LOW NOISE AUGMENTATION SYSTEM (LNAS)

Leiser Fliegen durch Energieoptimale Flugbahnen

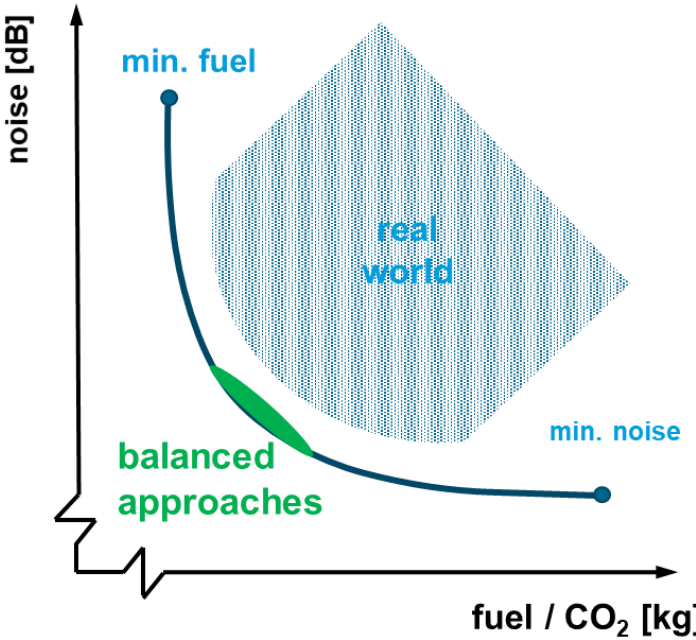
Lateral & vertical path

Landing gear

Speed brakes

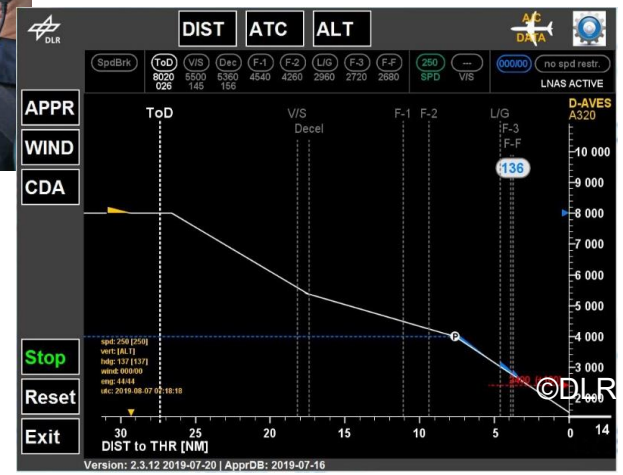
Thrust

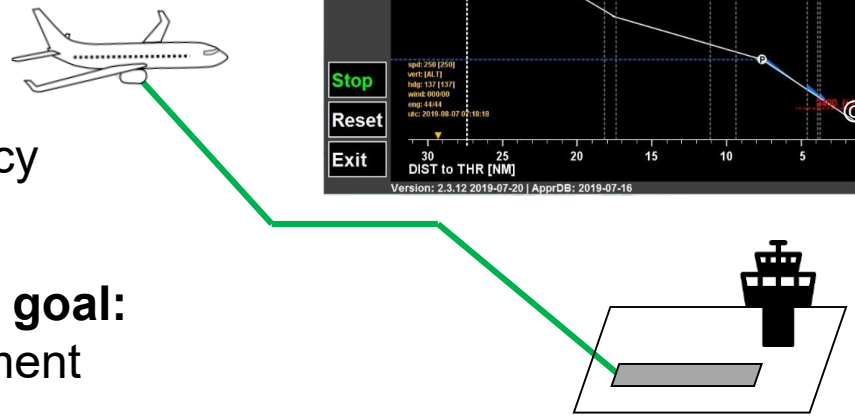
Flaps



Credit: DLR

LNAS Background and Status





Sustainable aviation for EU “Flight Path 2050”:

- 75% less CO_2 emissions
- 90% less NO_x emissions
- 65% reduction of perceived noise emissions

Short-term solutions:

- better aerodynamic performance and propulsion system efficiency
- further optimization of aircraft operations for emission reduction

DLR’s “Low Noise Augmentation System” (LNAS) targets this goal:

- low-power descent and approach by optimized energy management
- up to 25% fuel reduction and noise reduction up to 5 dB

Fethi Abdelmoula and Marco Scholz. *LNAS - a pilot assistance system for low-noise approaches with minimal fuel consumption*. Belo Horizonte, Brazil, September 09th - 14th 2018. 31st Congress of the International Council of the Aeronautical Sciences (ICAS). https://www.icas.org/ICAS_ARCHIVE/ICAS2018/data/papers/ICAS2018_0096_paper.pdf

- Application of LNAS on airline fleets for field tests
- Currently several hundred aircraft already performed thousands of optimized approaches

