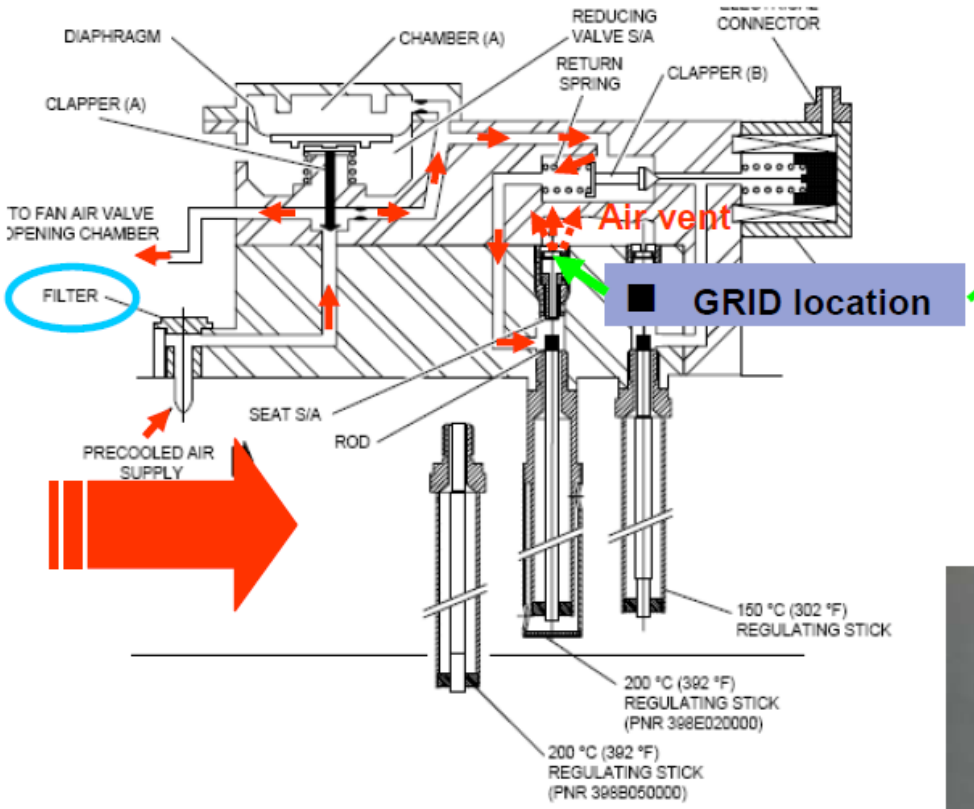
Temperature Control Thermostat = TCT / THC

Components Test Results

- PRV fault not confirmed
- FAV fault confirmed but impact on this event.
- THC fault confirmed

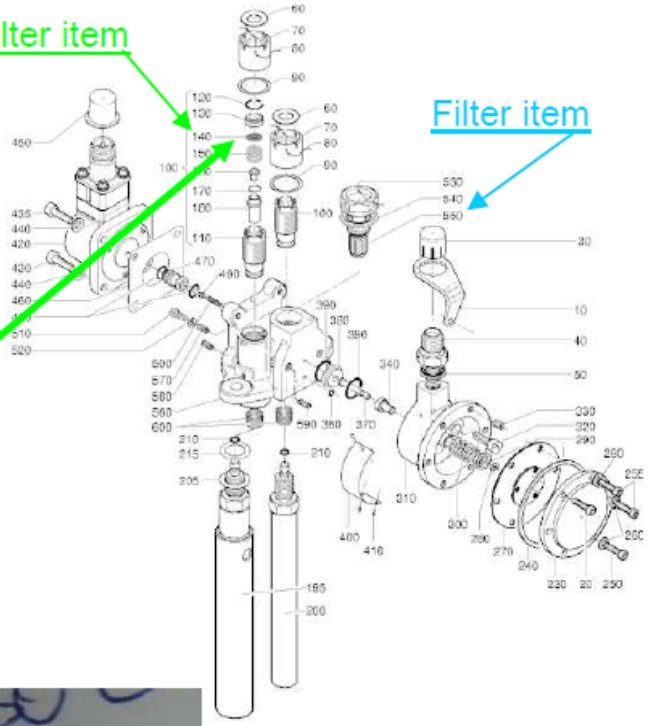
Root cause

Path of the bleed air into the THC in hot temperature condition



Grid filter item

Filter item

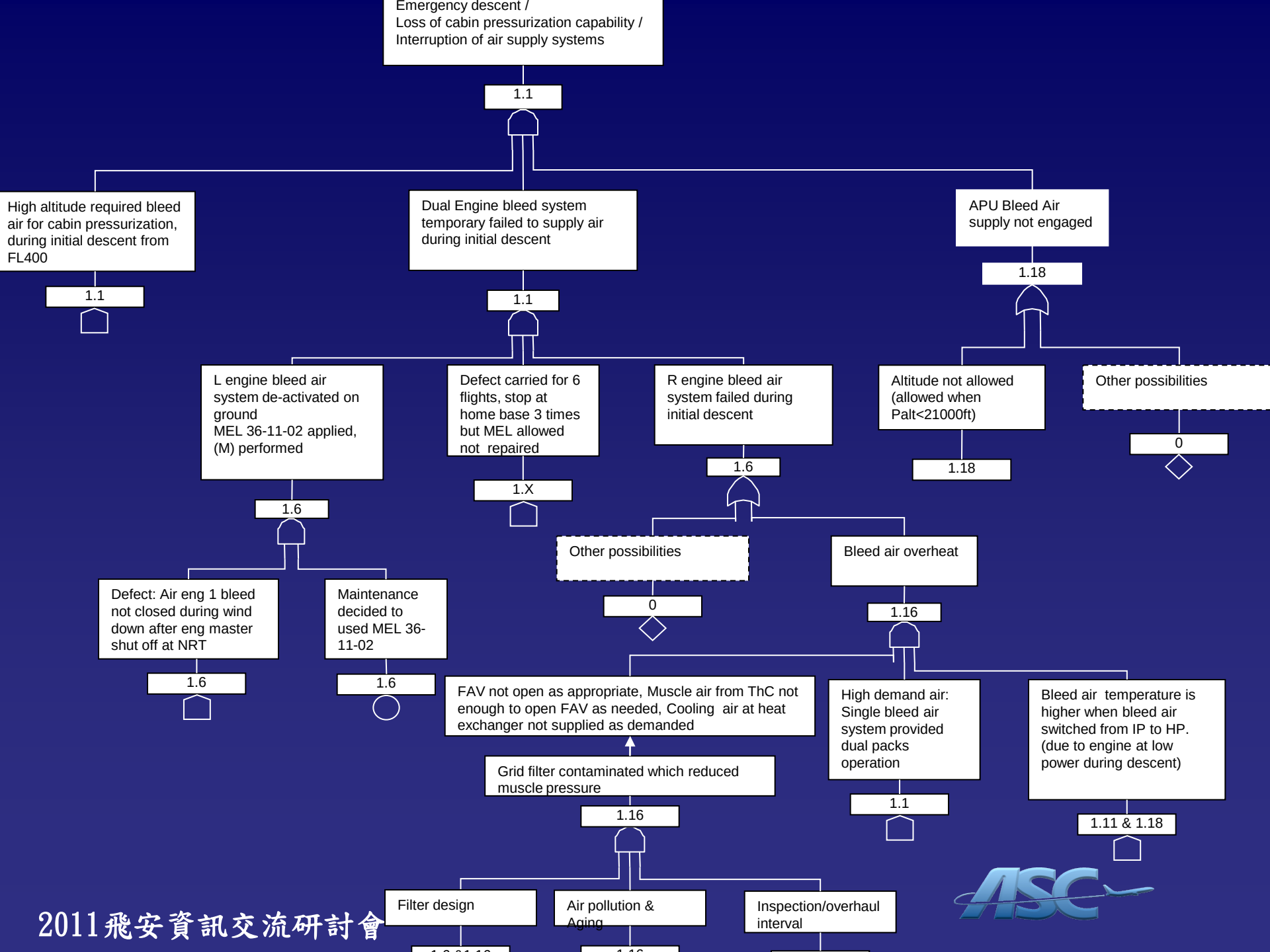


■ **Contaminated grid** (sample)

Case closed?

Engineering Investigation considerations

- System reliability and Components reliability
- Maintenance actions and MEL
- Rate of cabin altitude during occurrence, Highest cabin altitude
- Cabin leak rate, Maintenance records of door/window seal repair/replacement


Emergency descent /
Loss of cabin pressurization capability /
Interruption of air supply systems
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High altitude required bleed air for cabin pressurization, during initial descent from FL400
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Dual Engine bleed system temporary failed to supply air during initial descent
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APU Bleed Air supply not engaged
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Defect carried for 6 flights, stop at home base 3 times but MEL allowed not repaired
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Bleed air overheat
1.16
FAV not open as appropriate, Muscle air from ThC not enough to open FAV as needed, Cooling air at heat exchanger not supplied as demanded
Grid filter contaminated which reduced muscle pressure
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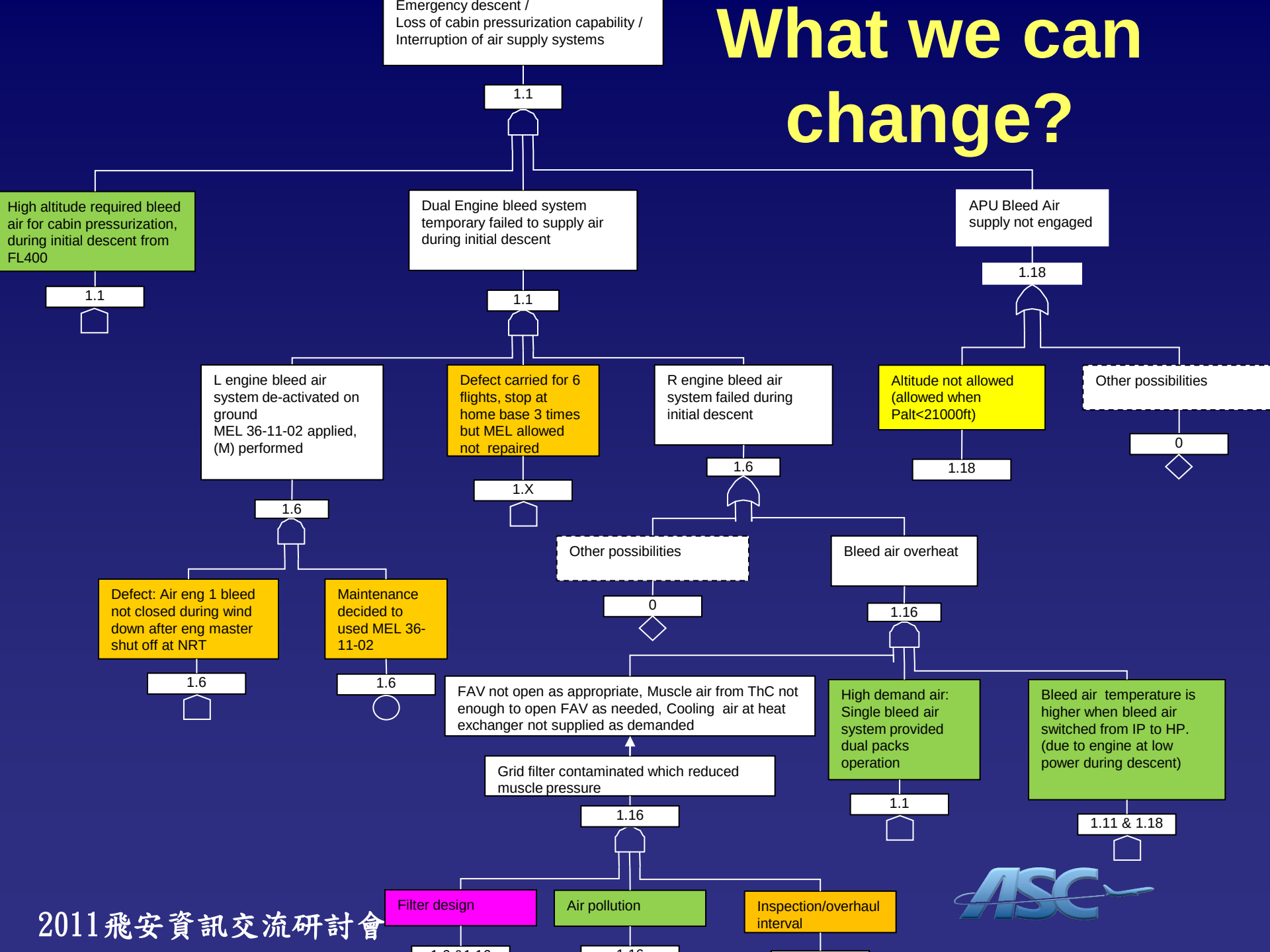
High demand air: Single bleed air system provided dual packs operation
1.1
Bleed air temperature is higher when bleed air switched from IP to HP. (due to engine at low power during descent)
1.11 & 1.18
Filter design
Air pollution & Aging
Inspection/overhaul interval

What we can change?



Airbus Actions Taken

- **1) THC improvement:**
  - The THC filter grid has been modified. The THC modification consists in replacing mesh filter by a pollution cover. This modification is covered by VSB 398-36-04.
  - This modification will be applied in production.
  - For in-service A/C, the VSB 398-36-04 is available since week 41 2009.
  - SIL will be updated in the aim to reflect these new improvements.

2) MPD update:

- MPD task ref 361143-01-1 asks for THC cleaning every 6000 FH. Previously, this task is not mandatory and only refers to SIL 36-055.
- It is planned to render this task mandatory by MPD revision. However, since the MRB process is lengthy, the MPD revision is not expected before 1Q 2011.
- Pending the MPD update, Airbus provides advance information through SIL 36-055.
- This SIL also recommends to customize the cleaning interval depending on the operating environment.

