Avionics developments for improved vertical profile

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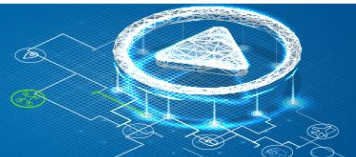
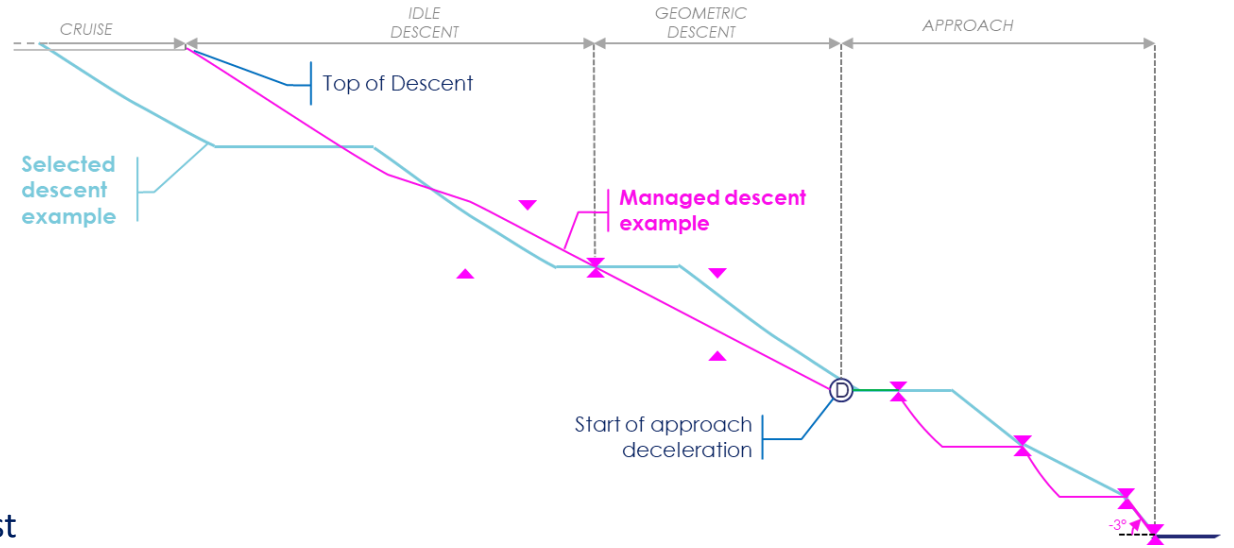


State of the art
Descent phase

- **How does an aircraft fly in descent phase ?**
  - **In managed vertical mode**, only available when the aircraft is flying its flight plan in lateral managed mode
    - DES : vertical path of the Flight Management System
  - **In selected vertical mode** otherwise, in case of ATC clearance
    - OP DES : open descent with IDLE thrust
    - FPA : constant Flight Path Angle
    - V/S : constant Vertical Speed
    - ALT : constant Altitude

    } with adapted thrust

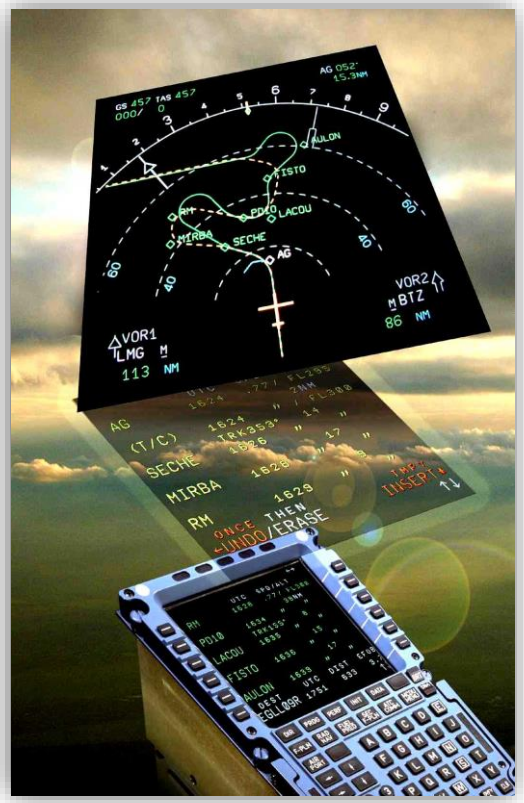
    ➔ Altitude constraints of the flight plan are disregarded