Credit: DLR

From the Basic Idea into Airline Operations During One Decade

Simulator trial
@ AVES

PhD Work
@ TU Braunschweig

Flight Test D-ATRA
@Frankfurt Airport

first tests at major airport

Flight Test D-ATRA
@Zürich Airport

continuous descent approach CDA

Operational Tests
@Lufthansa

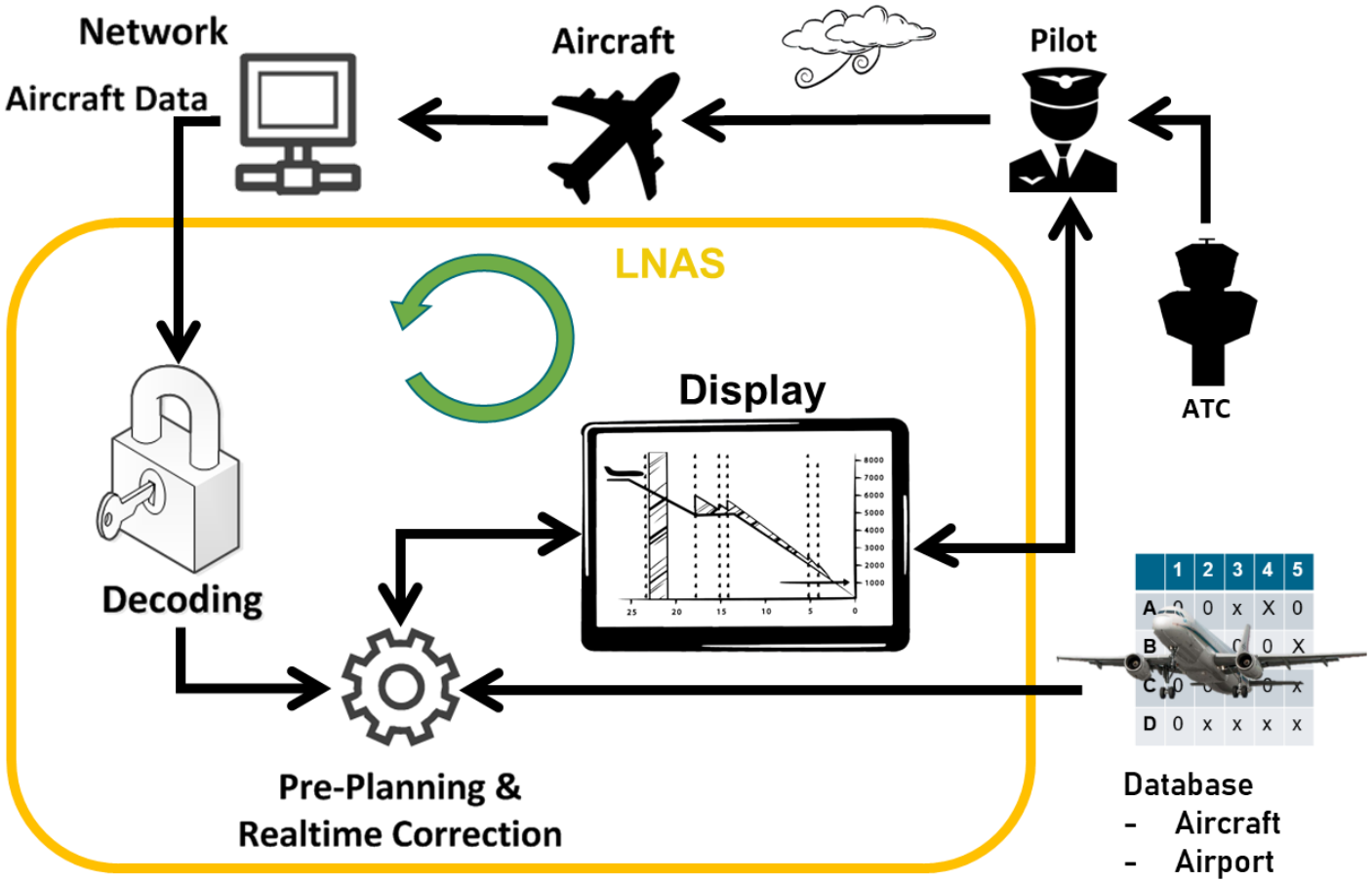
every day use in airline operations

2010 — **2015** — **2020**

TRL 1 → TRL > 6

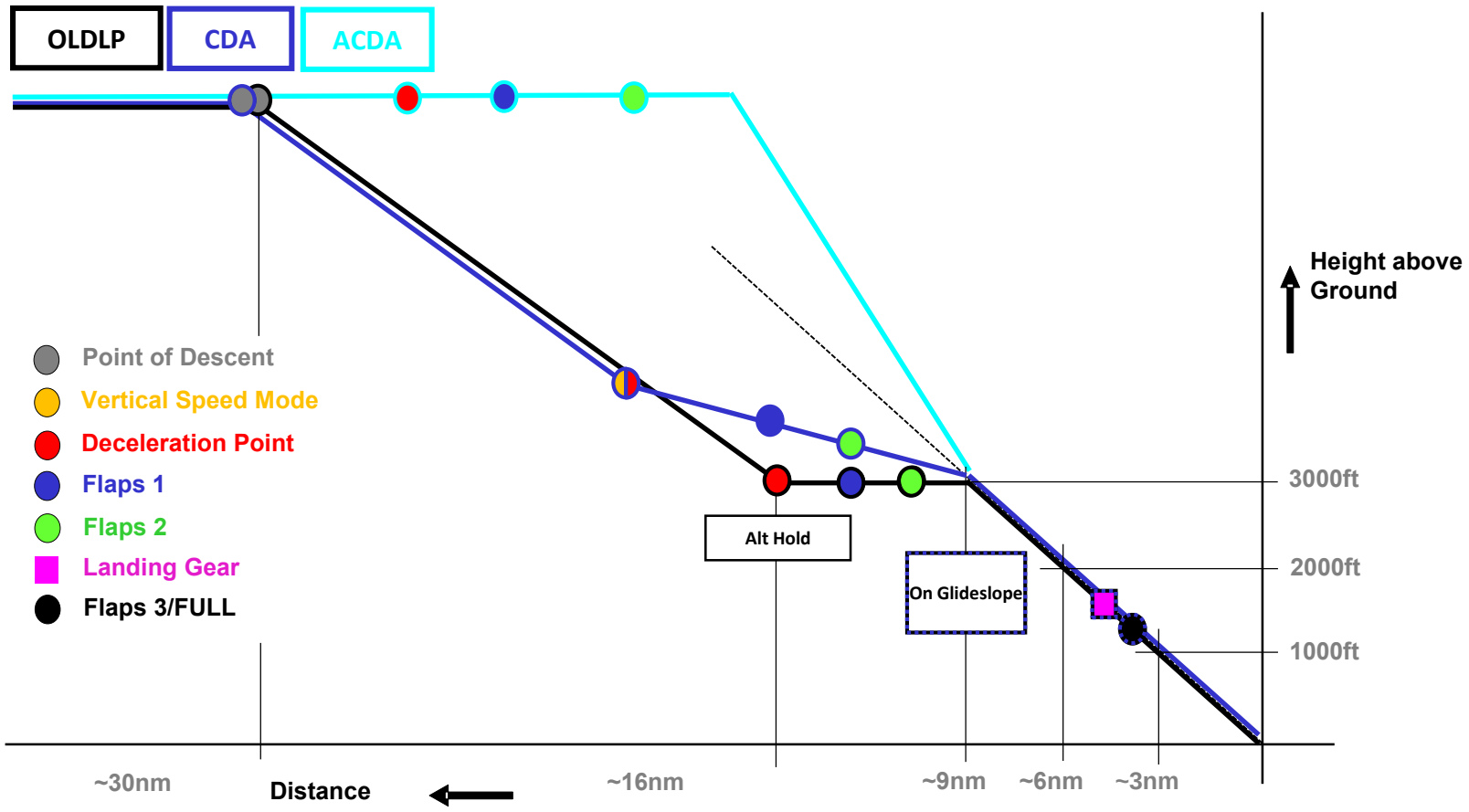
Credit: DLR

LNAS System Overview



Credit: DLR

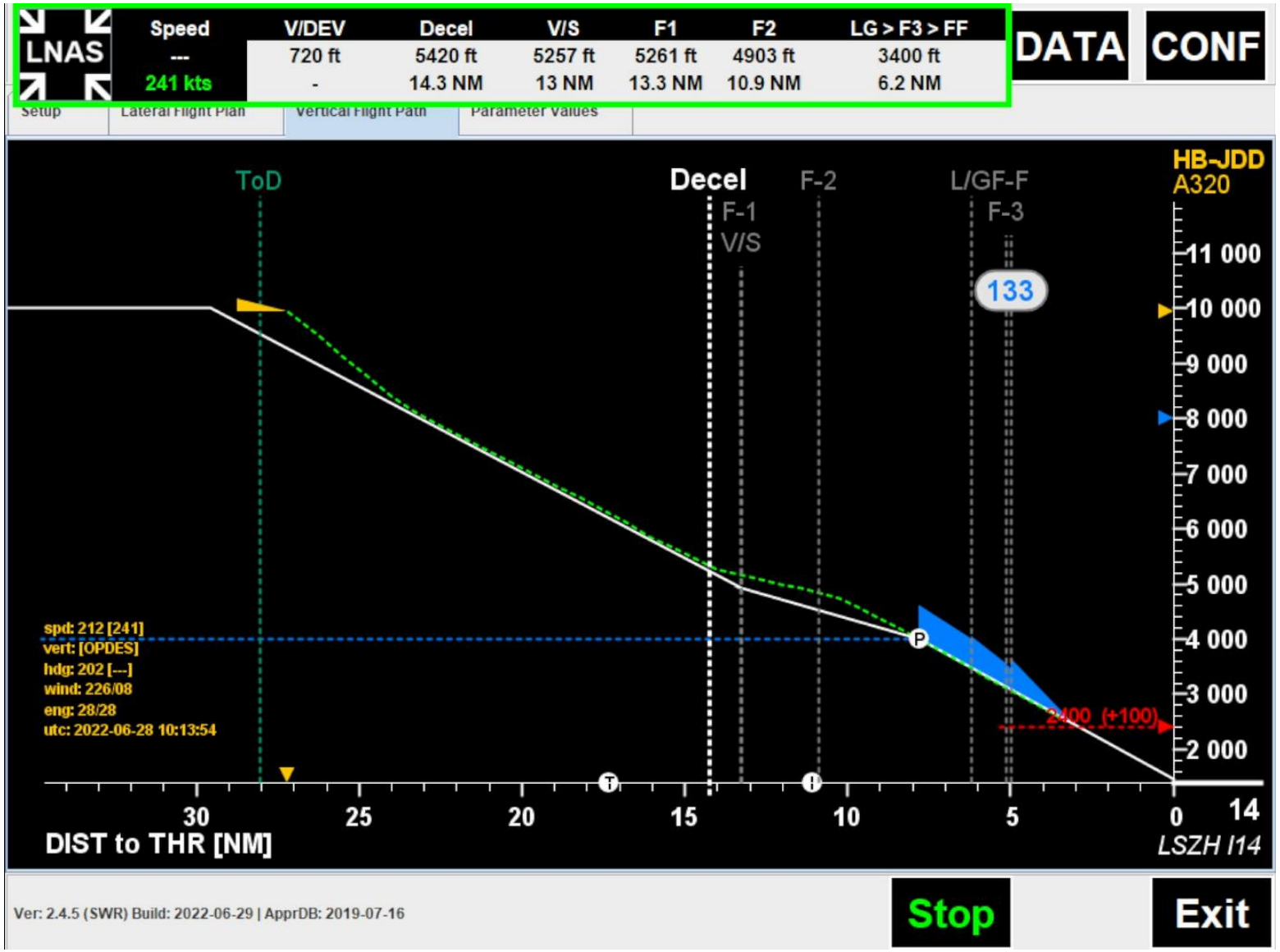
Different Approaches Optimized with LNAS



ACDA	Advanced Continuous Descent Approach
CDA	Continuous Descent Approach
OLDLP	Optimized Low Drag Low Power