Operator Actions Taken

- Thermostat (ThC) Reliability Recovery Plan:
  - Initial action - remove all ThCs with TSI > 15000 FH.
  - AMS task already raised to remove ThC based on 3100 FC life limit.
- New procedure in April 2009 rev of TSM to confirm if further troubleshooting is required when an a/c experiences PRV not closed fault.
- Temporary Restrictions imposed in A330 MEL from Sep 2008. No dispatch out of home base for ; ATA 36-11-01, 36-11-02, 36-11-03, 36-11-04, 36-11-05, 36-11-06, 36-11-07.

Operator Actions Taken

- Additional restrictions imposed on A330 operations from Jan 2009. CMS Fault message: THRM/FAN AIR-V/SENSE LINE must be investigated as per TSM 36-11-81-810-850[861] prior to next home base departure.
- A new MEL revision has been developed by CX Airbus Fleet Office and Engineering, and is still awaiting final approval from Airbus before being made permanent. This new MEL revision reintroduces an operational procedure whereby the APU is started in case of a subsequent bleed failure in flight.

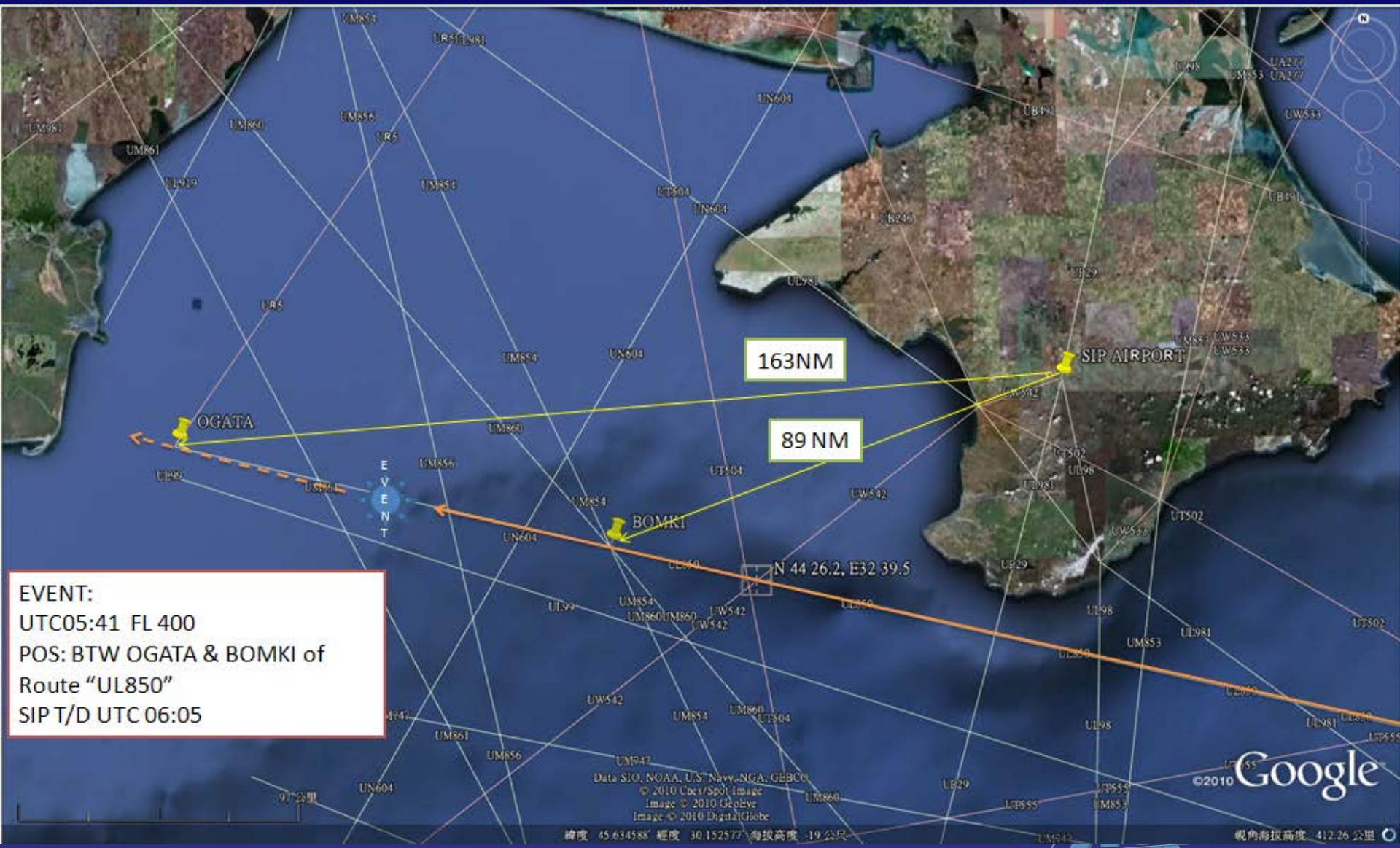
Beyond ASC investigation

- Parallel Investigation
- Actively worked with ASC from the site data collection to the final report.
- Required further investigation from ATC, operation and engineering aspects with comprehensive reasons.
- A320 vs A330 engine bleed air system

DBL-II 事故經過

- 民國99年12月，某航空公司一架機型A330-200客機，於0442時自曼谷國際機場起飛，目的地為奧地利維也納國際機場。於1307時，該機巡航於40,000呎高度，機長正於客艙輪休，當時由巡航機長坐於左座擔任監控駕駛員，副駕駛員坐於右座擔任操控駕駛員，ECAM顯示“AIR ENG 1 BLEED FAULT”及“AIR ABNORM BLEED CONFIG”訊息，飛航組員兩次嘗試重置無效後，依ECAM指示關閉1號供氣系統，當時客艙壓力高度仍穩定維持於8,000呎，亦無其它異常狀況，故繼續飛行，未通知PIC。

- 1333時，PM離開駕駛艙上廁所，駕駛艙留有PF一人，ECAM顯示“AIR ENG 2 BLEED FAULT”訊息，客艙壓力高度開始上升，PF嘗試重置一次無效後，便向航管要求下降高度。航管許可該機下降至36,000呎，並詢問該機是否宣告緊急狀況，PF回覆「negative」。下降過程中客艙壓力高度持續上升，PM因耳朵感覺到艙壓變化，而自廁所返回駕駛艙中。
- 1335時，ECAM顯示“CAB PR EXCESS CAB ALT”訊息，此時該機高度為37,028呎，客艙壓力高度到達9,536呎並持續上升，駕駛員依照ECAM指示戴上氧氣面罩，於1336時向航管要求下降高度至10,000呎，並請副事務長通知PIC返回駕駛艙。

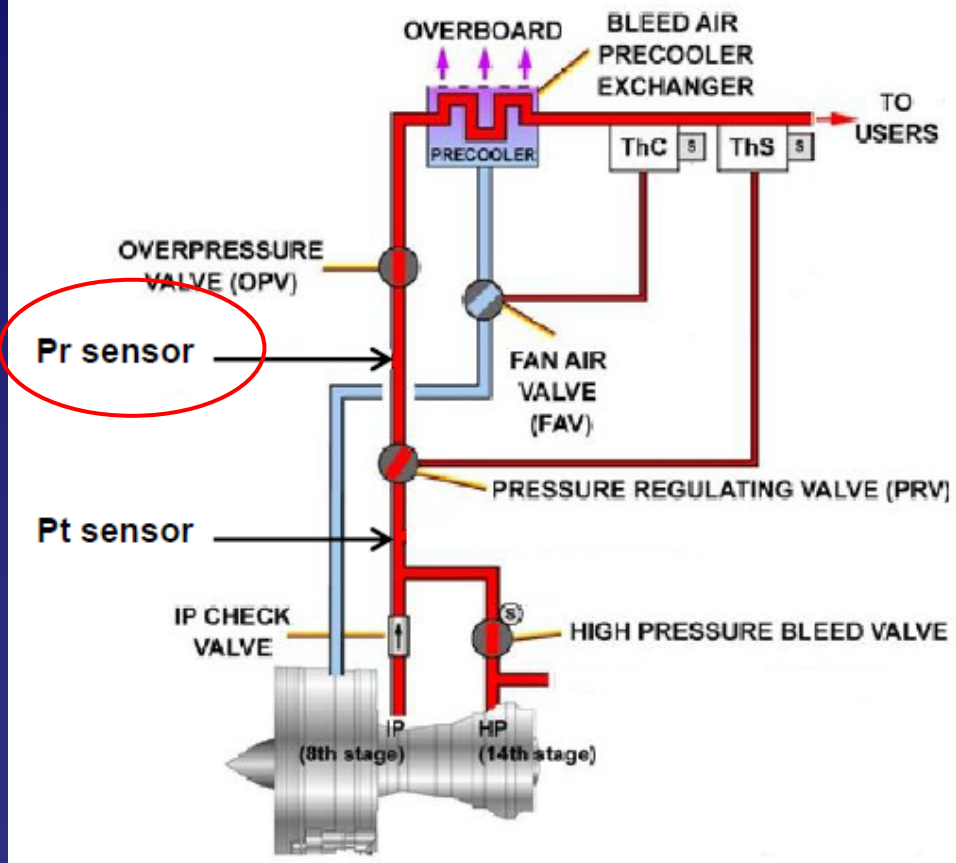

163NM
89 NM
SIP AIRPORT
OGATA
BOMKI
EVENT
N 44 26.2, E32 39.5
EVENT:
UTC05:41 FL 400
POS: BTW OGATA & BOMKI of Route "UL850"
SIP T/D UTC 06:05
Google

Replaced components

- 更換該機1、2號供氣系統Pr感測器，
  - P/N: ZRA380-00
- 發現更換下之Pr感測器其內部均有積水現象

Findings

Pressure regulation



Main components

. Pressure Regulating Valve (PRV)

Regulates upstream pressure at ~48 psig

. OverPressure Valve (OPV)

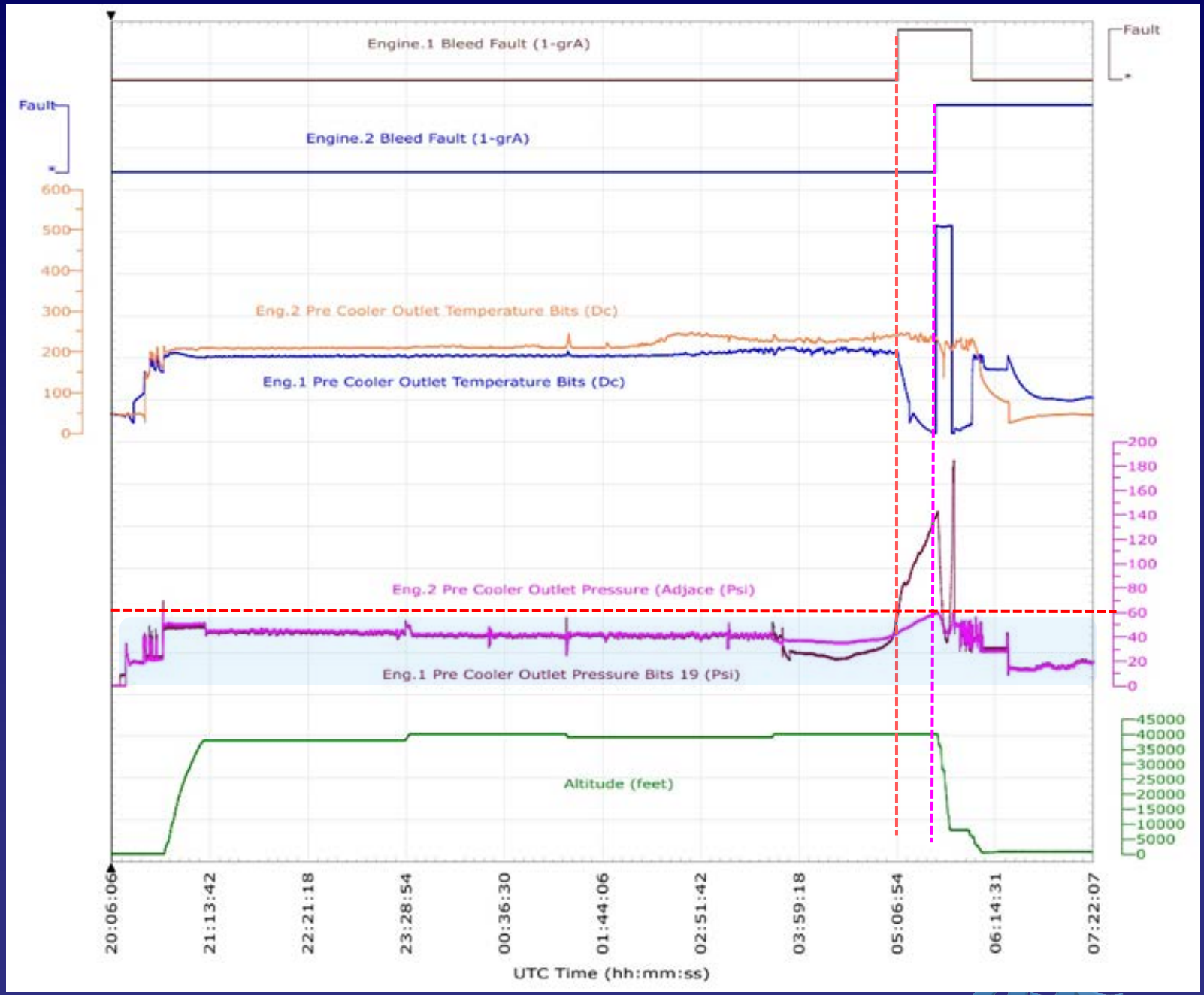
Closes if upstream pressure exceeds ~85 psig to protect downstream systems

. Pressure Regulated Sensor (Pr xducer)

Senses regulated pressure. Fault is triggered if pressure > 60 psig for 15 seconds

. Pressure Transfered Sensor (Pt xducer)

Senses transfered pressure. Main function is for T/S.