Flying in selected modes is generally not as fuel-efficient as flying in managed modes

State of the art
Use of vertical managed

- **Use of vertical managed mode is very low** according to SESAR EPP data collection (PJ31)
  - **0.6%*** of use vertical managed mode use below FL100, after a heading clearance
    - ➢ **There is a need to support an efficient vertical profile after a lateral ATC clearance**
  - **60%*** of use of managed mode above FL100, after an altitude clearance
    - ➢ **There is a need to support the transition from selected to managed mode after a vertical ATC clearance**

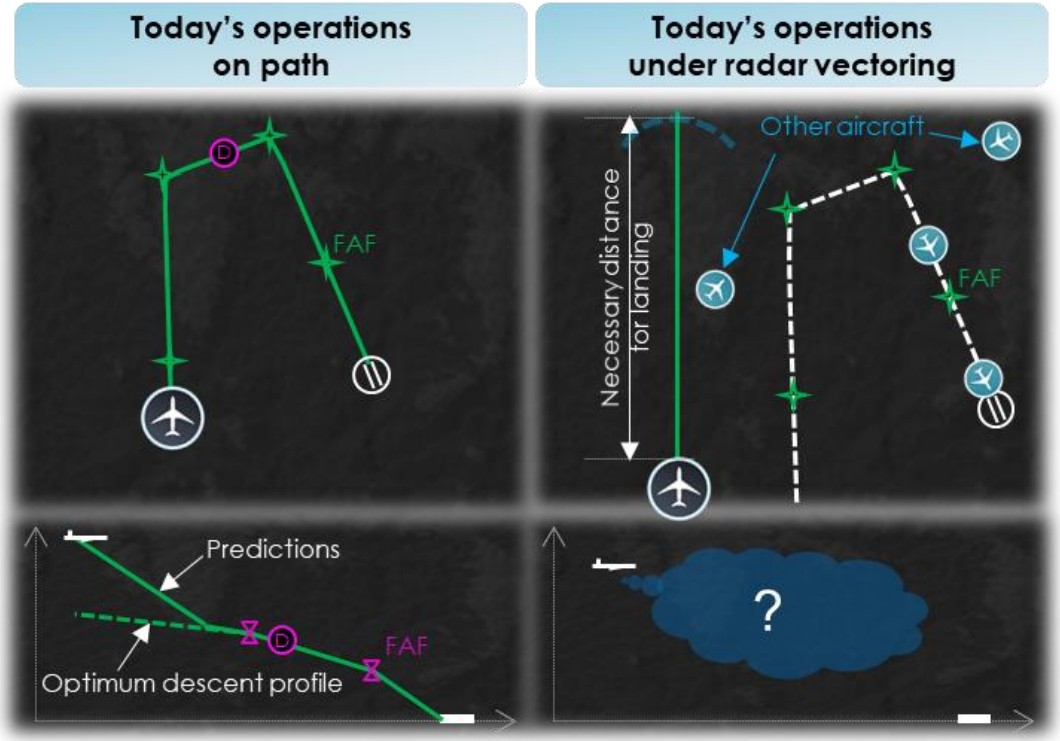


* Source : NATS data collection of PJ31, PJ31 appendix N

Usual operational practices justifies ***new developments to <u>support fuel-efficient flights</u>***

State of the art
Synthesis

- **The optimized Top of Descent is generally not used** in real operations to start the descent.
- **The radar vectoring method** is used to organize the traffic flows in order to optimize runway throughput on busy airports.
- **It is a usual practice for Air Traffic Control Operators** to vector the aircraft by assigning heading, speed or vertical instructions.
- **Conventional Flight Management System (FMS) provides limited crew awareness** when the aircraft leaves its pre-planned route.