Credit: DLR

Vertical Flight Path Display



LNAS user interface and functionalities

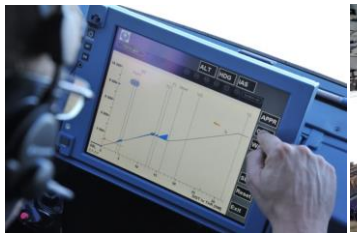
- current wind situation (required)
- runway ILS (automatically retrieved from aircraft data, FCU)
- speed restrictions (given as published)
- waypoints (pre-defined)
- approach procedure

Credit: DLR

Development Timeline to operational solution

2015 – 2016
LNAS LDLP Demo @ EDDF

Development and demonstration of LNAS (Low Noise Augmentation System) idle thrust approaches at Frankfurt Airport with LNAS EFB tool on DLR A320 ATRA

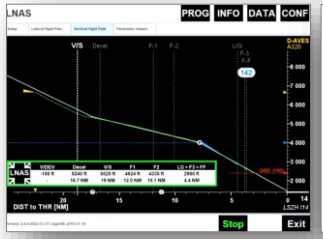


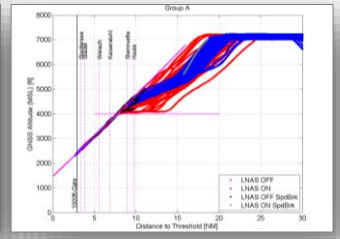
Umwelt- und Nachbarschaftshaus

Forum Flughafen und Region

2017 – 2020
LNAS CDA Demo @ LSZH

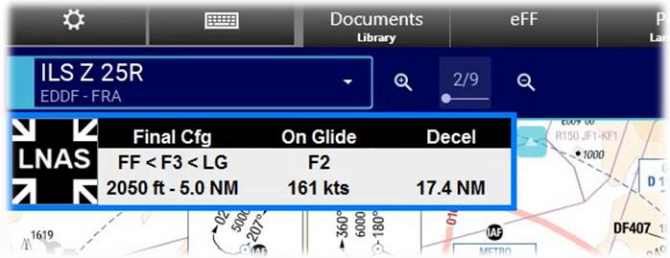
Development and demonstration of LNAS (Low Noise Augmentation System) idle thrust approaches at Zurich Airport with LNAS EFB tool on DLR A320 ATRA





2018 – 2023
LNAS Lufthansa trials @ EDDF

Operation in regular flight with Lufthansa using up to 200 aircraft of the A320 family (A319, A320, A321, A320Neo)



Umwelt- und Nachbarschaftshaus

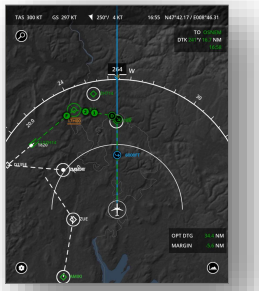
Forum Flughafen und Region

Credit: DLR

Development Timeline to operational solution

2020 – 2022
DYNCAT @ LSZH

Development of Flight Management System (FMS) prototype function DYNCAT (Dynamic Configuration Adjustments in the TMA) based on LNAS concept. Features: Distance-to-Go (DTG) / Requested Time of Arrival (RTA) / Permanent Resume Trajectory (PRT) function and energy cues for pilot.



2022 – 2025 D-KULT
LNAS Departure @EDDF

Extension of LNAS to wide-body aircraft B787/A330 (in previous projects exclusively A320 family)
New development LNAS-Departure

Focus on Frankfurt/Main airport, validation flights for departure with DLH A330
Primary optimization variables for LNAS: noise / fuel consumption

Bundesministerium für Wirtschaft und Klimaschutz

2020 – 2022
LNAS ACDA / SCDA Demo @ EDDK

Development and demonstration of LNAS (Low Noise Augmentation System) idle thrust approaches at Köln/Bonn Airport with LNAS EFB tool

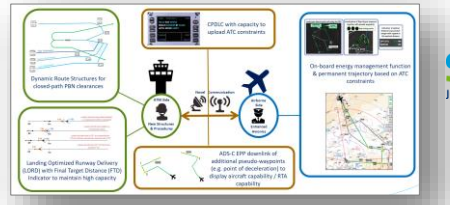
Ministerium für Umwelt, Naturschutz und Verkehr des Landes Nordrhein-Westfalen

2020 – 2022
ALBATROSS EXE-03 Demo @ LSZH

Demonstration of idle thrust approaches on SWISS A320neo using LNAS for ILS RWY14 with a closed-path waypoint sequence. Dynamic flaps and L/G extension to stabilize at 1'000 ft AGL.

2023 – 2026 DYN-MARS

Integration of DYNCAT into a combined ATM-aircraft environment using new enhanced navigation procedures (dynamic route structures) and air-ground communication systems (datalink and data sharing).



Credit: DLR

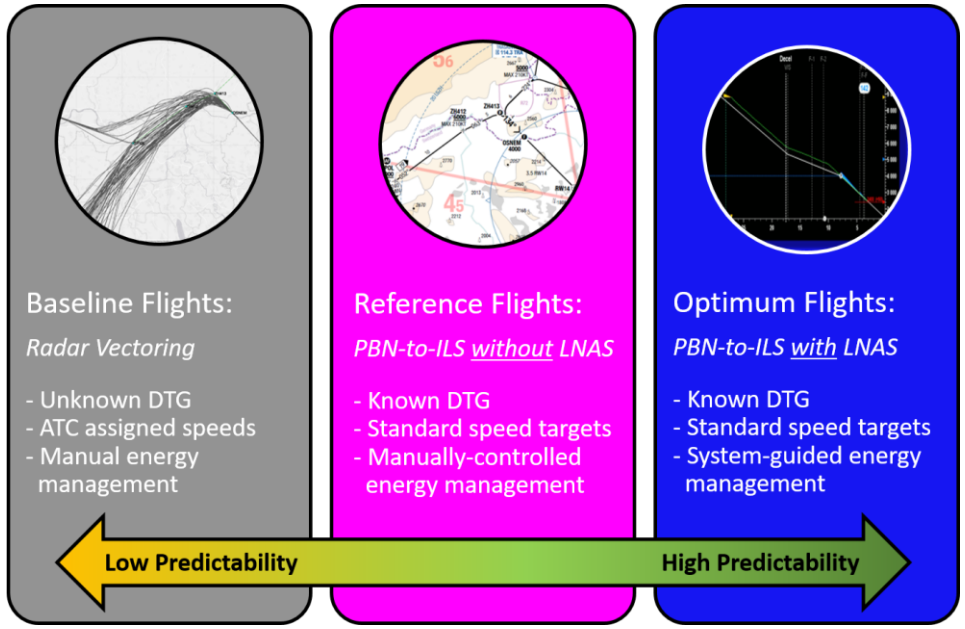
This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No **101017678**

ALBATROSS EXE-03 Demo
Zurich Airport

Scope: **Performance Base Navigation to ILS** procedure **with and without aircraft energy management assistance function**.

Objective: Demonstration LNAS benefit for Continuous Descent Approaches (CDA) applied to closed-path PBN-to-ILS procedures.