Engine.1 Bleed Fault (1-grA)
Fault
Engine.2 Bleed Fault (1-grA)
Fault
600
500
400
300
200
100
0
Eng.2 Pre Cooler Outlet Temperature Bits (Dc)
Eng.1 Pre Cooler Outlet Temperature Bits (Dc)
200
180
160
140
120
100
80
60
40
20
0
Eng.2 Pre Cooler Outlet Pressure (Adjace (Psi)
Eng.1 Pre Cooler Outlet Pressure Bits 19 (Psi)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
Altitude (feet)
20:06:06
21:13:42
22:21:18
23:28:54
00:36:30
01:44:06
02:51:42
03:59:18
05:06:54
06:14:31
07:22:07
UTC Time (hh:mm:ss)

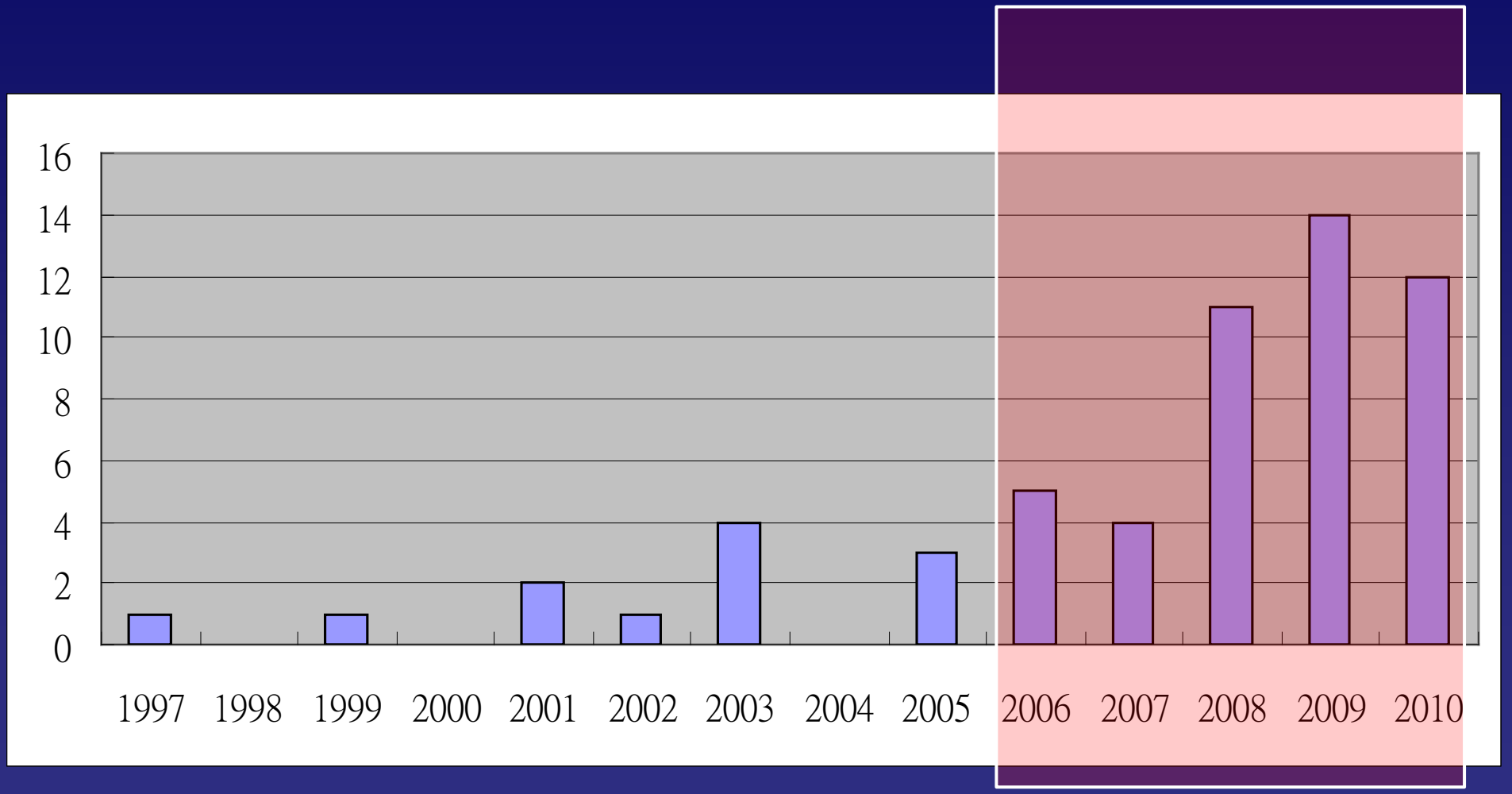
Test of Pr transducers

- Both transducers present the typical behavior of water presence.
- The smallest volume is encountered between the grid and the metallic membrane. If water is collected in this area, it may cause ice build-up at negative temperature that will affect the pressure cell behavior.

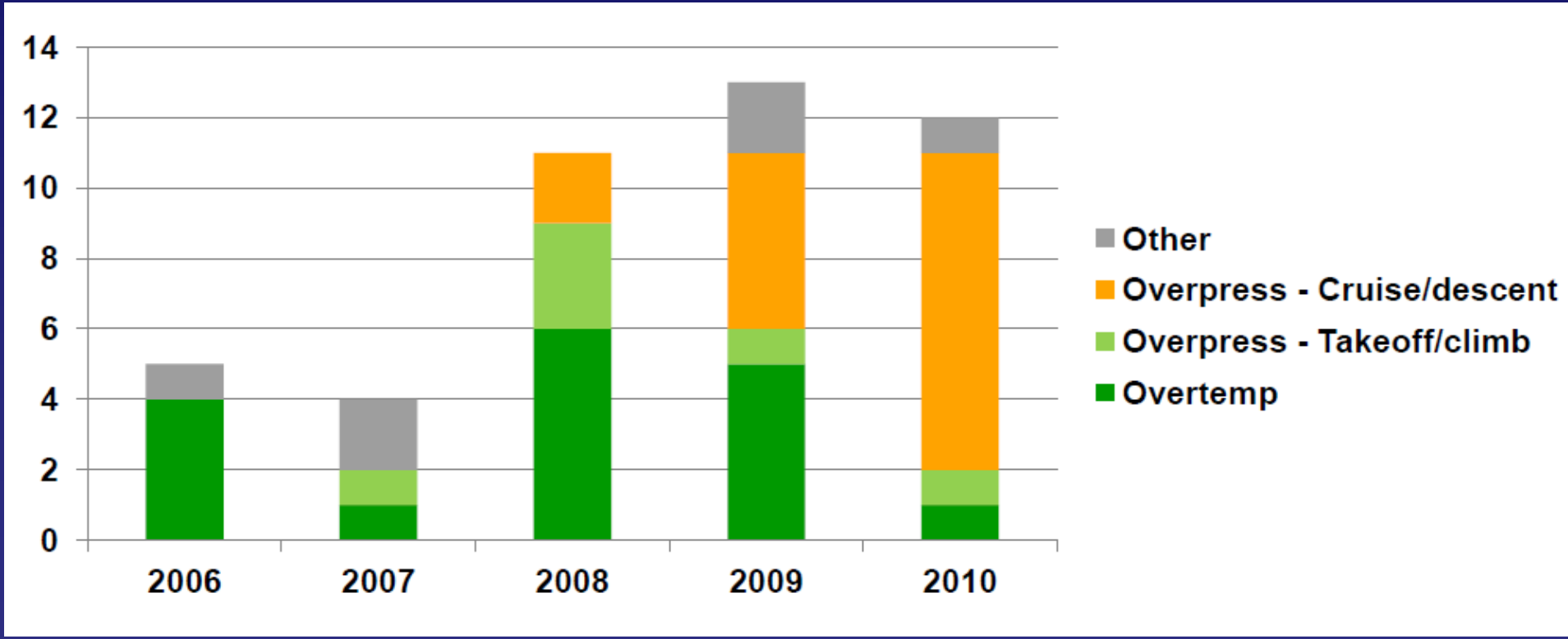
Engineering considerations

- System reliability and Components reliability
- Rate of cabin altitude during occurrence, Highest cabin altitude
- Cabin leak rate, Maintenance records of door/window seal repair/replacement

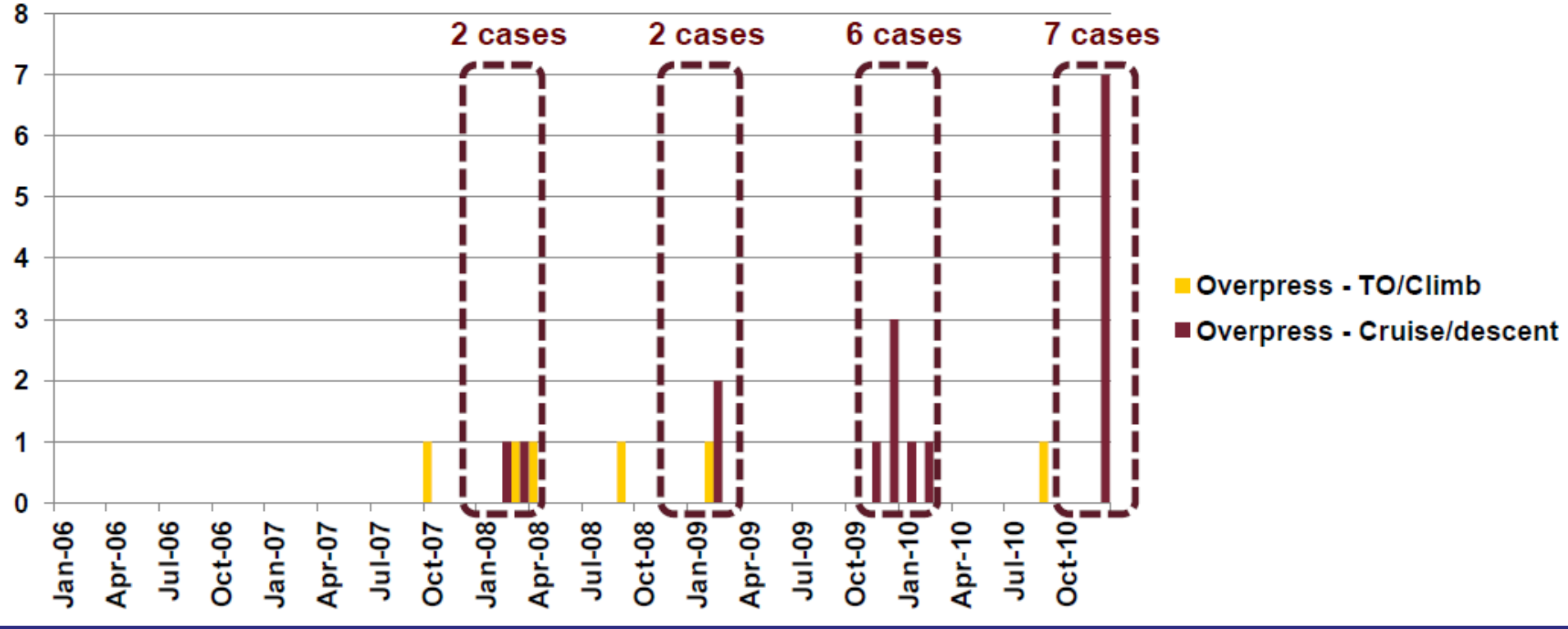
A330 DBL events



DBL Failure mode

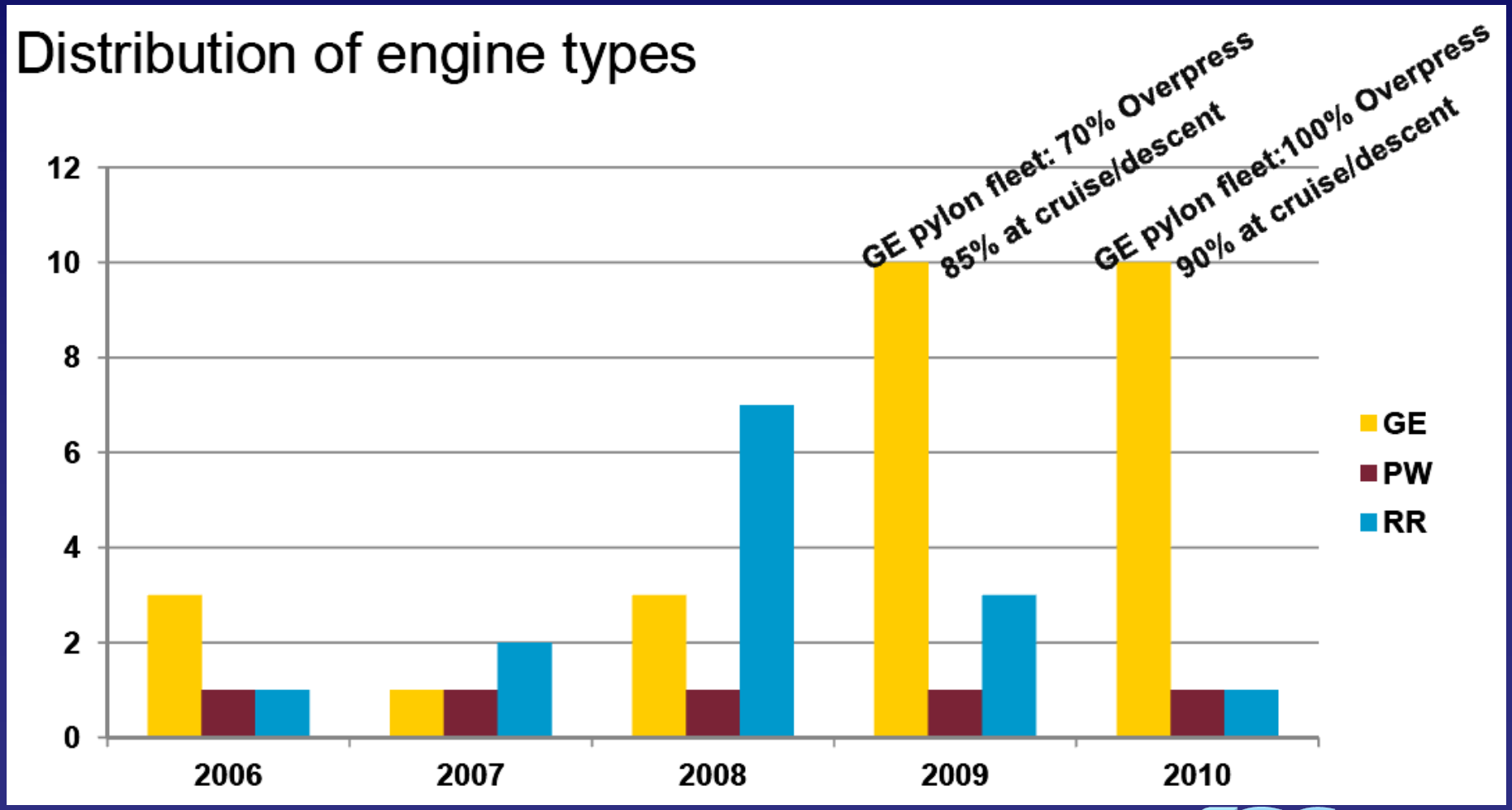


Failure and Seasons



Case	Altitude	Flight Phase	Season	Time elapsed for failure since take off	Time between 1st loss and 2nd loss.	SAT time in failure
1	410FL	During cruise	WINTER	8HRS	2 minutes	unknown
2	380FL	During cruise	WINTER		23 min	-65ºC
3	230FL	During cruise - descending	WINTER	4,5 HRS AFTER TAKE OFF	1,5 min	unknown
4	130FL	During cruise - descending	WINTER	4,5 HRS AFTER TAKE OFF	< 1min	-25ºC
5	371FL	During cruise	WINTER		12 min	unknown
6		During Cruise	WINTER	7,25 HRS AFTER TAKE OFF	unknown	unknown
7	380FL	During cruise	WINTER	10 HRS AFTER TAKE OFF	< 1min	-55ºC
8	25FL	During cruise - descending	WINTER		2 min	-70ºC

