G650 Driftdown Procedures and Systems' Assessment
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Scenario

North Atlantic / Random Route / Westbound
FL450 / M.0.98 / 80,000 lbs / ISA + 5°C
Slop R2, left engine flames out after crossing ETP 2

Scenario's Objectives:

1. Review relevant oceanic procedures
2. Aviate, navigate and communicate
3. Assess how an engine failure affects other systems
G650 Driftdown Procedures and Systems’ Assessment

- NAT High Level Airspace (OTS)
- Random Routes
- Equal Time Point (ETP)
- NAT OPS Bulletin 2018-005
- G650 Engine Out Driftdown Procedures
- G650 Engine Out Scenario
- G650 Systems’ Assessment
  - Electrical System
  - Hydraulic System
  - Flight Control System
  - Fuel System
  - Pneumatic System
North Atlantic (NAT) High Level Airspace (HLA) Organized Track System (OTS)

1. Uni-directional and concentrated flow of traffic between North America and Europe

2. The OTS consists of two (2) major alternating flows:
   - A westbound flow departing Europe in the morning
   - An eastbound flow departing North America in the evening
3. **Westbound Traffic crosses 030W between 1130-1930**
   OTS Tracks are published by Shanwick at 2200Z

4. **Eastbound Traffic crosses 030W between 0100-0800**
   OTS Tracks are published by Gander at 1400Z

5. Tracks are based on minimum time

6. A Track Message Identification (TMI) number provides OTS coordinates and flight levels available on each track

7. Special authorization, including RVSM, is required

8. The NAT’s OTS presents considerable challenges:
   - Very congested oceanic airspace with reduced vertical and horizontal separation
   - Large distances to a limited number of suitable alternate airports
   - No ATC radar surveillance
   - Direct pilot-controller communication is limited
9 Vertical Separation

10 Lateral Separation

PBCS Track

- Performance-based Communication & Surveillance
- FL350-390
- PBCS Authorization Required

Non-PBCS Track

11 Longitudinal Separation (Mach Number Technique)

- 10 minutes

- 5 minutes (PBCS Track)
Random Routes

1. Random routes are those which remain clear of the OTS

2. Random routes can also join or leave an outer track of the OTS

3. Random routes can be above (or below) an OTS track(s)
Equal Time Point (ETP)

An ETP is a geographical location along the route of flight in which it takes the same time to continue to the airport ahead as it does to return to the airport behind.

ETPs are also referred to as “Critical Point.”

ETPs are computed for long overwater flights and are based on ground speed (wind factor).

![Diagram of ETP with different wind conditions](image-url)
ETP formula:

\[
\text{Ground distance to ETP} = \frac{(D)(GSA)}{GS_A + GS_B} = \text{NM}
\]

\[D = \text{Airpport Behind} \rightarrow \text{Distance} \rightarrow \text{Airpport Ahead}\]

\[GSA = \text{Ground speed to continue to Airpport Ahead}\]

\[GS_B = \text{Ground speed to return to Airpport Behind}\]

TAS: 480 KCAS
Wind: P40 KTS
Dist: 2500 NM
GSA: 520 KTS
GSB: 440 KTS

\[ETP = \frac{(2500)(440)}{520 + 440} = 1146 \text{ NM}\]
In oceanic airspace ETPs are computed also between suitable alternate airports.

There are three types of ETPs:

1. Loss of engine ETP - (1E INOP)

   Engine Out Driftdown EB-16

   * Final driftdown altitude as per EB-16
② Loss of level ETP - Pressurization (DEPRESS)

Emergency Descent Procedure EH-2

Airport Behind

→ 430 NM

→ 560 NM

Airport Ahead

Wind

10,000' 10,000'

30 Kts Headwind
Ground Speed 240 Kts

30 Kts Tailwind
Ground Speed 300 Kts

③ Maintain level ETP - Medical (MEDICAL)

Airport Behind

→ 390 NM

→ 600 NM

Airport Ahead

Wind

80 Kts Headwind
Ground Speed 400 Kts

80 Kts Tailwind
Ground Speed 560 Kts
- Plot ETPs on plotting chart

- Do not enter ETPs into FMS otherwise ADS-C will send position reports of non-existing waypoints to ATC

- Alternate airports can be ahead or behind (left or right) of current position

- As you cross each waypoint along your route make a mental note and brief where your alternate airport is. This could help you decide direction of turn ( L 45° R ) (Doc 4444)

- ETP fuel calculations assume a straight line to the alternate airport and do not take into account OTS tracks, weather deviations or an IAP

- The Quad Four maneuver (15nm lateral offset), and a descent below the OTS tracks before a turn to the alternate airport is made, will require more fuel

- Starting the APU (back up AC power) will increase fuel consumption by 264 lbs/hour (less fuel on landing)
Contingency procedures in NAT HLA airspace associated with inability to comply with assigned clearance.