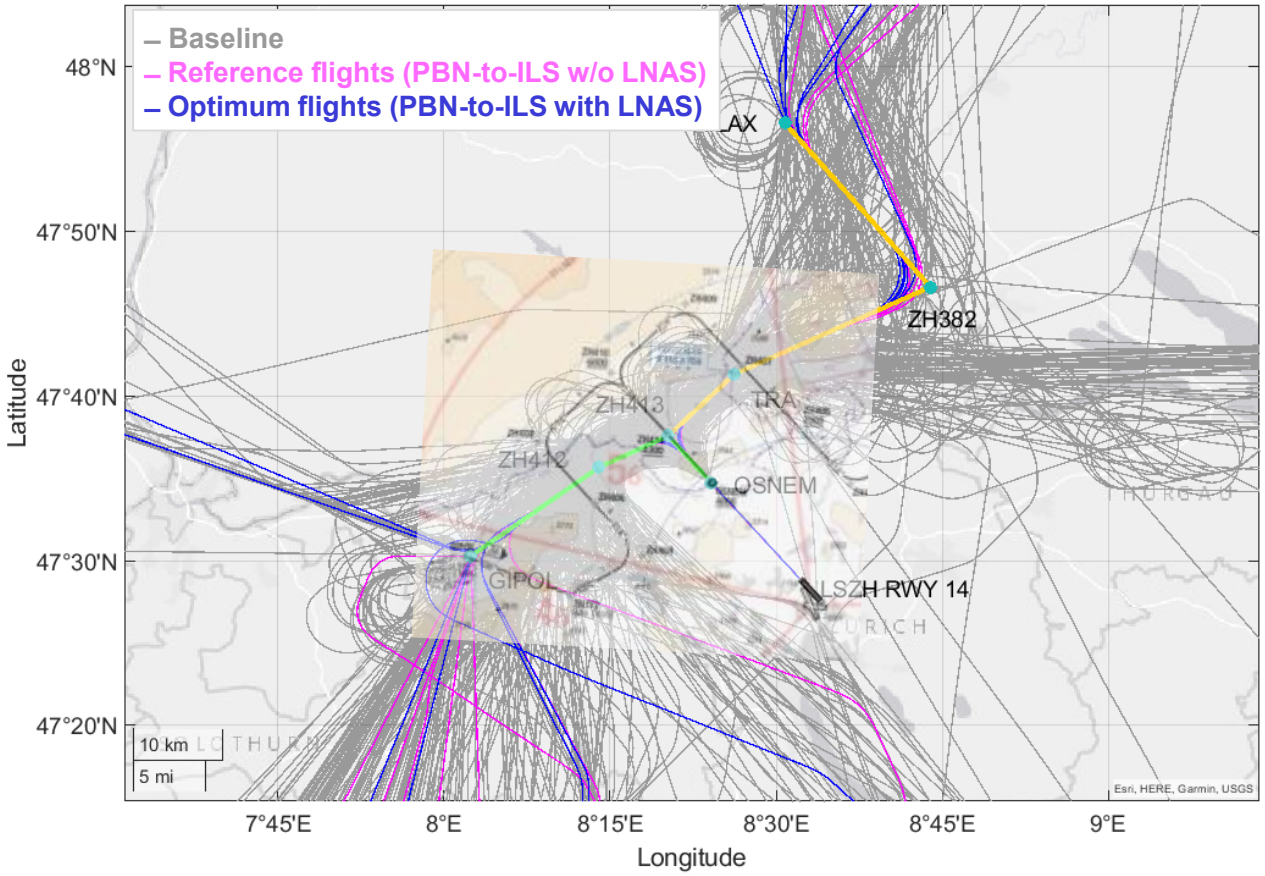
LNAS: EFB application as demonstrator for the capabilities of future FMS solutions to enable the perfect descent in a high-density air traffic environment.



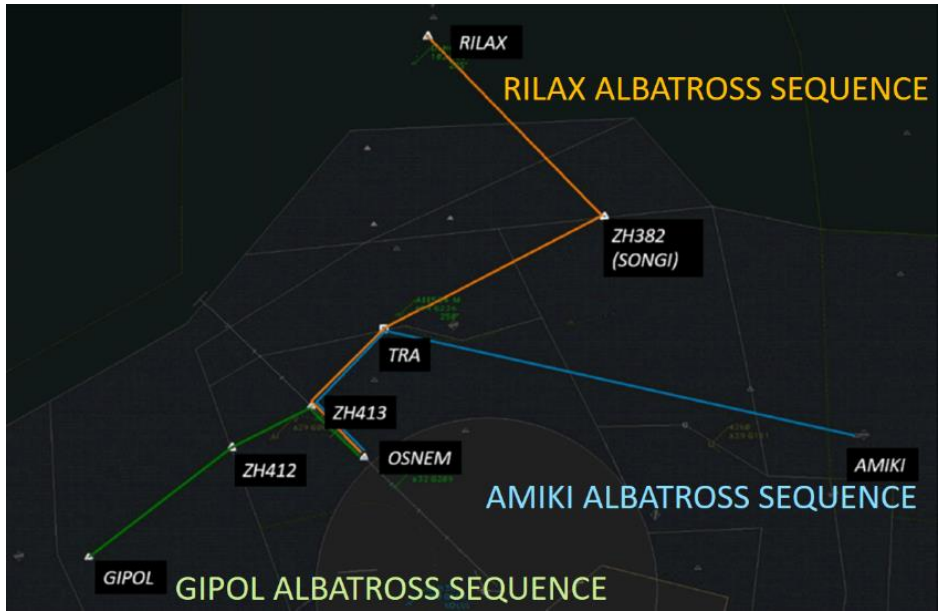
This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No **101017678**

From Radar Vectoring to PBN-to-ILS with LNAS
Flight tracks

Plan view of the Baseline Flights (grey), the Reference Flights (magenta), and the Optimum Flights with LNAS (blue). It is well seen how the reference and optimum flights follow the PBN-to-ILS procedure.



Waypoint sequence of the temporarily published PBN-to-ILS procedure for LSZH RWY14 used for the reference flights and optimum flights.



Credit: DLR

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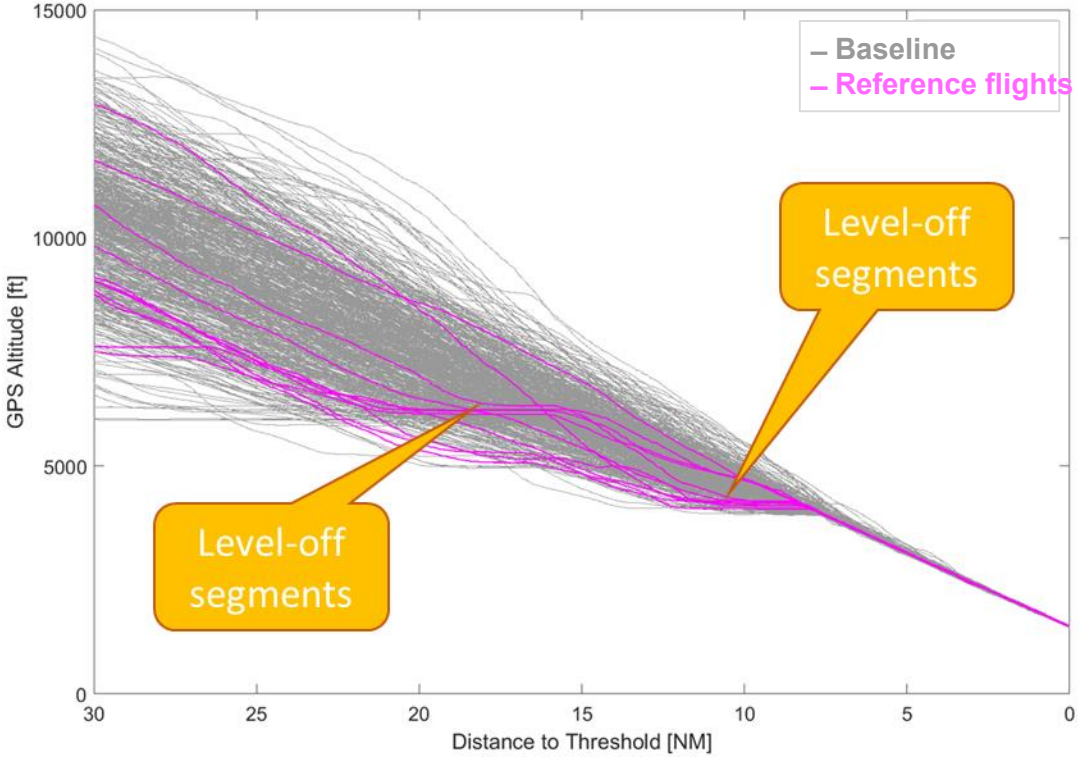
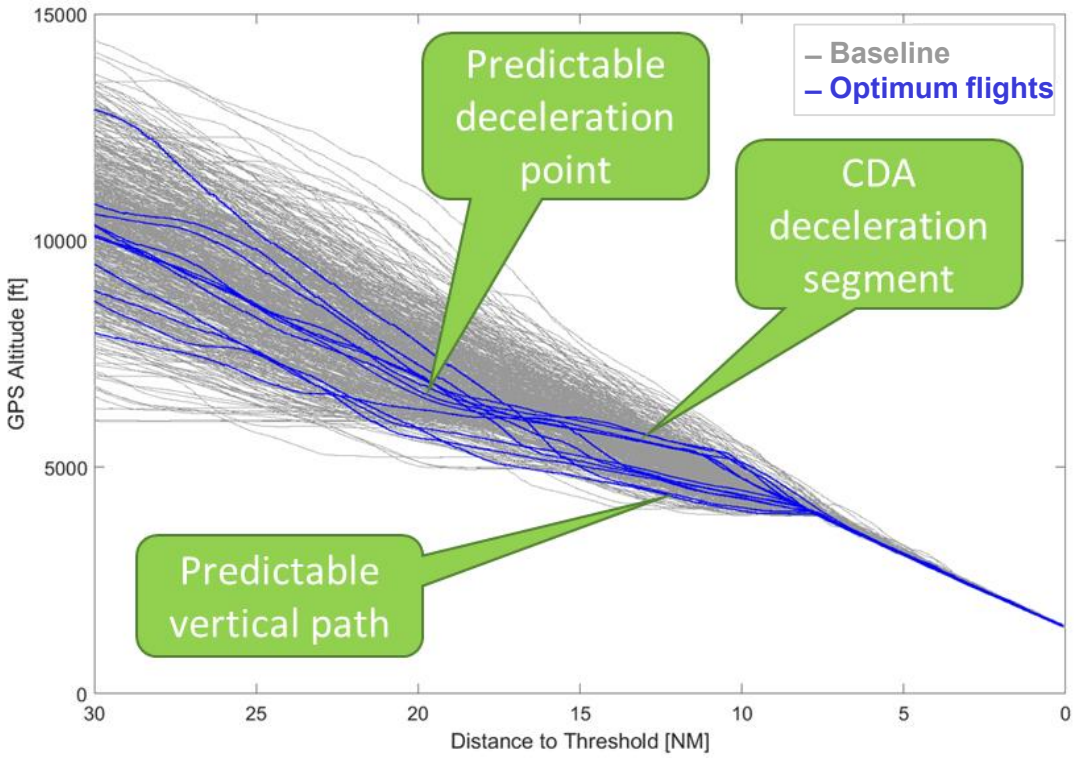
Demonstration Results
Vertical Flight Profiles