Overpressure VS engine type



Airbus Actions Taken

- **TFU REF : 36.11.00.069**
  - This failure mode is related to a faulty regulated pressure indication. This failure mode is linked to the presence of water in the regulated pressure transducer sensor section (i.e. internal part of XDCR connected to sense line), combined with negative temperature surrounding the XDCR.
- **Following additional actions are on-going:**
  - - Thermal insulation of XDCR against low temperature is under investigation.
  - - XDCR design improvement under investigation, target is Jun/11
  - - Creation of an AMM task to clean sense line installed between PRV and XDCR 8HA(1/2), advance copies available end Feb/11

Airbus Actions Taken

- - To remove on a regular basis the XDCR 8HA(1/2). Further to this removal, ACMM 36- 11-08 test will be applied to the XDCR (identification of presence failure mode). Then the ACMM 36-11-08 will provide a specific drying procedure to remove the water contained in XDCR .
- - On a same regular basis , a preventive cleaning of the sense line (from PRV to XDCR) will allow to mitigate the risk of water accumulation in the XDCR / sense line. Experience at one operator show that a 3A interval is proving satisfactory.

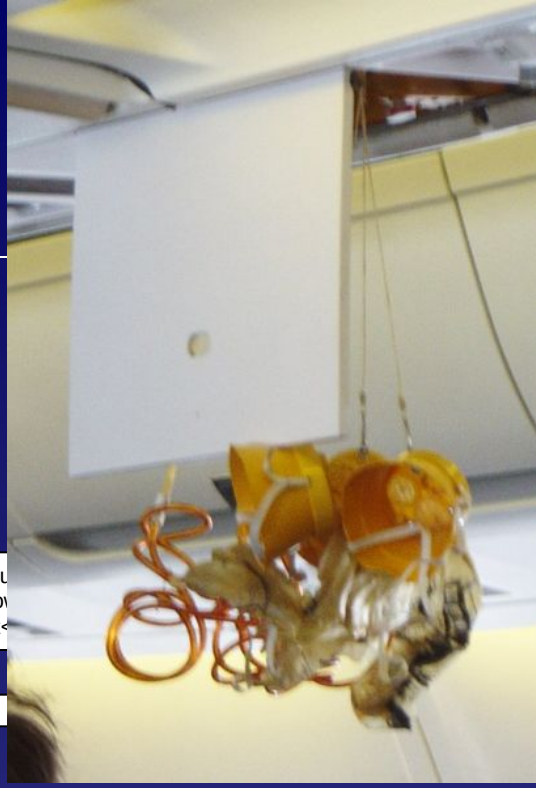
Case still under investigation

Lessons learnt

- Watch and follow up technical information from manufacturer
- Proactively monitor and rectify system fault especially for sensitive system
- Well communicate with investigation agency

報告完畢

Loss of cabin pressurization capability



Emergency descent /
Loss of cabin pressurization capability /
Interruption of air supply systems

High altitude required bleed air for cabin pressurization, during initial descent from FL400

1.1

1.1

L engine bleed air system de-activated on ground
MEL 36-11-02 applied, (M) performed

1.6

Defect: Air eng 1 bleed not closed during wind down after eng master shut off at NRT

1.6

Maintenance decided to used MEL 36-11-02

1.6

Defect carried for 6 flights, stop at home base 3 times but MEL allowed not repaired

1.X

R engine bleed air system failed during initial descent

1.6

Other possibilities

0

Bleed air overheat

1.16

FAV not open as appropriate, Muscle air from ThC not enough to open FAV as needed, Cooling air at heat exchanger not supplied as demanded

Grid filter contaminated which reduced muscle pressure

1.16

Filter design

Air pollution

Inspection/overhaul interval

High demand air: Single bleed air system provided dual packs operation

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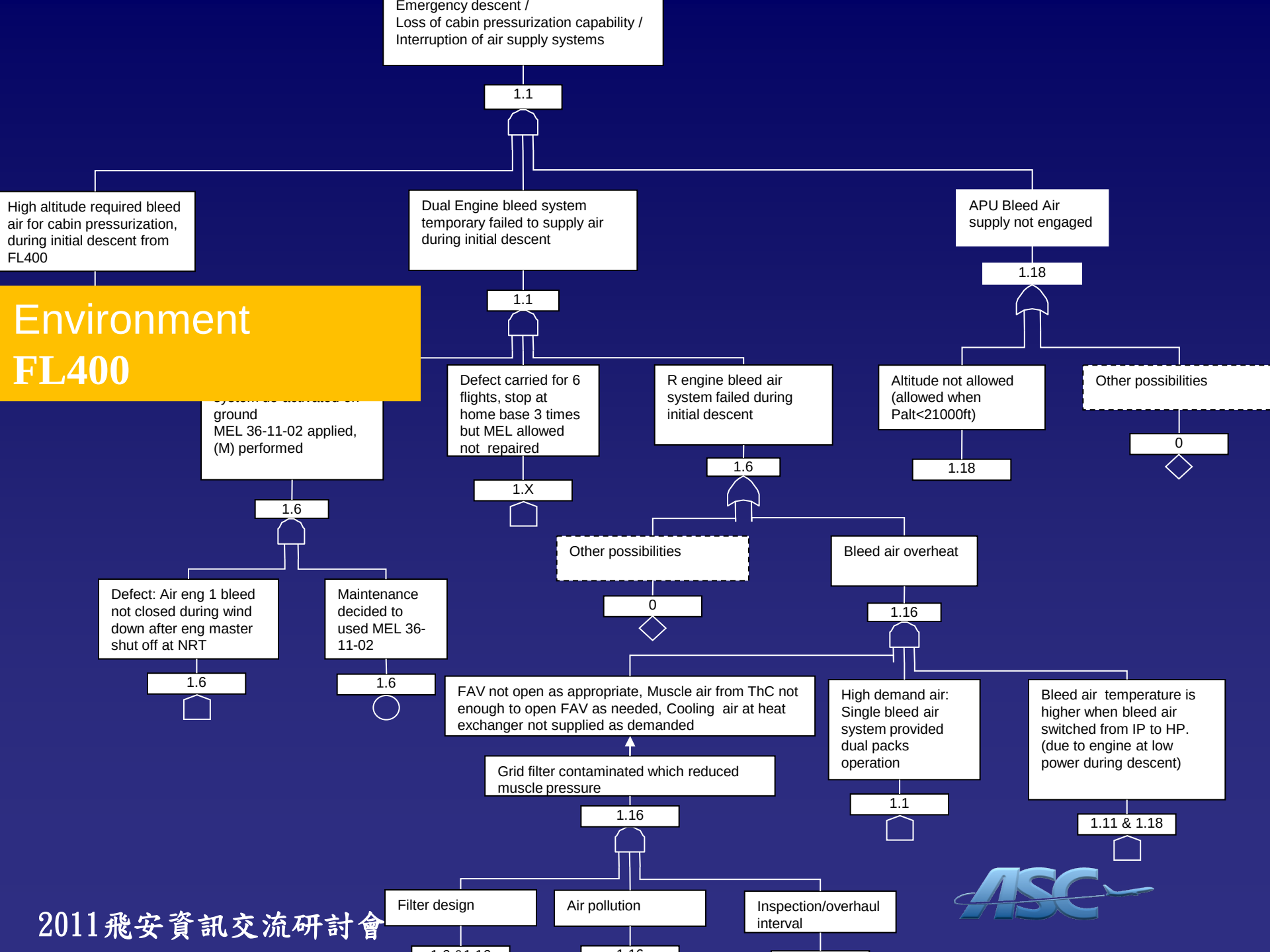
Bleed air temperature is higher when bleed air switched from IP to HP. (due to engine at low power during descent)

1.11 & 1.18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Dual Bleed Loss

Other possibilities

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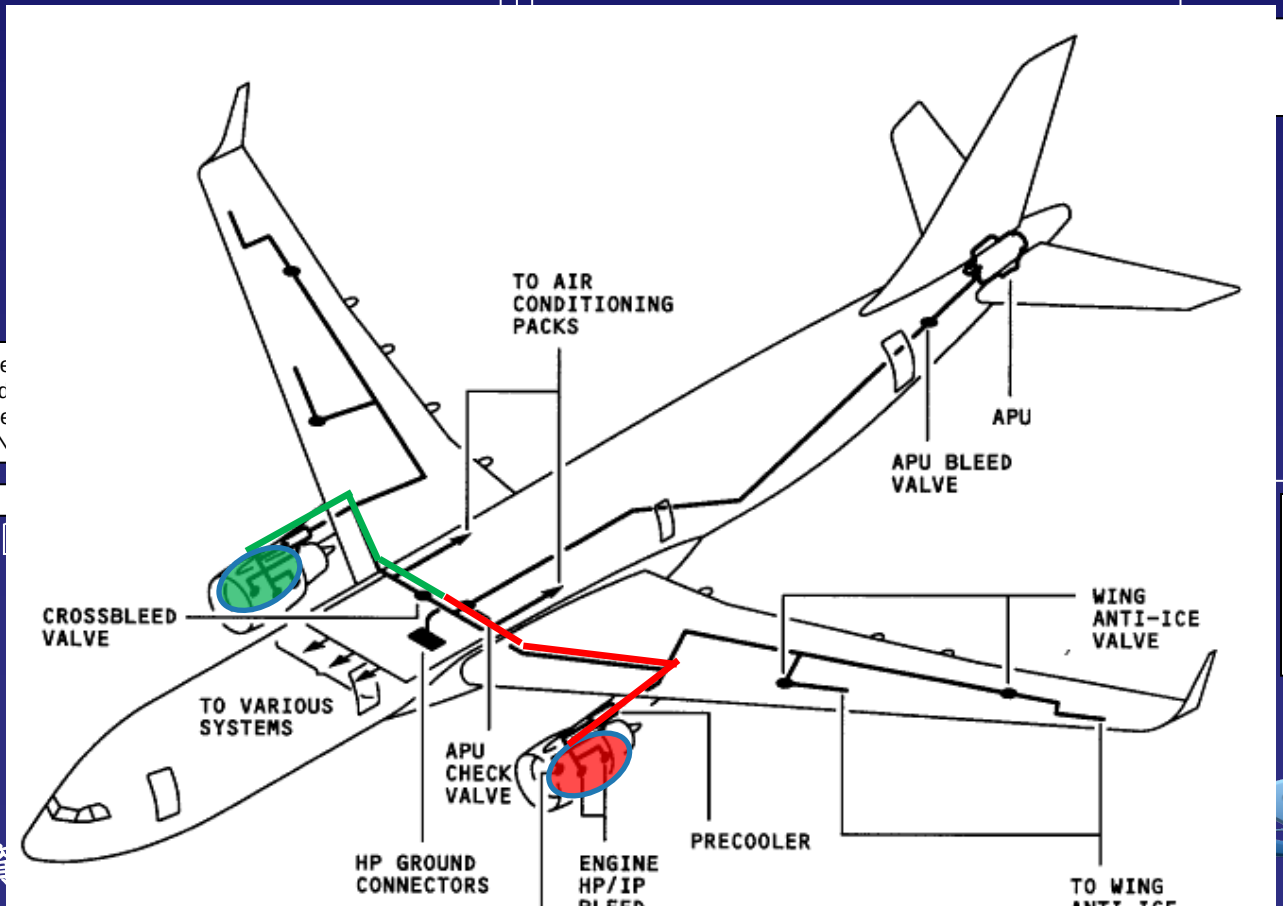
Defect: Air e
not closed c
down after e
shut off at N