Special Procedures

If a revised ATC clearance cannot be obtained:

1) Turn \(30^\circ\) or more away from the track.

\[ \begin{align*}
\text{L} & \quad \text{or} \quad \text{R} \\
\geq 30^\circ
\end{align*} \]

Direction of turn based on position of aircraft in relation to other OTS tracks, direction to the alternate airport, SLOP, etc.
2A) If able to maintain assigned flight level:
A) Acquire same direction 5 nm offset track

B) Once established on a 5 nm offset climb or descend as follows:

Below 41,000’ 1000’

500’

AT 41,000’ 1000’

500’

Above 41,000’ 1000’

500’
2B) If unable to maintain assigned flight level:

A) Minimize rate of descent to what's operationally feasible

B) Acquire same direction 5 NM offset track

C) DESCEND below FL290

D) Once below FL290 establish and maintain a vertical offset of 500' from normal levels and proceed as required until ATC clearance is received
3) Establish communications with ATC and nearby aircraft on **121.5** and **123.45 MHz**

4) Turn on all external lights

5) Ensure transponder is ON
Deviations around severe weather

Revised ATC clearance not possible

1) If < 5 NM deviation — maintain assigned flight level

2) If > 5 NM deviation — adjust altitude as follows:

"Turning North descend, Turning South climb."
"Turning North descend, Turning South climb."

SAND = South Ascend North Descend

3) Establish communications with ATC and nearby aircraft on 121.5 and 123.45 MHz

4) Turn on all external lights

5) Ensure Transponder is ON
Wake Turbulence

1) Strategic Lateral Offset Procedures (SLOP)
2) Standard Operating Procedure throughout NAT region
3) Pilot selects one of three options:
   - Cleared track centerline
   - 1 NM right of centerline
   - 2 NM right of centerline
4) No ATC approval is required
5) Coordination with preceding aircraft, if required, on 123.45 MHz
6) A wake turbulence encounter must be reported
AFM: NONE

AOM: [CHAPTER 28] S.E. RANGE, 2B-24-00

The G650's MCDU calculates and displays single engine range information - range and time to fuel reserves and to zero fuel at the optimum LRC altitude and speed when operating with one engine inoperative (OEI).

1) PERF

2) LSK 5R - S.E. Range

S.E. RANGE 1/1
CRZ ALTITUDE  CRZ SPEED
FL350  207
RANGE < RES FUEL > ETE
660  02+07
RANGE < ZEROFUEL > ETE
1283  03+57
- This section describes the driftdown procedure:

1. At the failure of an engine, apply MCT on operating engine. Deceleration is performed at the initial altitude before start of the descent.

2. Descent Mach is maintained until descent KCAS is intercepted.

3. At the final driftdown altitude, the start cruise KCAS is the single engine long range cruise (LRC).

4. Adjust thrust as required to maintain the start cruise KCAS.

- This section also provides an example that explains how to use and interpret the driftdown charts.

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**QRH:**

- This section provides two (2) sets of charts each for ISA +5°C and +20°C.

- Temperature adjustment notes are also provided.
G650 ENGINE OUT SCENARIO

1. LEFT ENGINE ROLLED BACK AND FLAMED OUT
2. AIRCRAFT YAWED LEFT
3. AUTOThROTTLE DISENGAGED
4. CRUISE SPEED BEGAN TO DECAY

With the loss of 50% of available thrust the aircraft will not be able to maintain altitude

The primary objective is to get away from the track and to descend below the OTS in order to proceed direct to the enroute alternate airport
① FLY THE AIRCRAFT

- The autopilot will remain engaged
- The autothrottle will disconnect
- There will be a bit of yaw as the left engine rolls back and forth while the FADEC attempts to keep the engine from flaming out but it eventually does
- Regain and maintain directional control

② SET MAXIMUM CONTINUOUS THRUST (MCT) ON OPERATING ENGINE (SMC/TRS)

To determine MCT press  on SMC then press LSK 4L. MCT EPR will be boxed

- Advance R thrust lever until EPR matches MCT
- Apply rudder and trim as necessary
Call for Engine Out Driftdown checklist

Expect speed to continue decaying

As the Pilot Monitoring (PM) reaches for his iPad, turns it on, opens GAC's PlaneBook, and selects:

- QRH
- Engines - EB
- Engine Out Driftdown Charts ............ EB-16

Select HDG on Guidance panel, sync it and rotate HDG knob > 30° Right (direction to Equal Time Point (ETP) Alternate Airport - XYZ3
CREATE A 5 NM OFFSET (MCDU/PROGRESS page)

1) PROG
2) NEXT NEXT
3) Scratch Pad: R 5
4) LSK 1R

Select LNAV on Guidance Panel

Ensure FMS is captured/annunciated on PFD's Flight Mode Annunciator
• The PM should have by now determined the driftdown Mach/KCAs and initial cruise altitude from the Engine Out Driftdown Charts (EB-16)

1) **PERF**
2) LSK 1L - Perf Init
3) **PREV**

### Engine Out Driftdown

<table>
<thead>
<tr>
<th>Initial Altitude</th>
<th>Initial Driftdown Weight - 1000 Lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td></td>
</tr>
<tr>
<td>85</td>
<td></td>
</tr>
<tr>
<td><strong>80</strong></td>
<td><strong>1000 Lb</strong></td>
</tr>
<tr>
<td>75</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>47</td>
<td></td>
</tr>
<tr>
<td><strong>45</strong></td>
<td><strong>0.83/224</strong></td>
</tr>
<tr>
<td>43</td>
<td></td>
</tr>
</tbody>
</table>

**Mach/KCAs**

- **Airborne Performance Init-16 5/5**
- B/OW 54,600 10/195
- FUEL (Cruise) 23,150 (23,150) 1750
- CARGO 500 80,000

**Descent Mach/KCAs**

- TIME
- FUEL
- DIST
- START CRUISE ALTITUDE

- **0.83/224**
- 49
- 47
- 45

**Cruise Altitude**

- **24,500**
4 Set Driftdown Speed and Altitude

- Deceleration from Mach **0.88** to Driftdown Mach **0.83** should be at the initial altitude of **45,000 ft** before the start of the descent.
- Expect speed decay to increase while turning away from the track.
- Ideally, descent commences once established on the **5 nm offset**.
- Speed control
5. Commence driftdown

An engine out driftdown is a trade off of available altitude for maximum forward distance.

The AFM, AOM and QRH do not provide guidance as to which vertical mode to use.

FLCH

The use of FLCH to accurately maintain the driftdown Mach/KCAS would seem logical. Unfortunately its use may result in oscillations as the AFCS continuously corrects for speed deviations.

The use of VS/FPA may be a better option.
What if?

If the engine had failed prior to crossing ETP 2 a diversion to XYZ 2 would have been necessary.

Once established on a same direction 5 NM lateral offset an expedited descent through FL290 (below OTS tracks) would have been required before initiating a turn-back diversion across the flow of adjacent traffic above.
Communicate - Time To Alert Everyone

- ATC: Declare Mayday and intentions

- Datalink (CPDLC/ADS-C)

  1) NAV
  2) LSK 1R - ATC
  3) ATC Logon/Status 1/2
  4) LSK 6L - ATC Index
  5) LSK 1L - Emergency
  6) LSK 1L - Mayday
  7) Populate Emergency Report
  8) Verify it and send it

   Emergency Report 1
   Mayday
   Divert to Descend to
   XYZ 3 24500
- **OTHER TRAFFIC:**

  - **Broadcast your situation, position and intentions on 121.5 and 123.45 MHz**
  - **Turn on all external lights**
  - **Monitor TCAS**
  - **Look for contrails/traffic**

③ **Secure failed engine**

  - **QRH**

  - **Engines - EB**

  - **Engine Shutdown Inflight............... EB-14**

⑧ **APU START:**

  - **APU provides an additional source of:**
    
    - **Backup Electrical AC power**
    - **Pneumatic bleed air for engine air start**
QRH

- Alternate Normals - NG
- APU Inflight Operation ............... NG-8

- Maximum Altitude for APU start =
  Starts are possible from 30,000' to 39,000'

  Guaranteed at or below 30,000'

9. Change Destination Airport

- Once safely below the OTS (< FL290) proceed
direct to the ETP Airport (make sure to enter and
verify the correct ICAO code)

- Update flight plan winds

- If you haven’t already received a revised ATC
clearance contact ATC and request one
- Squawk Transponder Code 7700
- Set ADS-C to Emergency
Flight crew to cabin crew: TEST

T = Type of emergency
E = Exit/Evacuation plan
S = Signals (2 minutes, 10 seconds, EZ Victor)
T = Time to prepare

Flight Dispatch/Maintenance Department

Notify your dispatch team about your situation, intentions and requirements

The above can be done through your communications service provider (CSP)

Arrival and Landing

D = Destination
A = Arrival
L = Landing
C = Cruise Altitude
A = Activate vectors
R = RAIM
Electrical System:

The failure of either engine will result in:

1. Loss of an Integrated Drive Generator (IDG)

The remaining IDG is capable of powering the entire electrical power system
Electrical System:

2. Break Power Transfer

Failure of either engine will result in a momentary interruption in power to an ESS DC bus.