- reference and optimum flights had conservative targets with respect to energy management
- manually-controlled energy management reveal level segments although performing CDA

- level-offs were entirely avoided for all LNAS flights → clear CDA
- from 16 NM all flights are in a V/S segment approaching the glideslope before or at the FAF.

Credit: DLR

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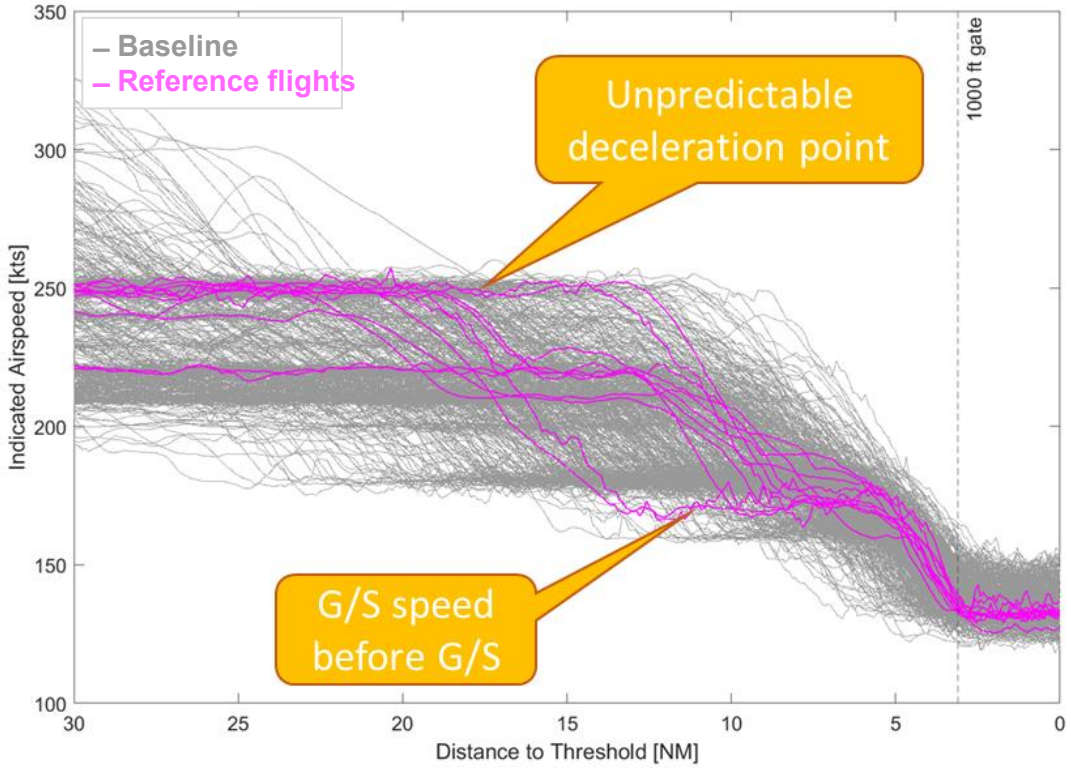
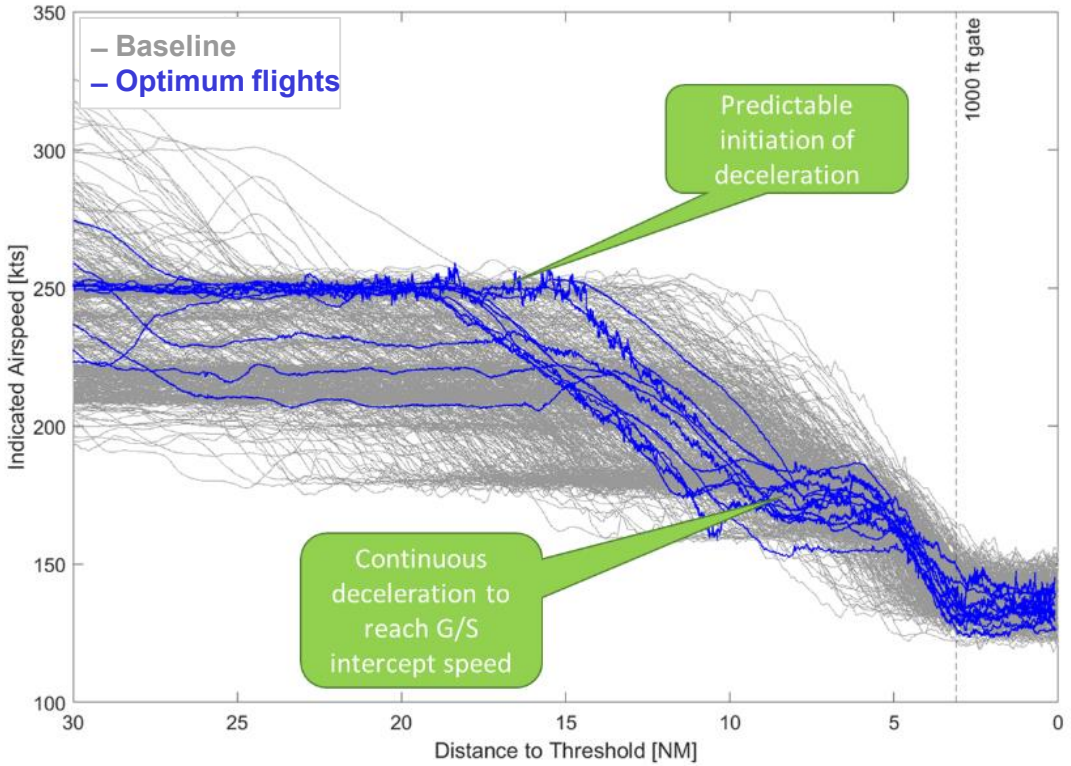
Demonstration Results
Speed Profiles



- target: reach G/S with 170 kt for a standard CONF sequence.
- flights w/o speed restrictions tend to be high on energy on the last 15 NM → deviation from standard CONF sequence
- some flights reached 170 kt too early
  → large spread of DECEL initiation



- LNAS allows reducing spread of the speed distributions
- LNAS-assisted speed profiles repetitive and speed reductions are almost linear.
- DECEL location and speed at G/S intercept are predictable