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1.11 & 1.18

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Loss of cabin pressurization capability /
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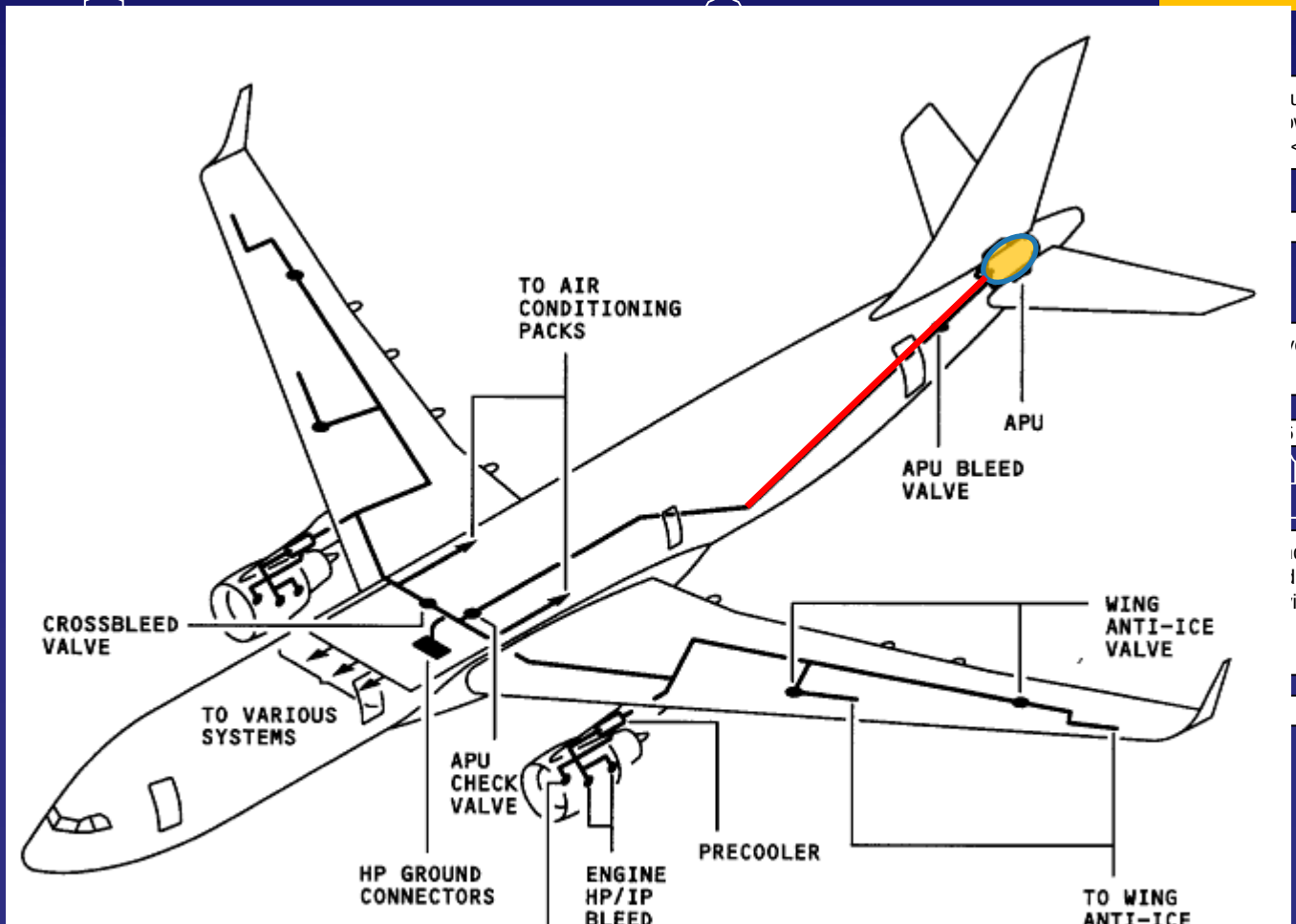
APU Air not engaged



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wed when
<21000ft)

1.18

Other possibilities

0

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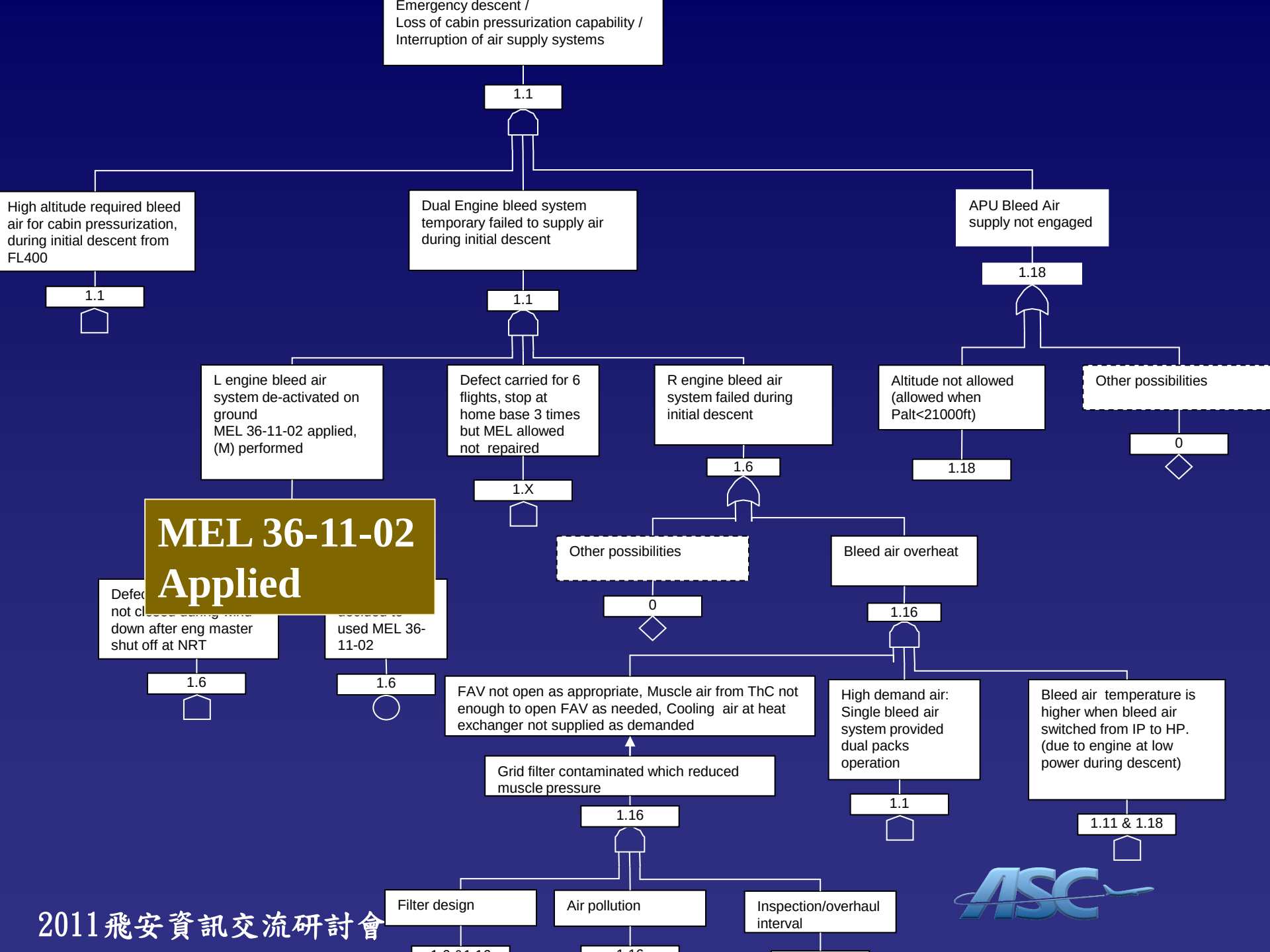
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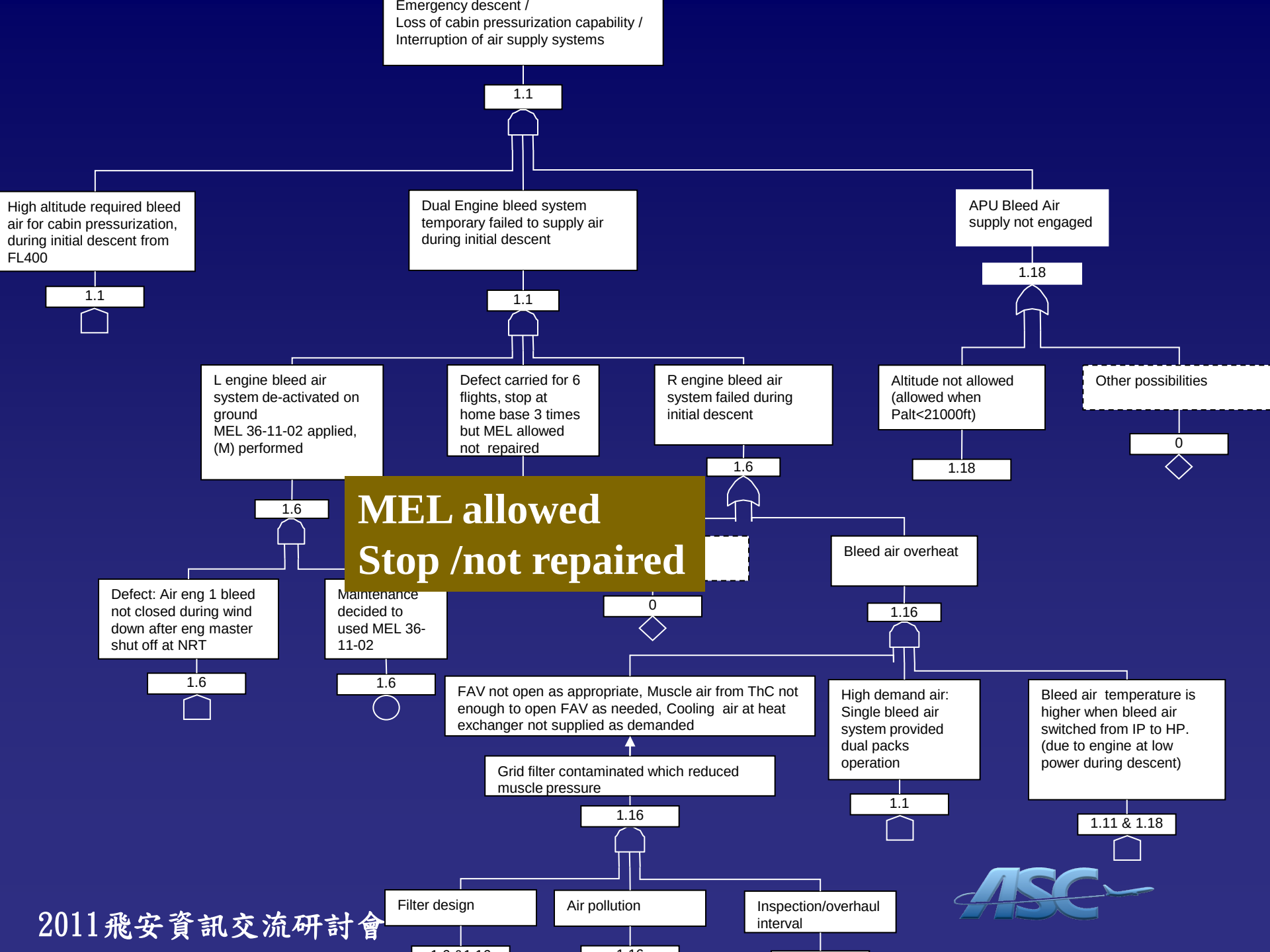
Altitude not allowed (allowed when Palt<21000ft)
1.18
Other possibilities
0
MEL 36-11-02 Applied
Other possibilities
0
Bleed air overheat
1.16
down after eng master shut off at NRT
1.6
used MEL 36-11-02
1.6
FAV not open as appropriate, Muscle air from ThC not enough to open FAV as needed, Cooling air at heat exchanger not supplied as demanded
Grid filter contaminated which reduced muscle pressure
1.16
High demand air: Single bleed air system provided dual packs operation
1.1
Bleed air temperature is higher when bleed air switched from IP to HP. (due to engine at low power during descent)
1.11 & 1.18
Filter design
Air pollution
Inspection/overhaul interval