A break power transfer will result in the activation of emergency power (E-batts)

\[
\begin{array}{c}
\text{FWD E-BATT} \\
\text{AFT E-BATT}
\end{array}
\rightarrow \text{ON when } \begin{array}{c}
\text{LESS DC} \\
\text{ESS DC}
\end{array} < 20 \text{ Volts,}
\text{even momentarily}
\]

3. Crew Actions:

- Re-arm E-batts (otherwise they’ll discharge)

- Reset RA1 or RA2 miscompare on affected primary flight display (PFD)

( SMC/SENSOR/RA1 OR 2 )
Hydraulic System:

The failure of either engine will result in:

1. Loss of an engine-driven Hydraulic pump (EDP)
2. If the left engine fails the Power Transfer Unit (PTU) will take over the duties of the inoperative EDP as soon as hydraulic system pressure drops below 2400 psi
Hydraulic System:

The following components will be lost:

- Redundant hydraulic power to flight controls
- Left Thrust Reverser
- Mid spoiler panel

③ If the Right engine fails the R Hyd System will be unavailable and the following components will be lost:

- Redundant hydraulic power to flight controls
- Right Thrust Reverser
- Inboard spoiler panel (outboard spoiler panel OK)
- Parking brake - outboard

Limitations:

285 KCAS / M 0.90 due surface failure
Flight Control System:

1. **The Flight Control System (FCS) is electrically-controlled and hydraulically-actuated.**

   ![Diagram of the Flight Control System]

There is sufficient redundancy to ensure that the failure of an engine does not adversely impact its capability.

From an **Electrical** point of view, the failure of an integrated drive generator (IDG) due to an engine flameout does not affect the Flight Control Computers (FCC). The remaining IDG can power the entire electrical power system, including both FCCs.

From a **Hydraulic** point of view, the failure of either engine will result in the loss of an engine-driven hydraulic pump (EDP).
The failure of the **LEFT** engine will result in a number of hydraulic actuators powered by the **L** Hydraulic system going into a damped state. The remaining actuators, powered by the **R** Hydraulic system, will power all primary flight controls.
The failure of the right engine will result in a number of hydraulic actuators powered by the right hydraulic system going into a damped state. The remaining actuators, powered by the left hydraulic system, will power all primary flight controls.

Ailerons: OK
Elevators: OK
Rudder: OK
Spoilers: OK

L Hydraulic System
R Hydraulic System

(outboard spoiler panel OK)
Fuel System:

The failure of either engine will not affect any fuel system components.

1. A fuel imbalance condition will quickly develop and must be addressed as per:
   - QRH
   - ALTERNATE NORMALS - NG
   - Fuel balancing Inflight ....................... NG-2B

1) Open crossflow valve
2) Turn off pumps on light side. One at a time!
Fuel System:

2. The crossflow valve has a five (5) minute timer to alert the crew that it is still open. The CAS message turns amber (CAUTION) and a double-chime aural tone will sound.

The crossflow valve on the fuel synoptic page will also turn amber.

After reassessing the status of the fuel imbalance, the crew should then reset the timer by cycling the crossflow valve closed and then open.
③ Caution should be exercised to ensure there is always positive fuel pressure prior to cycling the crossflow valve. Without pump pressure the operative engine will:

A) < 20,000' = suction feed
B) > 20,000' = run erratically and flameout
Pneumatic System:

The failure of either engine reduces the pneumatic system's redundancy but not its capability.

1. The remaining engine can provide the necessary bleed air (High pressure and temperature) via its own side's pneumatic system.

2. Opening the Isolation Valve allows the operating engine to provide bleed air to the opposite side's ECS pack.

3. A single ECS pack can sustain all air conditioning and pressurization requirements. Single pack operations are limited to a maximum altitude of 48,000 feet.
Since a descent to a much lower altitude is required following the failure of an engine at cruise altitude, single pack operation will not have an adverse impact.
In the event icing conditions are present during the descent and diversion to the enroute alternate airport, the operative engine's wing anti-ice system can provide the necessary hot bleed air to heat up the other wing. This is possible via a crossover duct.
6 Cowl anti-icing protection is only available for the operating engine.
Questions, comments or errors?
ivan.luciani@gmail.com

Thank you!