Credit: DLR

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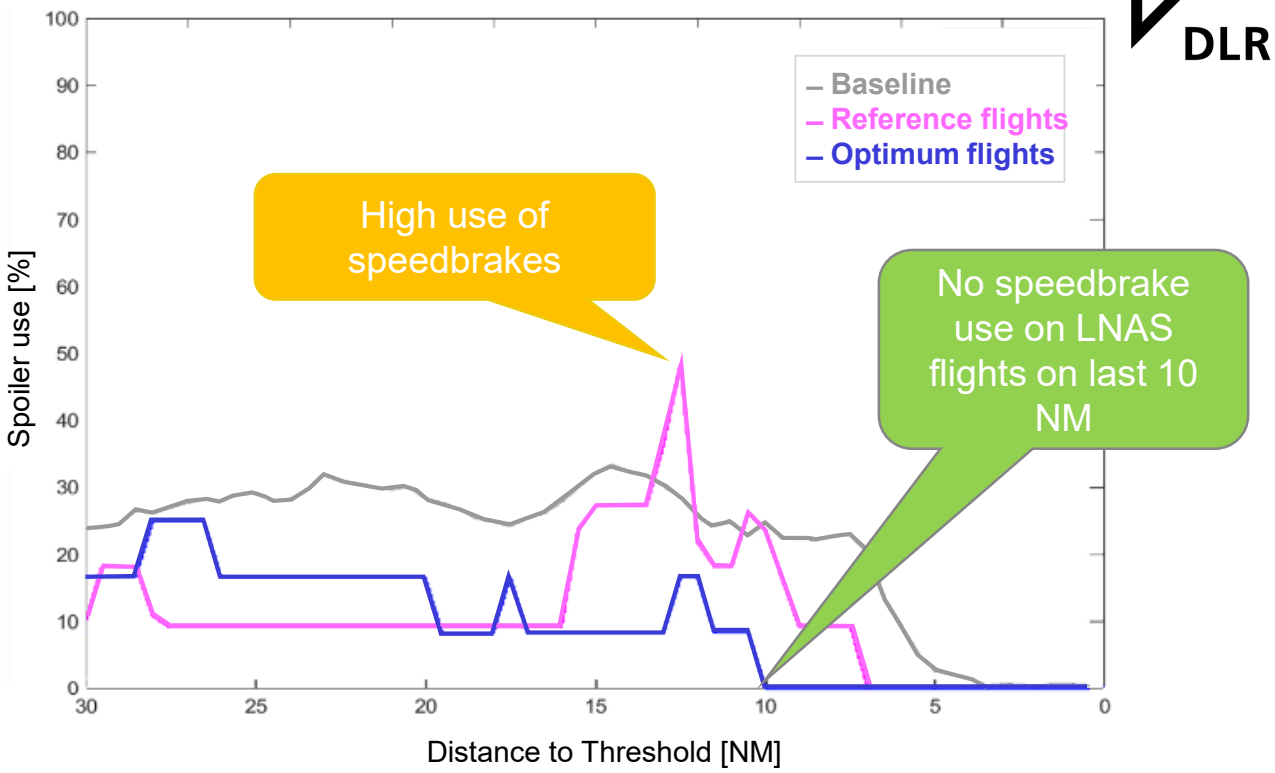
Demonstration Results
Aircraft configuration

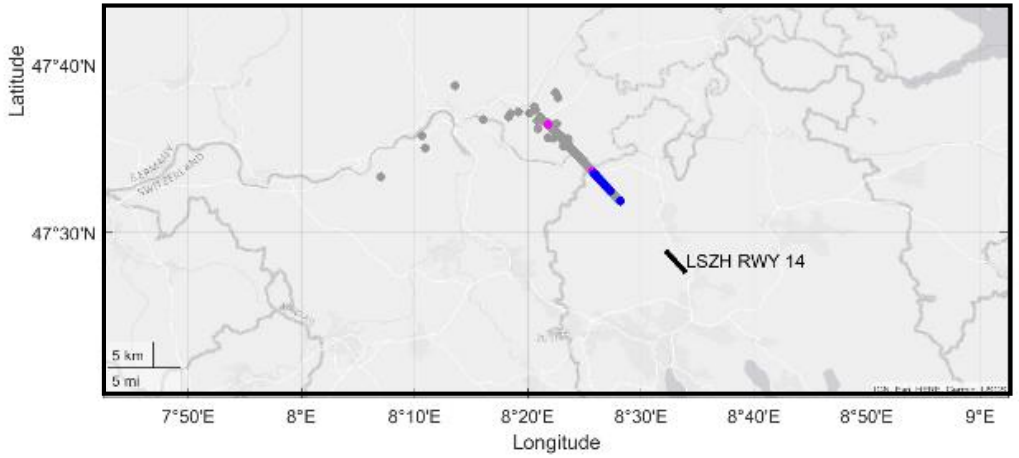
Speedbrakes:

- major contributor for an increase in noise emission when used at lower altitudes and closer to the runway
- **reference flights:** higher tendency to correct flightpath or speed at a range of 15 to 10 NM to the runway
- **LNAS optimized flights:** usage of speedbrakes in an earlier phase of flight to correct high energy cases → positive effects on noise emissions at low altitudes near the airport.



Landing Gear:

- optimal timing of gear extension crucial for both **low noise emission and fuel efficiency**.
- comparable results for reference flights and LNAS flights
- recommendation of gear extension point low hanging fruit.



Credit: DLR

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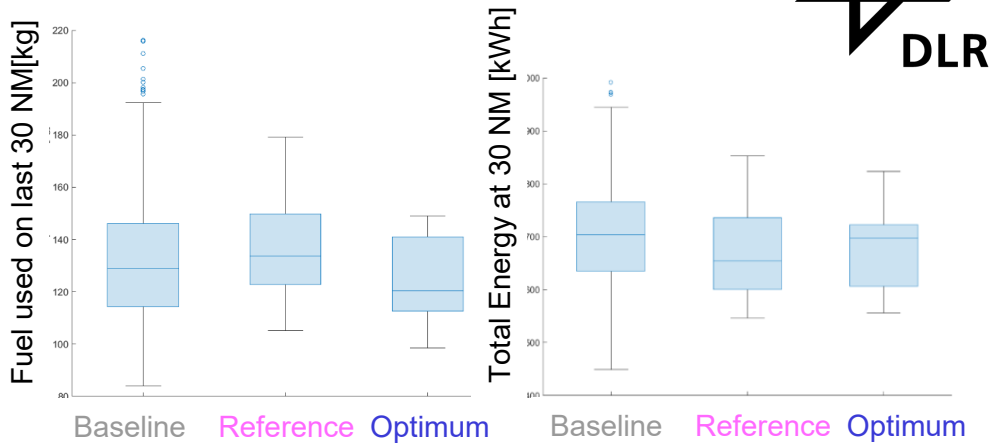
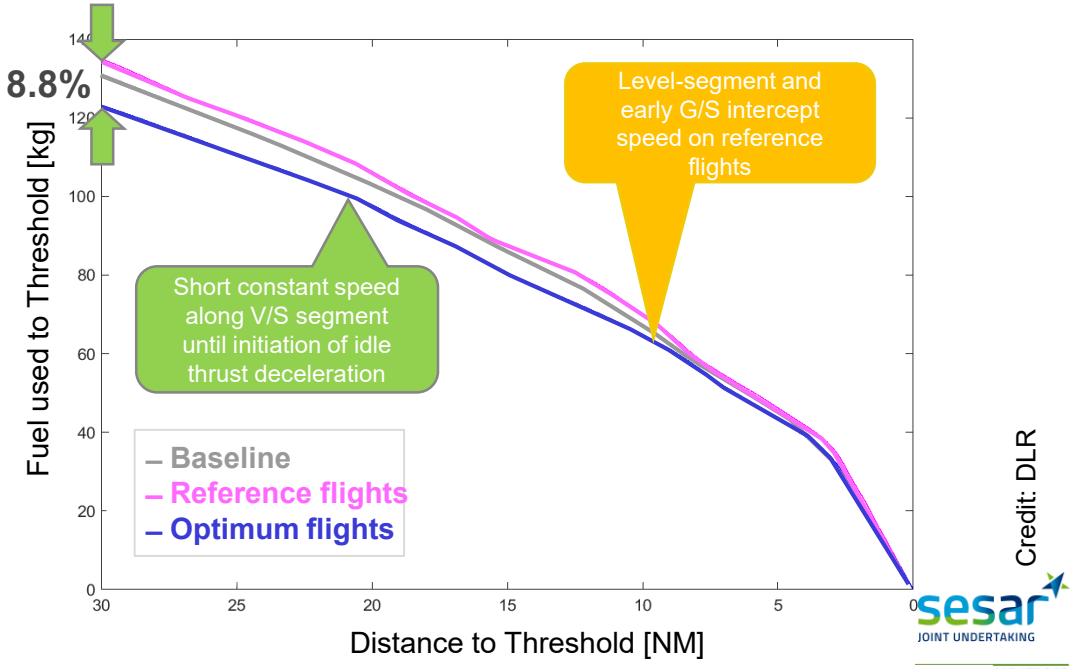
Demonstration Results
Fuel burn

Fuel consumption is computed from the threshold backward

- **8.8% fuel saving** along the PBN-to-ILS trajectory using **LNAS**.
- **manually-controlled** energy management reference flights **more conservative** → **2.9% more fuel** than the **baseline** flights.
- **LNAS optimized flights** along PBN-to-ILS trajectory resulting **6.1% lower fuel burn** than the **baseline** flights.