Emergency descent /
Loss of cabin pressurization capability /
Interruption of air supply systems
1.1
High altitude required bleed air for cabin pressurization, during initial descent from FL400
1.1
Dual Engine bleed system temporary failed to supply air during initial descent
1.1
APU Bleed Air supply not engaged
1.18
L engine bleed air system de-activated on ground
MEL 36-11-02 applied, (M) performed
Defect carried for 6 flights, stop at home base 3 times but MEL allowed not repaired
R engine bleed air system failed during initial descent
Altitude not allowed (allowed when Palt<21000ft)
Other possibilities
1.6
1.6
1.18
0
MEL allowed
Stop /not repaired
Defect: Air eng 1 bleed not closed during wind down after eng master shut off at NRT
Maintenance decided to used MEL 36-11-02
0
Bleed air overheat
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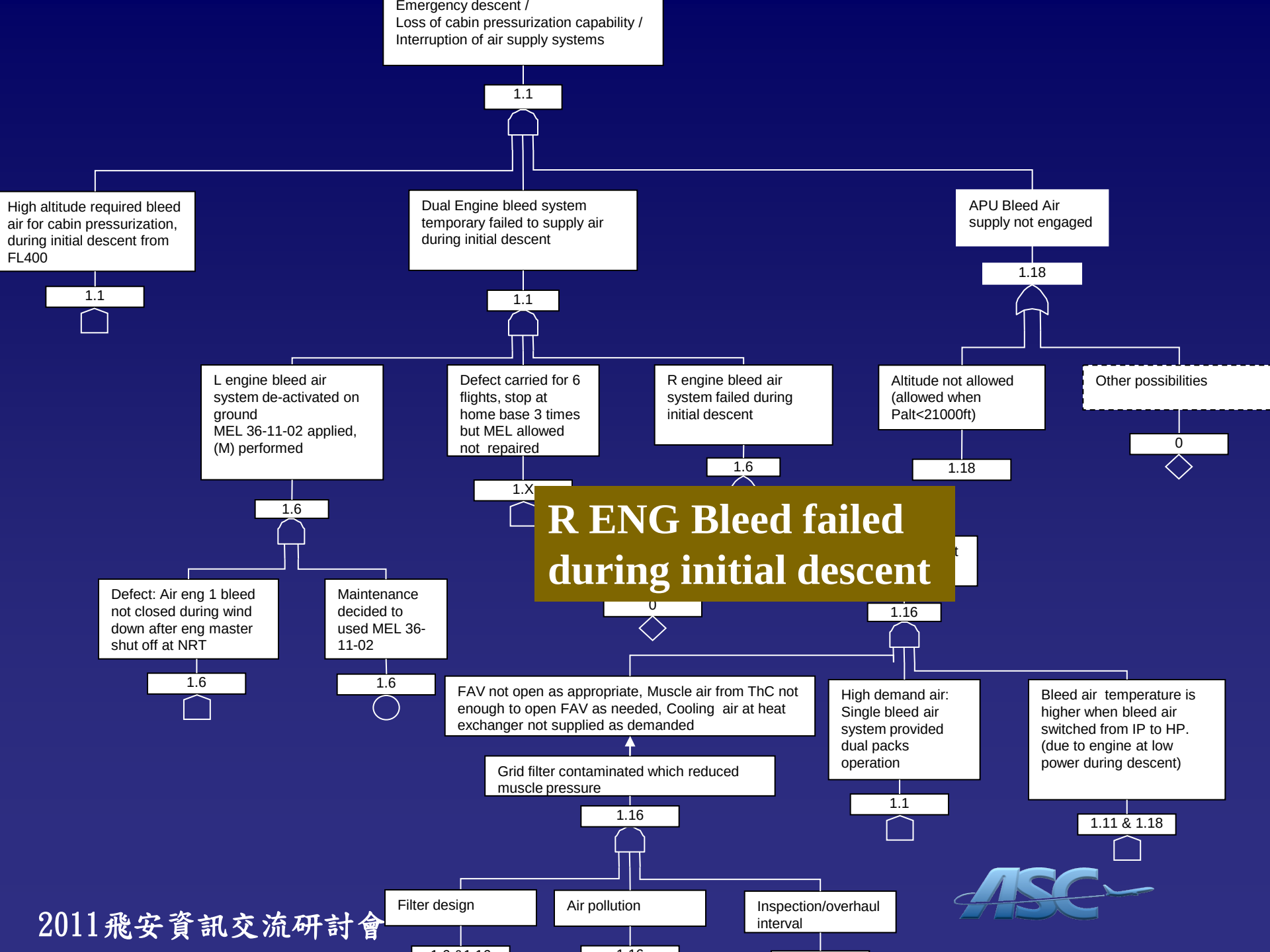
Inspection/overhaul interval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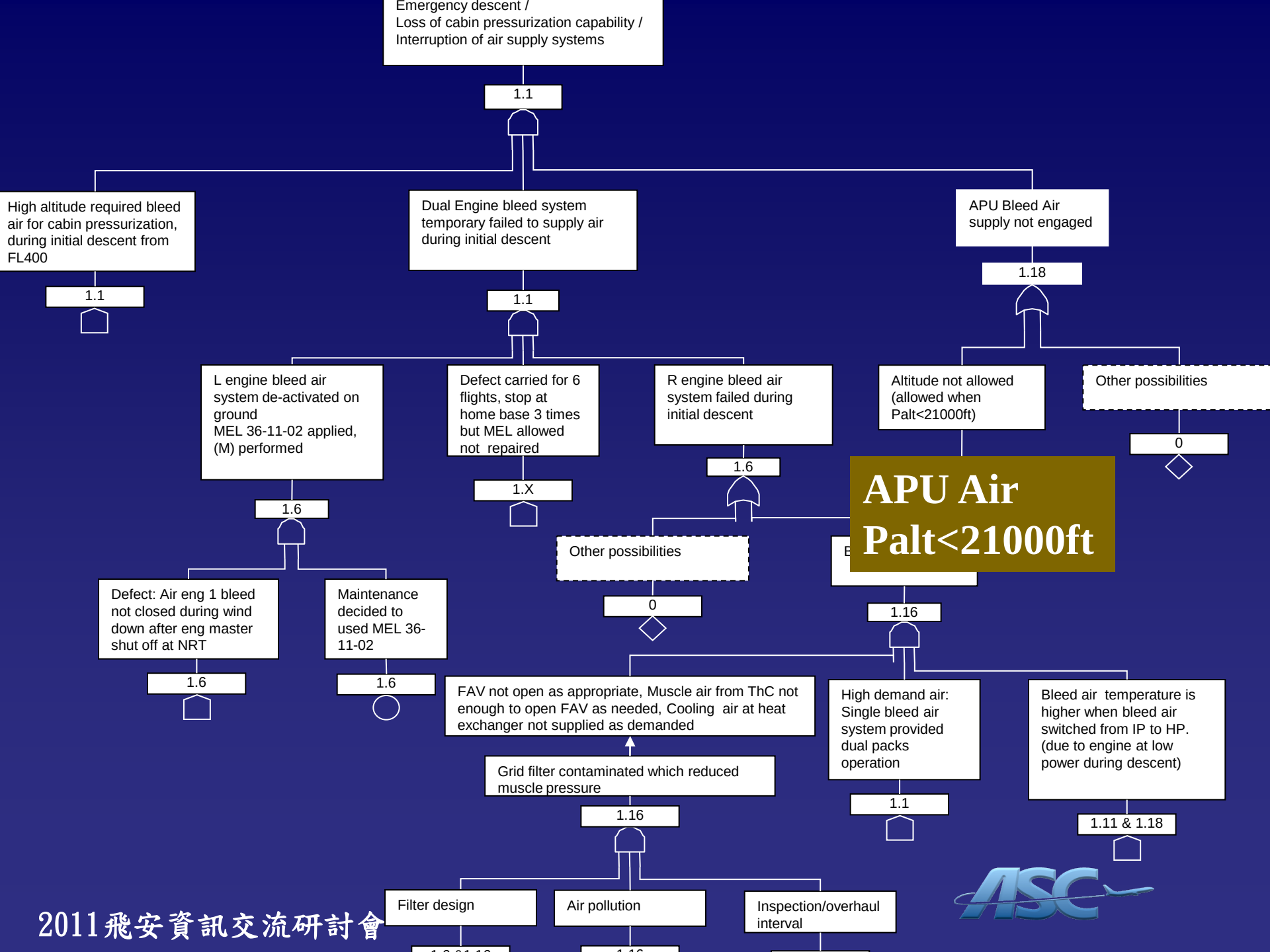
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APU Air Palt<21000ft
Other possibilities
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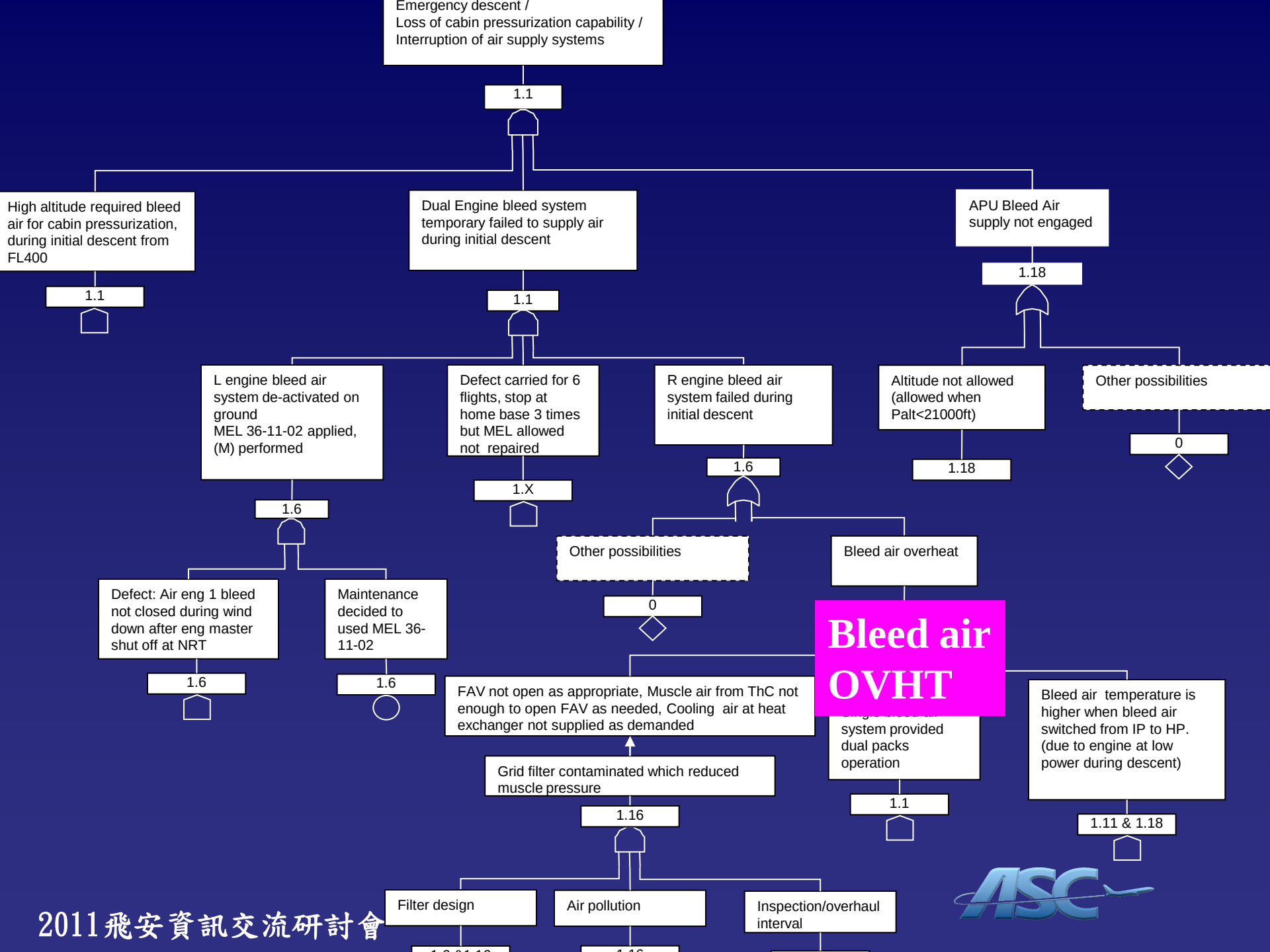
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Defect: Air eng 1 bleed not closed during wind down after eng master shut off at NRT
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Maintenance decided to used MEL 36-11-02
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Other possibilities
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Bleed air overheat
Bleed air OVHT
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Grid filter contaminated which reduced muscle pressure
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system provided dual packs operation
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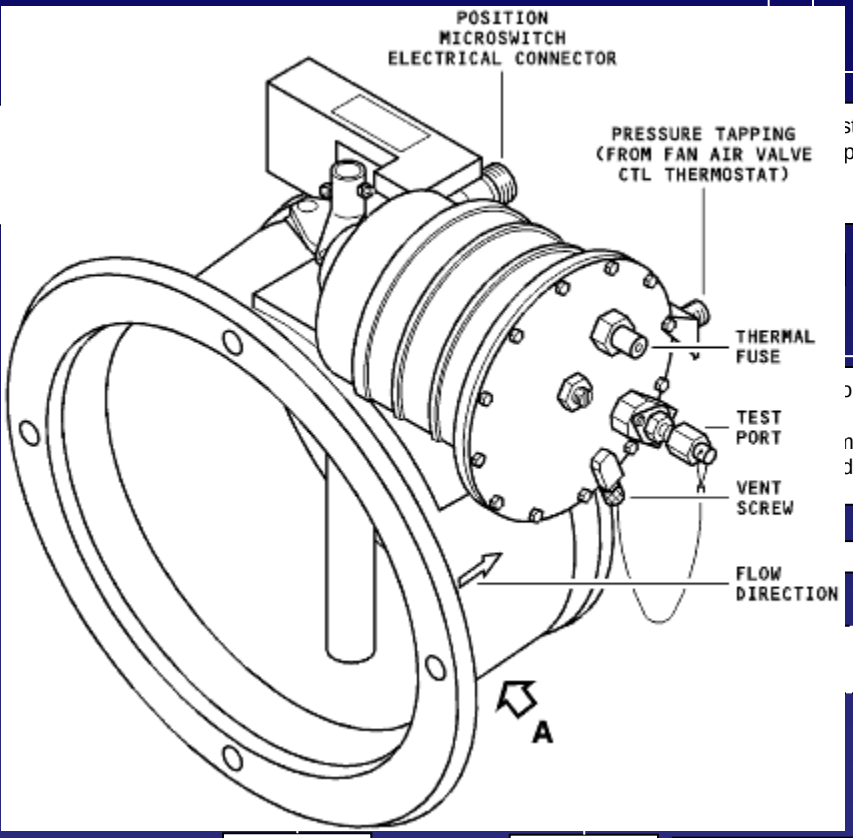
Filter design
Air pollution
Inspection/overhaul interval

Emergency descent /
Loss of cabin pressurization capability /
Interruption of air supply systems

1.1



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APU Bleed Air
supply not engaged

1.18

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R engine bleed air
system failed during
initial descent

1.6

Altitude not allowed
(allowed when
Palt<21000ft)

1.18

Other possibilities

0

Other possibilities

0

Bleed air overheat

1.16

1.6

1.6

FAV not open as appropriate, Muscle air from ThC not enough to open FAV as needed, Cooling air at heat exchanger not supplied as demanded

Grid filter contaminated which reduced muscle pressure

1.16

High demand air:
Single bleed air
system provided
dual packs
operation

1.1

Bleed air temperature is
higher when bleed air
switched from IP to HP.
(due to engine at low
power during descent)