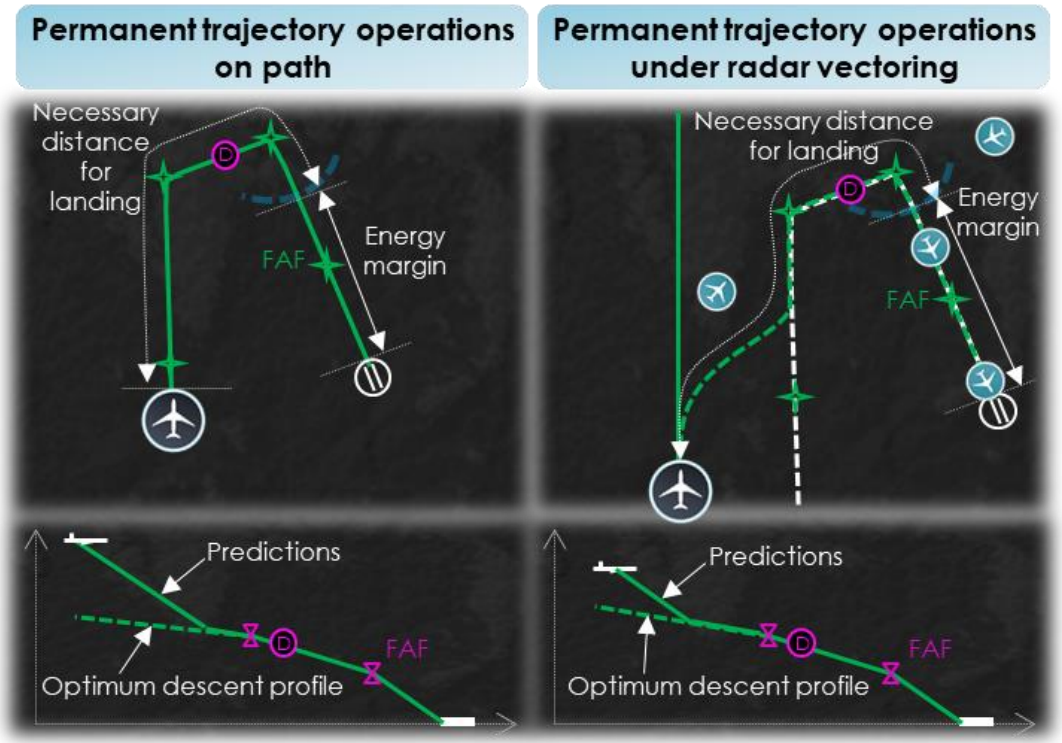


*With current systems and practices, the crew must use rules of thumb and **subjective evaluation of remaining miles** to perform and monitor an efficient descent to the destination.*

FMS developments for improved vertical profile

Permanent Resume Trajectory (PRT) : concept overview

- **Provide a constant disclosed flight trajectory** to resume the flight plan in the most likely way according to operational feedback when in lateral selected mode
- **Improve situation awareness** through explicit and adjustable trajectory updated in real time
- **Improve aircraft guidance** as a flight efficient reference for both lateral and vertical
- **Enabler towards more autonomous aircraft** as it is permanent and continuous, then verifiable



*A **new concept of <u>Permanent Resume Trajectory (PRT)</u>** has been introduced and matured by Thales in the PureFlyt™ FMS product.*

FMS developments for improved vertical profile

Permanent Resume Trajectory (PRT) : seamless operations

- **Optimize the flight strategy** that can be graphically displayed to the pilots
- **Improve safe decision-making** and reduce the risk of a non-stabilized approach following an ATC tactical intervention
- **FMS underlying assumptions are presented** and might be adjusted
- **Help to minimize fuel consumption and CO_2 emissions** and contribute to limit environmental footprint of air transport,
- **Help to reduce the noise footprint** in the vicinity of airports, facilitating Continuous Descent Operations (CDO)