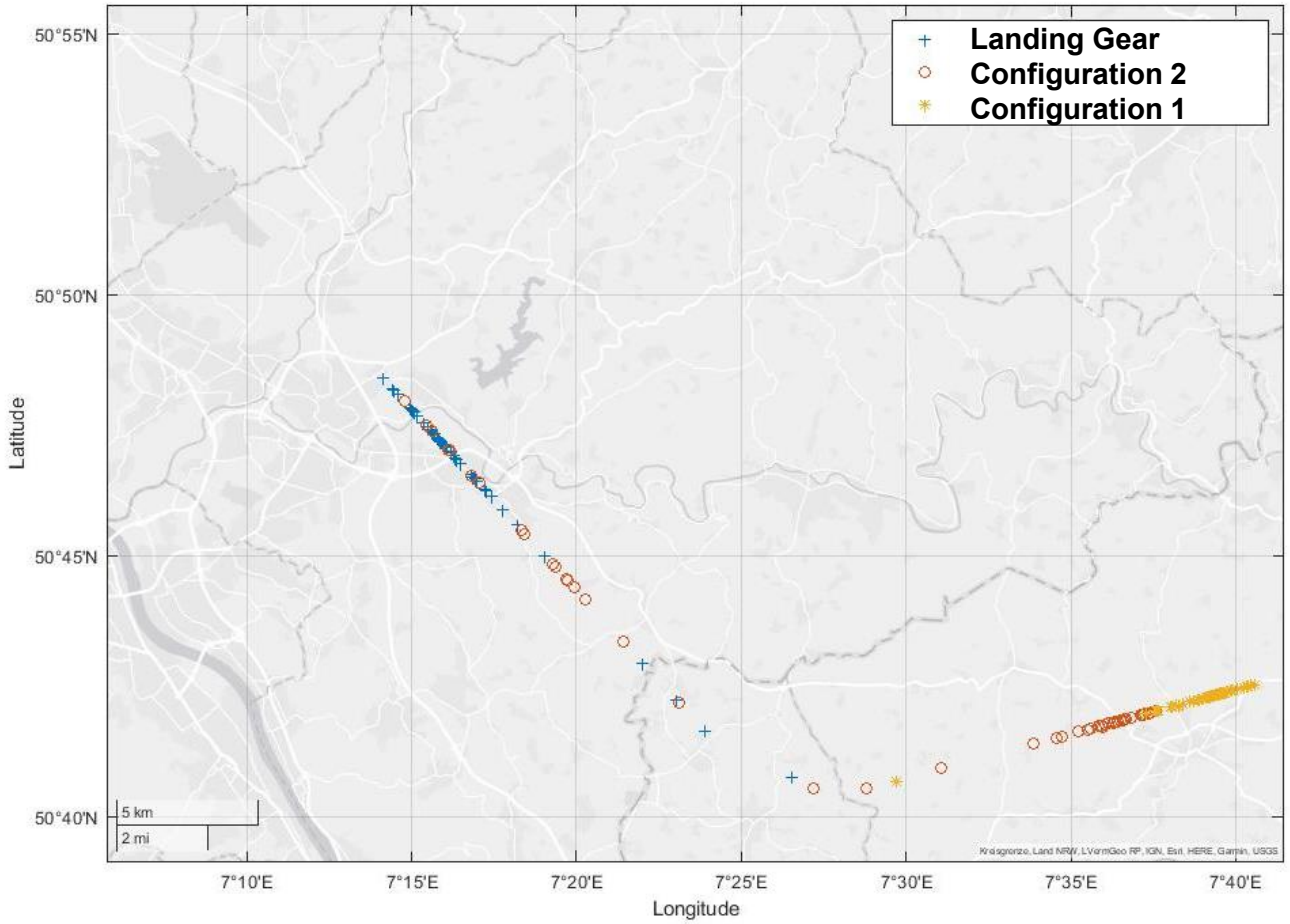
LNAS ACDA / SCDA Demo Cologne / Bonn Airport

- Simulator study at DLR's Air Vehicle Simulator (AVES) in Braunschweig
- Airbus A320 Simulator campaign with focus on approach to EDDK for ACDA experiment (with and without LNAS support)
- Evaluation of system performance with new features:
  - before: energy optimal approach strategy
  - new: accepting G/S intercept from above with flyable trajectories while avoiding speed brakes
  - change from CDA to ACDA when passing CDA TOD without action

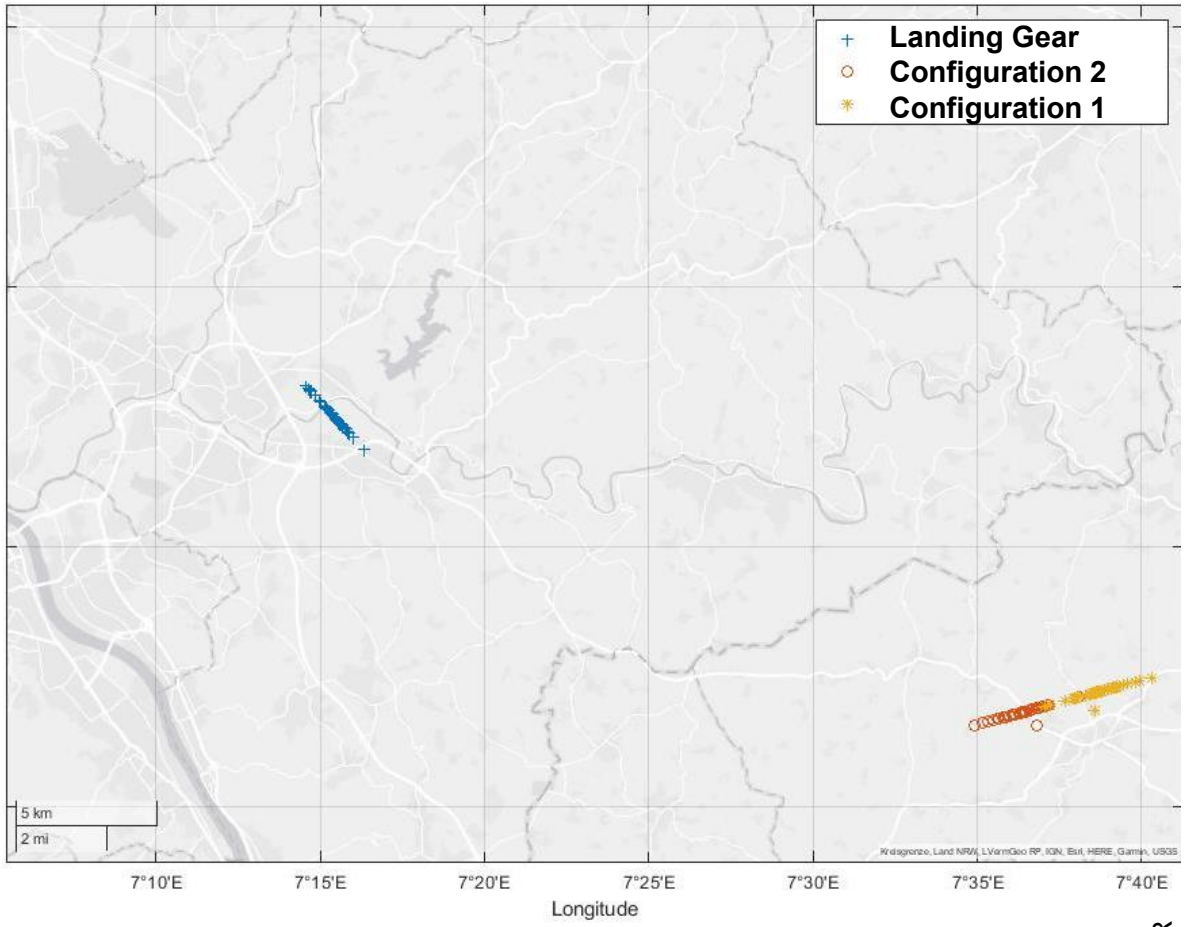
Credit: DLR

LNAS ACDA / SCDA Demo Cologne / Bonn Airport
Aircraft Configuration

ACDA without LNAS (manual optimization)