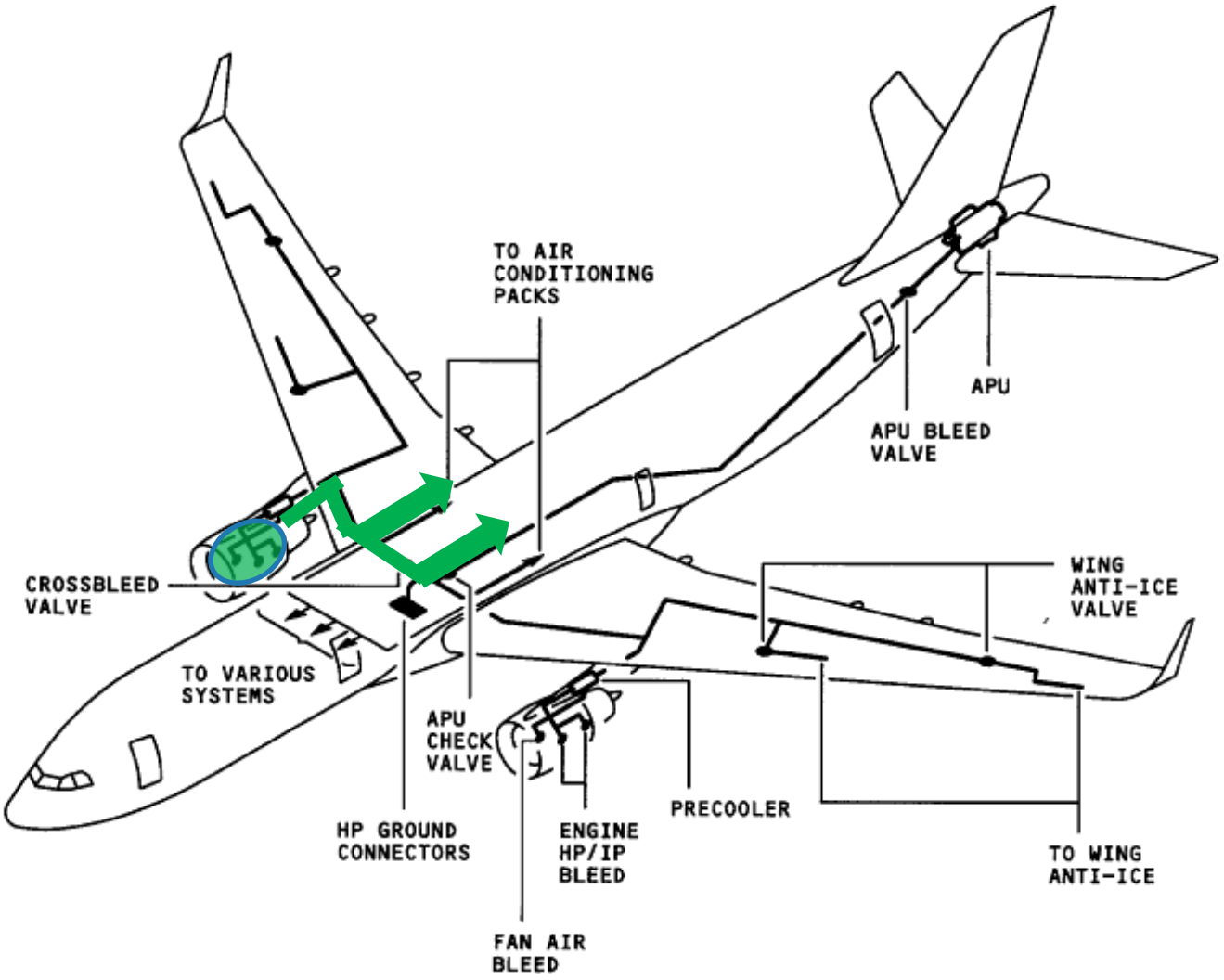
1.11 & 1.18

FAV could not fully open

Filter design

Air pollution

Inspection/overhaul
interval



APU Bleed Air supply not engaged

1.18

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1.18

Other possibilities

0

overheat

16

and air: ed air ovided s operation

Bleed air temperature is higher when bleed air switched from IP to HP. (due to engine at low power during descent)

1.11 & 1.18

Grid filter contaminated which reduced muscle pressure

1.16

Filter design

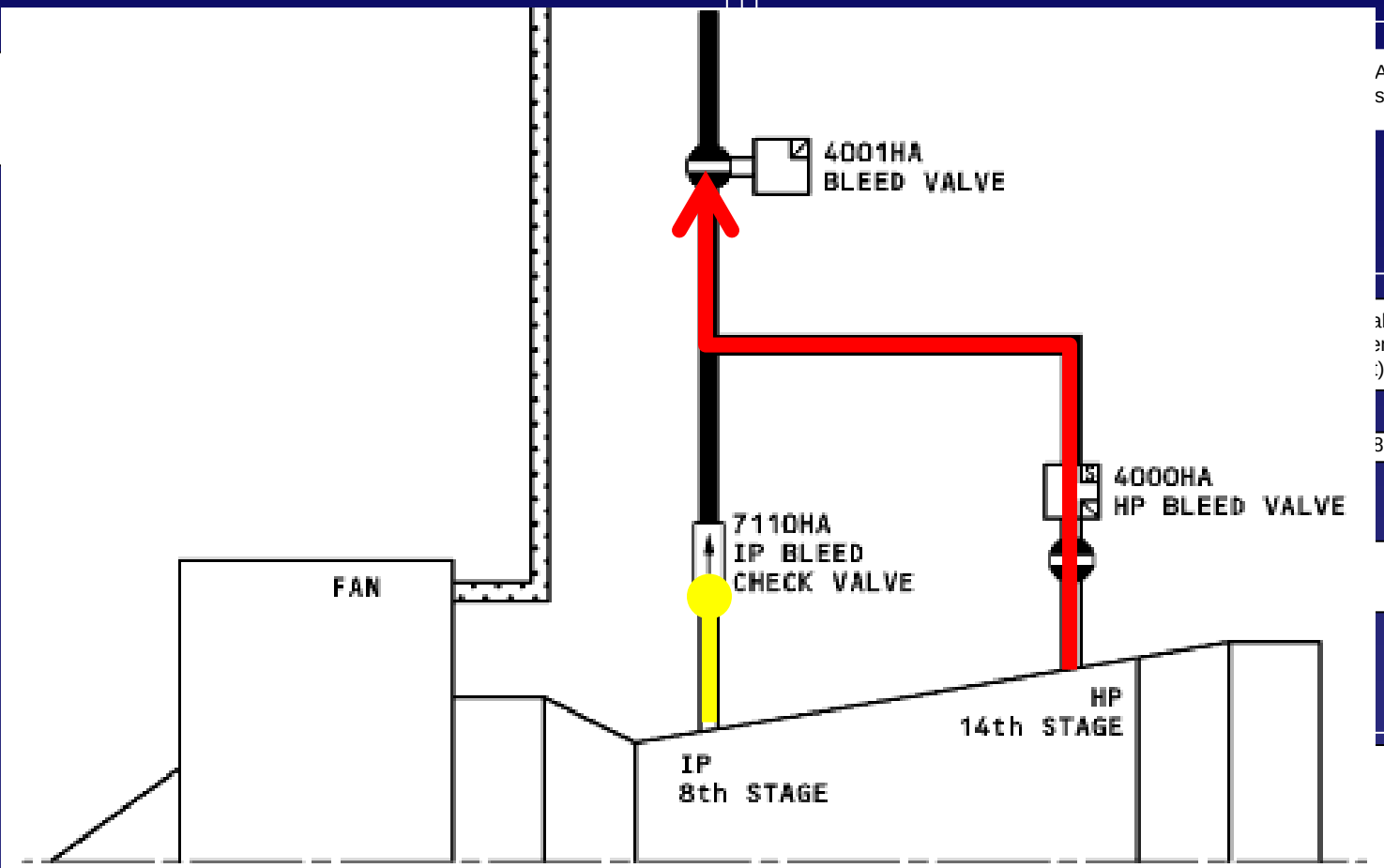
Air pollution

Inspectio interval

One bleed for two packs

Emergency descent /
Loss of cabin pressurization capability /
Interruption of air supply systems

1.1



APU Bleed Air
supply not engaged

1.18

allowed
en
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Other possibilities

0

3

Bleed air temperature is higher when bleed air switched from IP to HP. (due to engine at low power during descent)

muscle pressure

1.16

1.1

Filter design

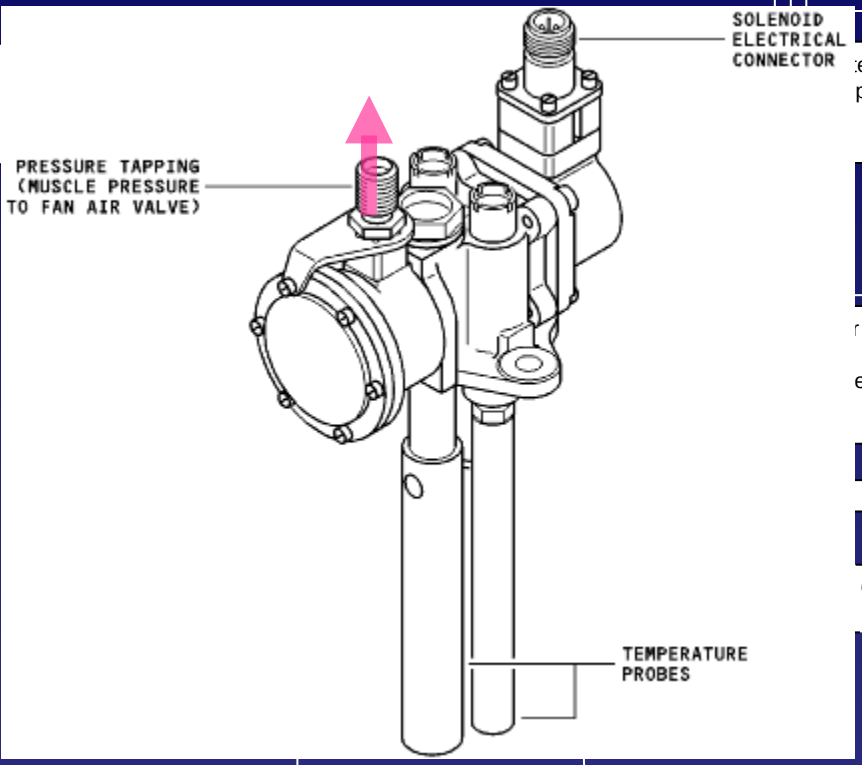
Air pollution

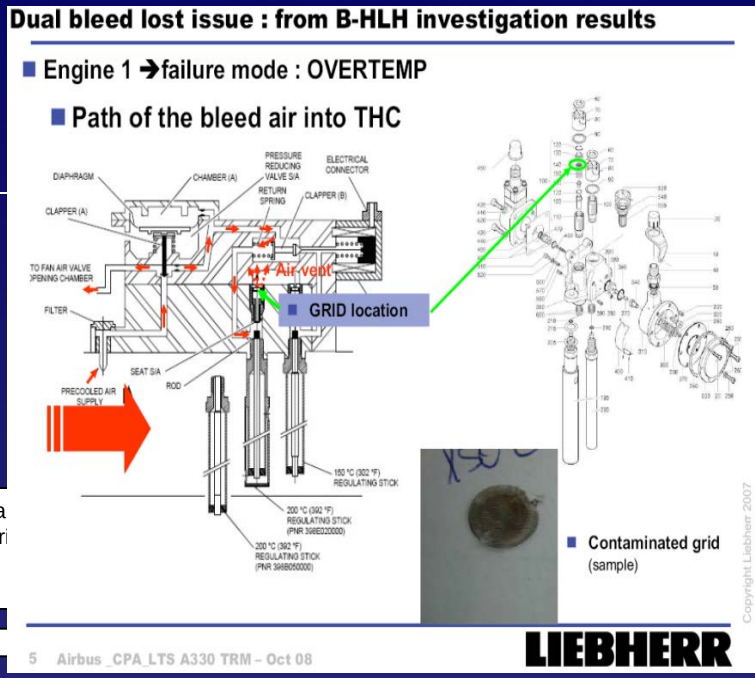
Inspection/overhaul interval

Air source from IP to HP

Emergency descent /
Loss of cabin pressurization capability /
Interruption of air supply systems

1.1





R engine bleed a
system failed duri
initial descent

1.6

Other possibilities

0

Bleed air overheat

1.16

1.6

1.6

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Grid filter contaminated which reduced muscle pressure

High demand air: Single bleed air system provided dual packs operation

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Bleed air temperature is higher when bleed air switched from IP to HP. (due to engine at low power during descent)

1.11 & 1.18

Grid filter contamination
Muscle pressure reduced

Emergency descent /
Loss of cabin pressurization capability /
Interruption of air supply systems

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Altitude not allowed (allowed when Palt<21000ft)

1.18

Other possibilities

0

Other possibilities

0

Bleed air overheat

1.16

Defect: Air eng 1 bleed

Maintenance ed to MEL 36-2

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Filter design

Air pollution

Inspection/overhaul interval

Filter design

201

Emergency descent /
Loss of cabin pressurization capability /
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Altitude not allowed (allowed when Palt<21000ft)

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Other possibilities

0

Defect: Air eng 1 bleed not closed during wind down after eng master shut off at NRT