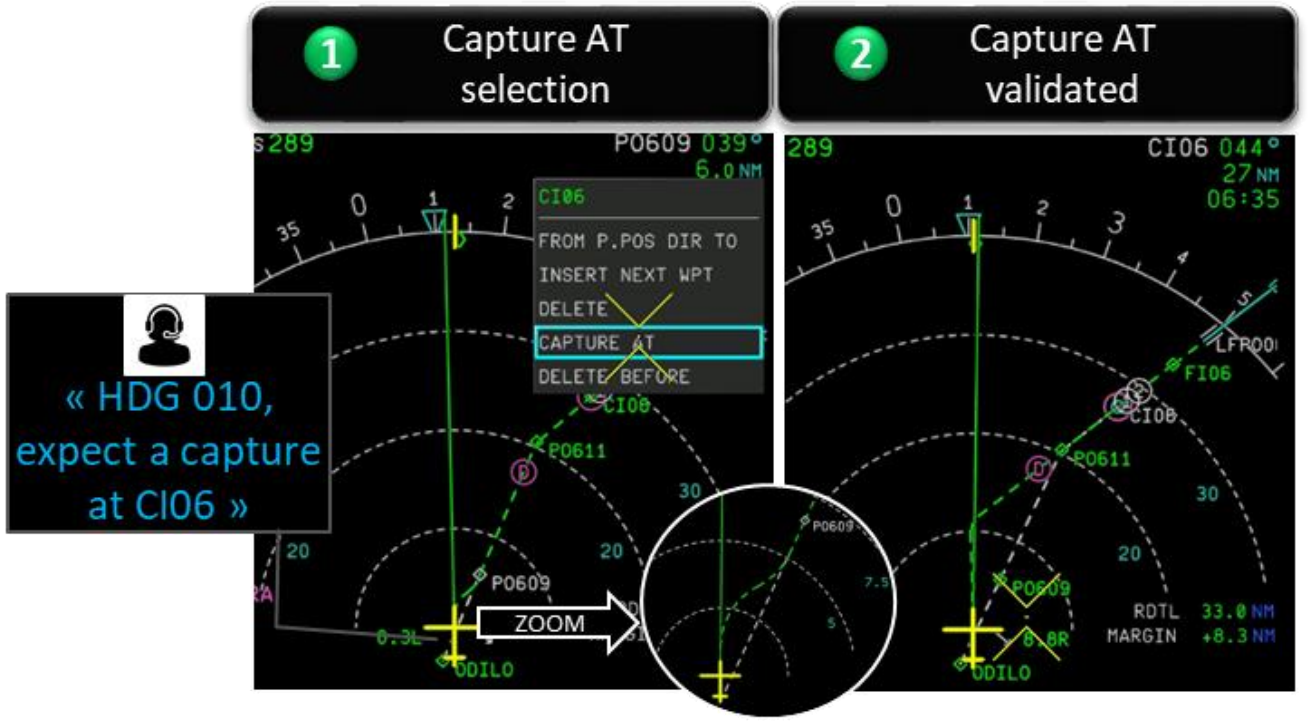
Source: SESAR 2020, Wave 1, PJ01-03B, display visual and layout reproduced by courtesy of AIRBUS

*The permanent trajectory **facilitates the energy management**, **allows fuel savings** and **improves safe decision-making***

FMS developments for improved vertical profile

Permanent Resume Trajectory (PRT) : trajectory tuning

- **Facilitate air/ground communication** as the pilot can adjust the permanent trajectory
- **Various adjustments are possible** for each operational situation
  - **Flight plan leg to be captured** in order to anticipate a future DIRECT TO instruction
  - **FPLN interception point** in order to anticipate a future heading instruction
  - **Remaining distance** to fly
  - **Estimated time of arrival** at a delivery waypoint



Source: SESAR 2020, Wave 1, PJ01-03B, display visual and layout reproduced by courtesy of DSNA-DTI

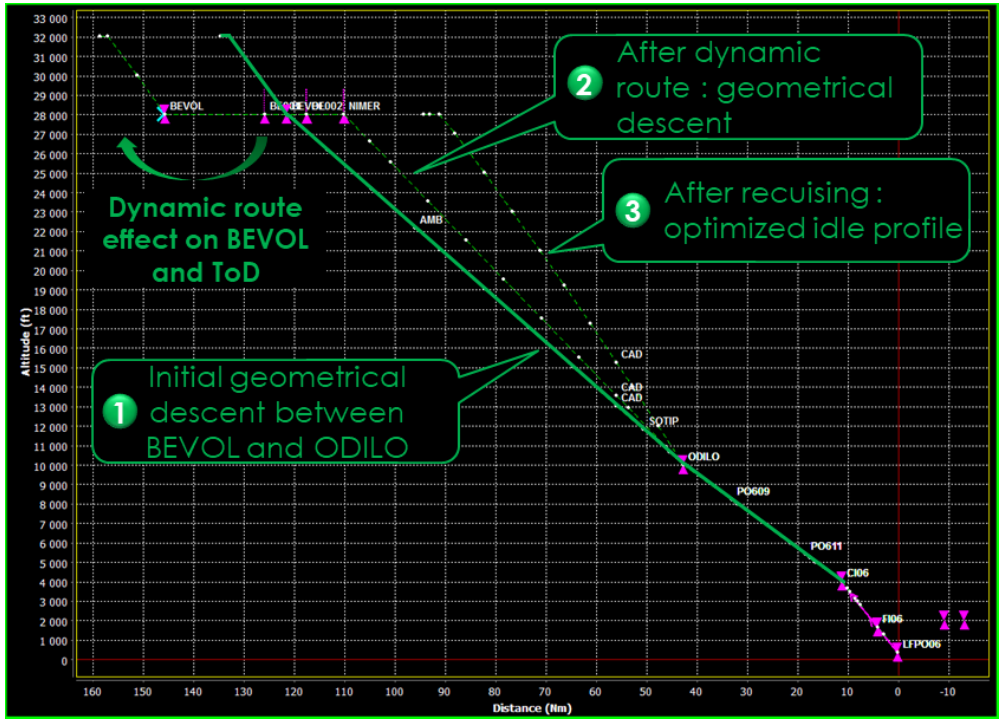
PRT provides benefits without any development on the ground