1.6

Maintenance decided to used MEL 36-11-02

1.6

Other possibilities

0

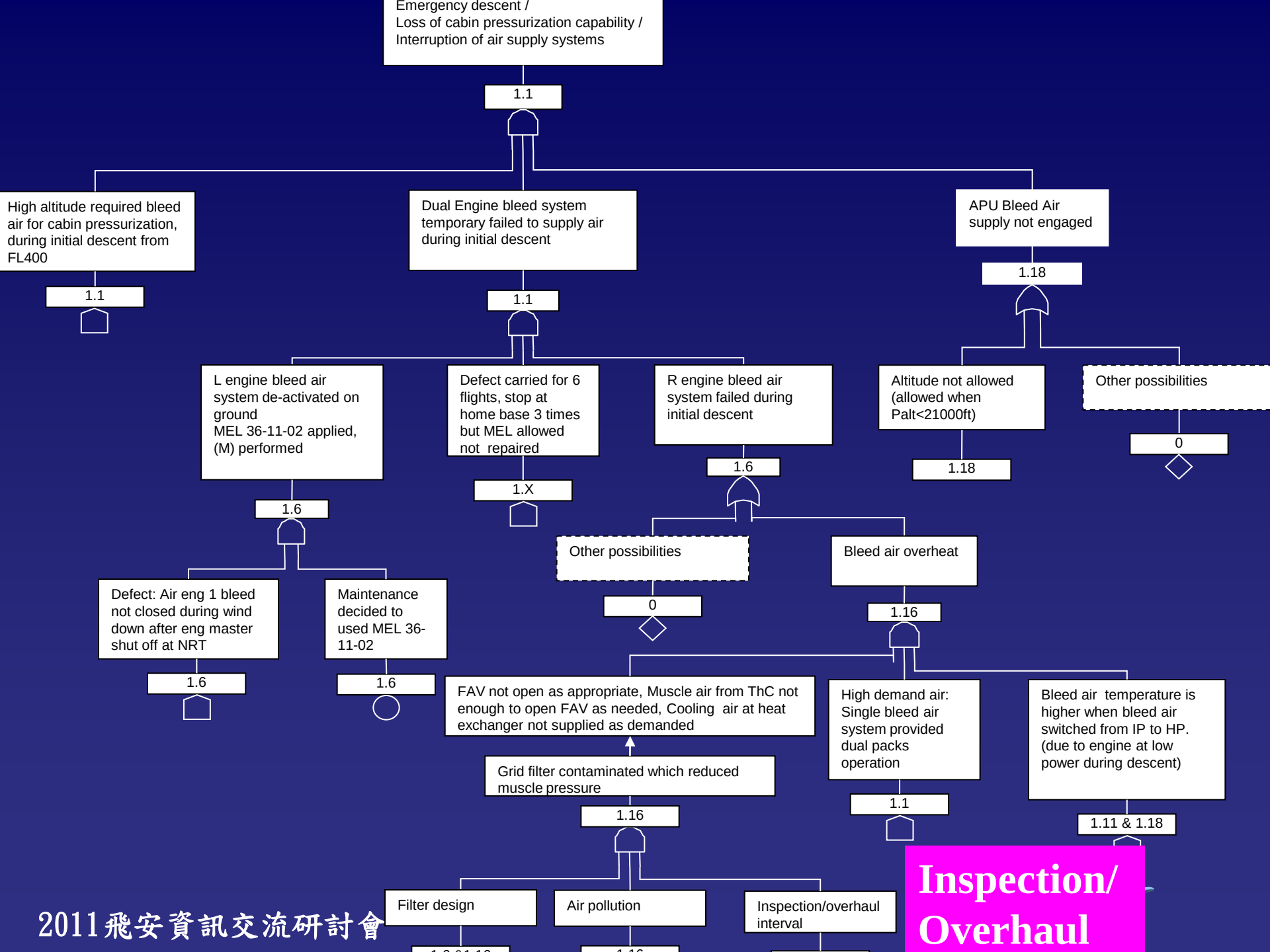
FAV not open as appropriate, Muscle a
enough to open FAV as needed, Coolin
exchanger not supplied as demanded

Grid filter contaminated which red
muscle pressure

1.16

Air pollution/ aging

Air pollution & Aging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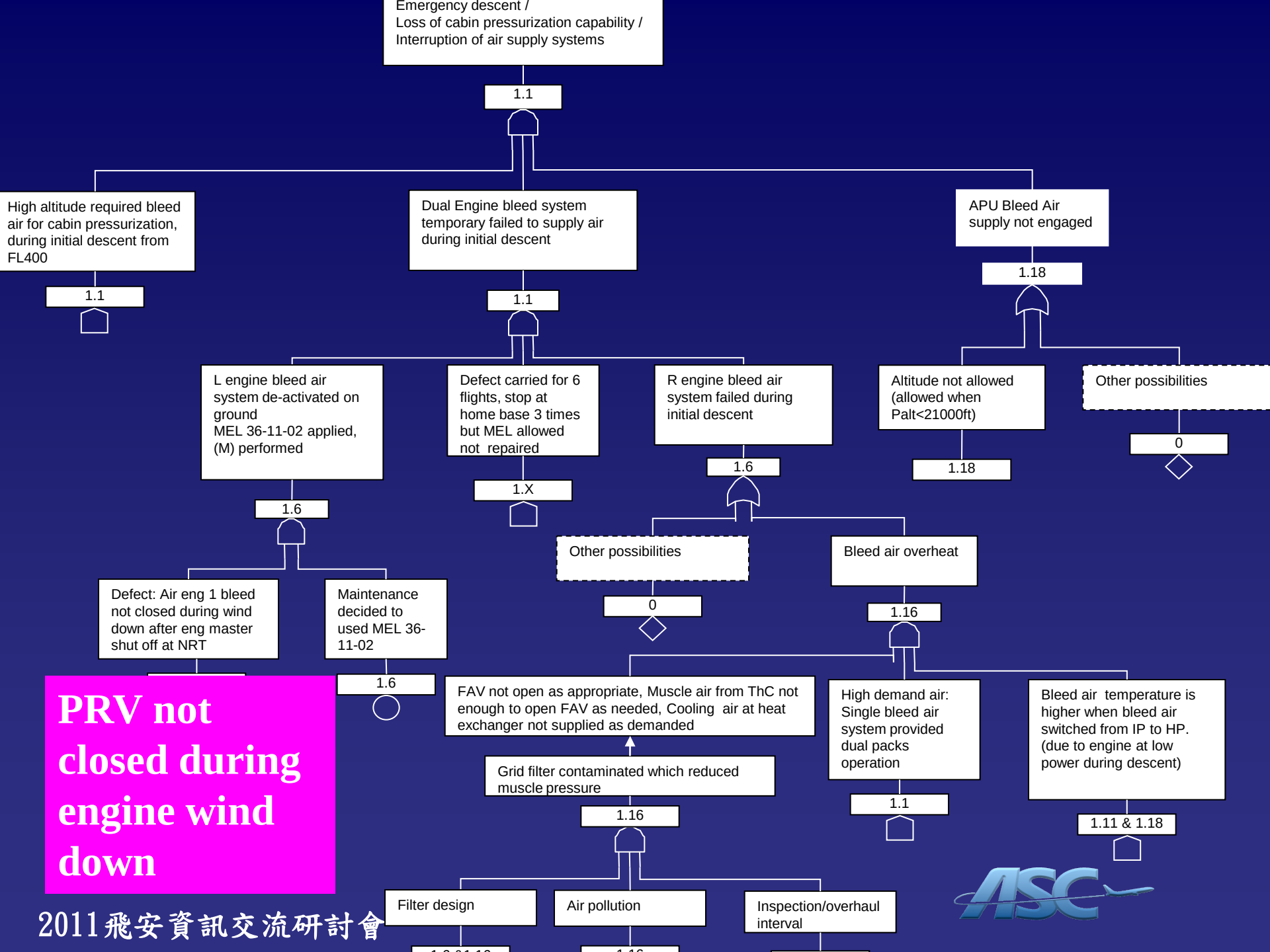
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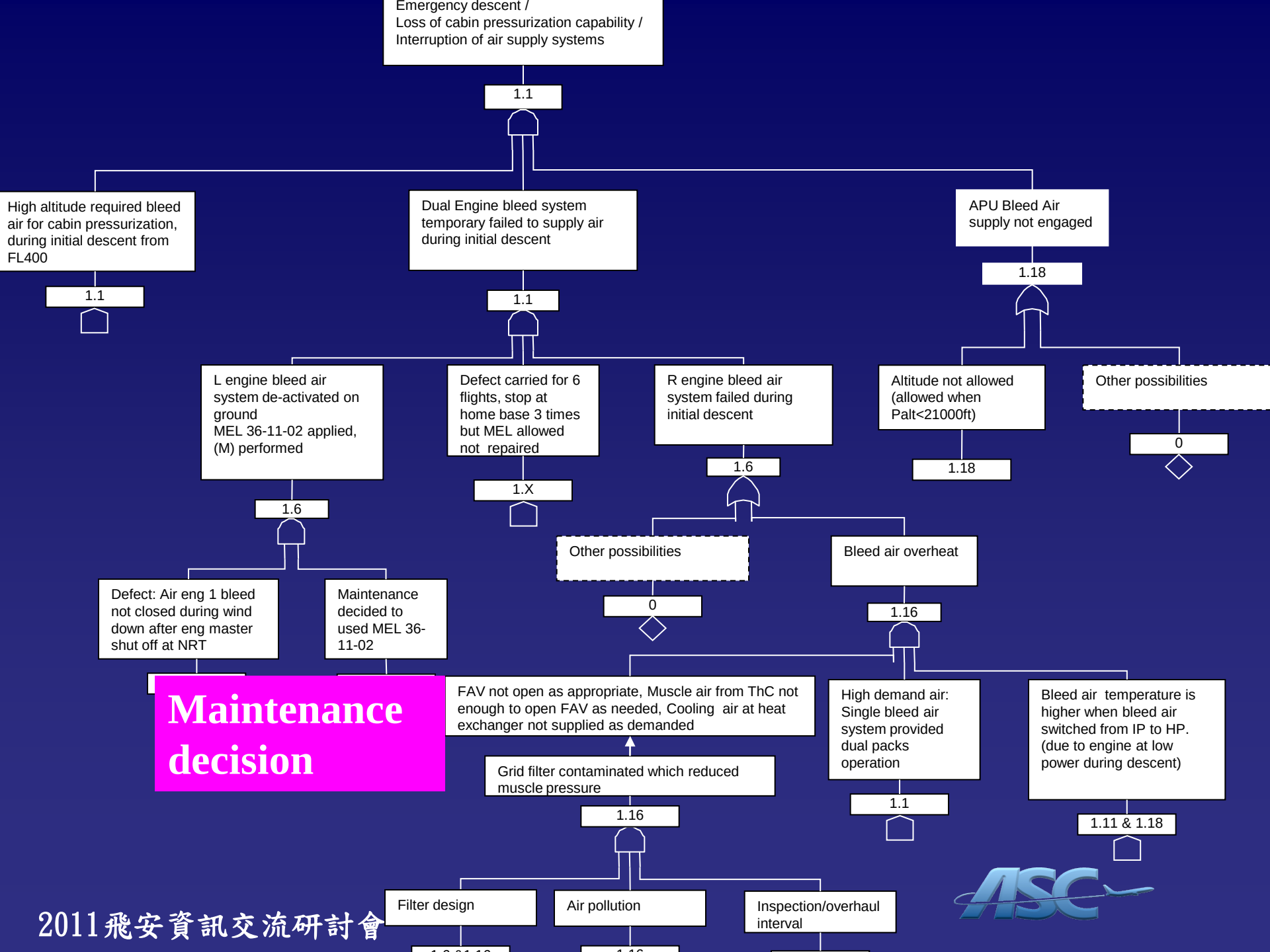
Air pollution
Inspection/overhaul interval
PRV not closed during engine wind down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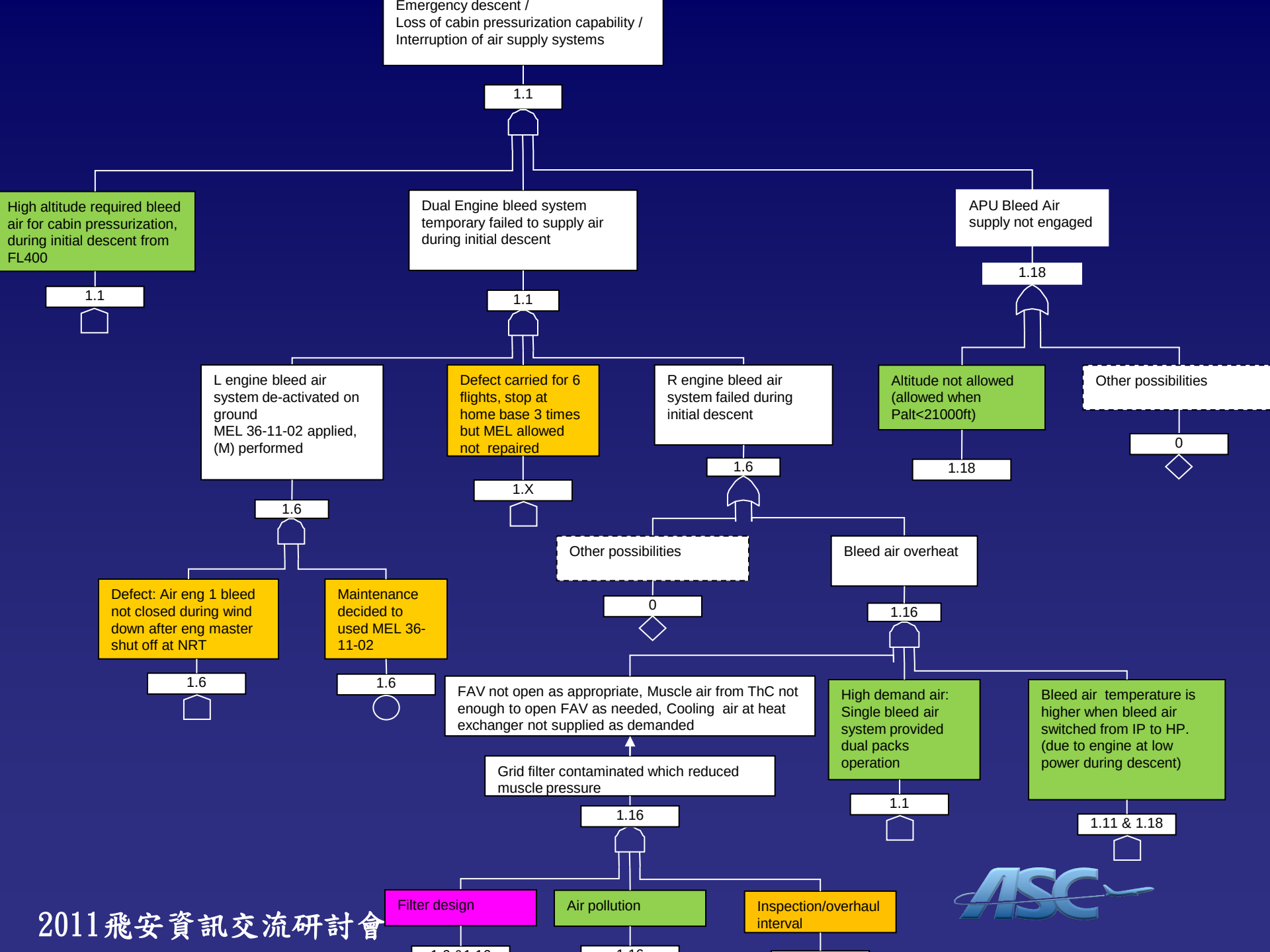
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