but integrating the controller intent in the cockpit would improves the flight efficiency even more.

FMS developments for improved vertical profile

Re-cruising : operational principle and benefits

- **Descent may start much before the optimized Top Of Descent** due to operational constraints (letter of agreement, traffic density, etc.)
- **Staying higher longer at a re-cruise level is a fuel-efficient practice** compared to early continuous descent
- **Re-computing a « new » Top Of Descent** at the new cruise level helps the pilot to save fuel by a low-power (IDLE) profile instead of usual geometrical or vertical speed descent
- **An "equivalent descend when ready" instruction** from the executive controller might enable to use this « new » Top Of Descent



Source: SESAR 2020, Wave 1, results from PJ01-03B

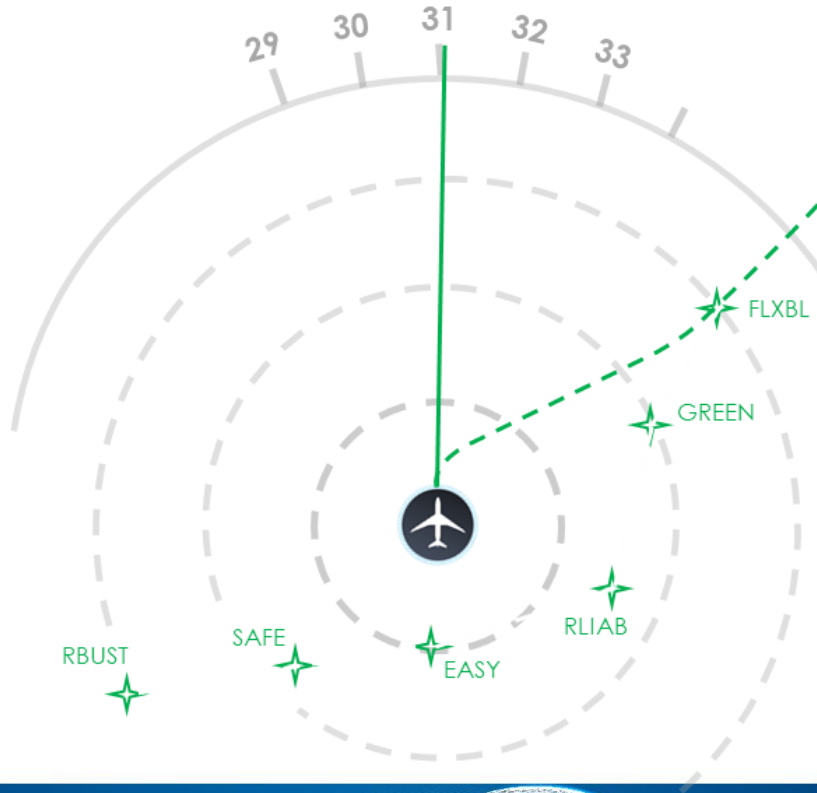
*In case of early descents, re-cruise helps to **save fuel**, by simply staying higher longer.*
*Thus, contrary to common beliefs, **introducing a level segment is more fuel efficient than flying a shallow CDO** .*

Conclusion

- **Avionics systems such as the FMS have an important role to play in greener operations**

- **PRT** is an eco-friendly, reliable and intuitive function
  - **Green** through fuel and noise efficiency improvement
  - **Safe** through trajectory securing and energy management
  - **Easy** through explicit system underlying assumptions
  - **Scalable** through on-board adjustments

- **Re-cruise** is an efficient principle to save fuel



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