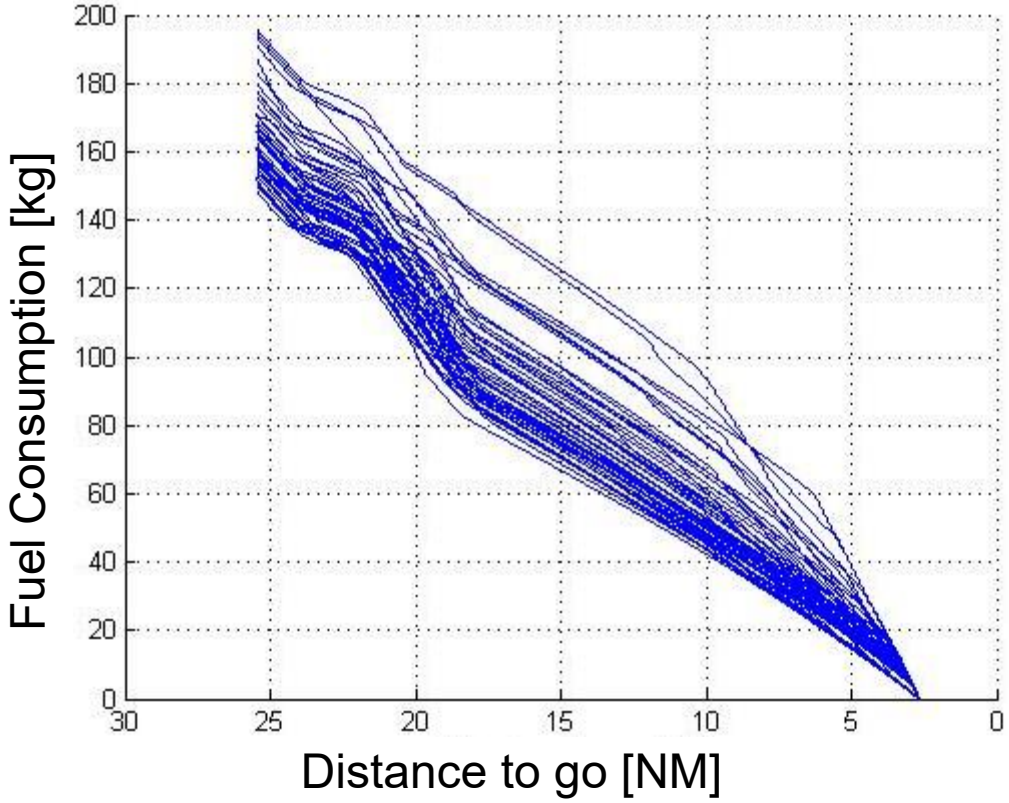


ACDA with LNAS Support

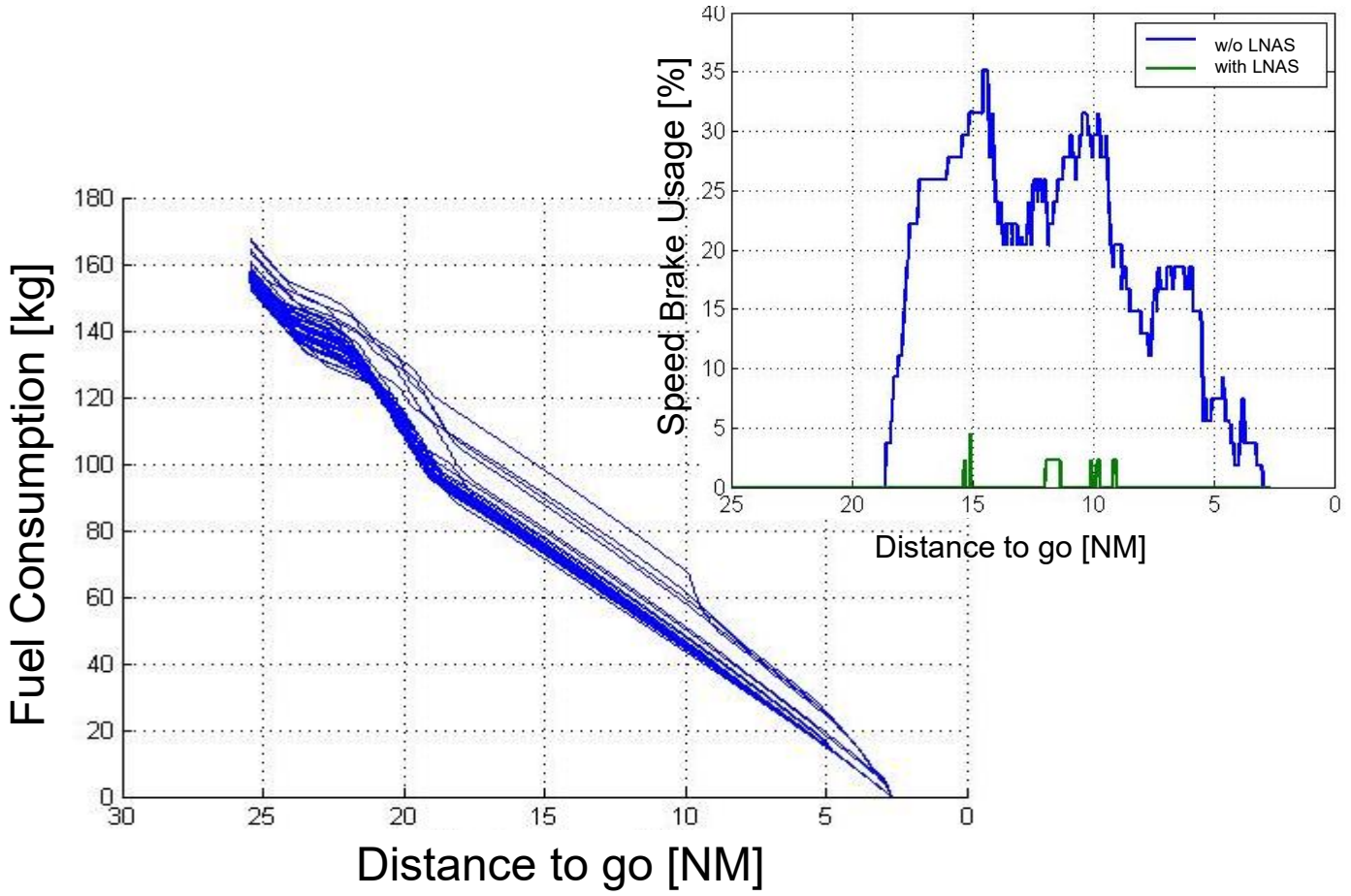


Credit: DLR

LNAS ACDA / SCDA Demo Cologne / Bonn Airport
Fuel Consumption



without LNAS (manual optimization)



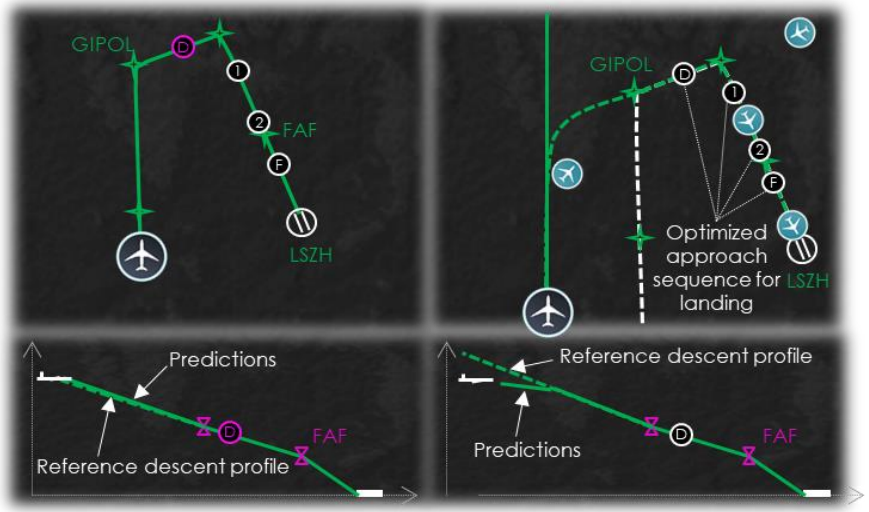
with **LNAS** Support
less variation with visible decrease

Credit: DLR

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No **893568**

Integration of LNAS into Avionics
SESAR 2020 ER4 DYNCAT, 2020 – 2022 (www.DYNCAT.eu)

- Development of an FMS prototype function for dynamic configuration pseudo waypoints and energy management
- Navigation display indication of
  - Distance-to-Go (DTG) or Indicated Time of Arrival (ITA)
  - Permanent Resume Trajectory (PRT) function
    - expected flight trajectory based on controller intent
    - facilitates the energy management, allows fuel savings and improves safe decision-making
- Energy cues for pilot
  → comparable to LNAS display indications



Credit: THALES AVS

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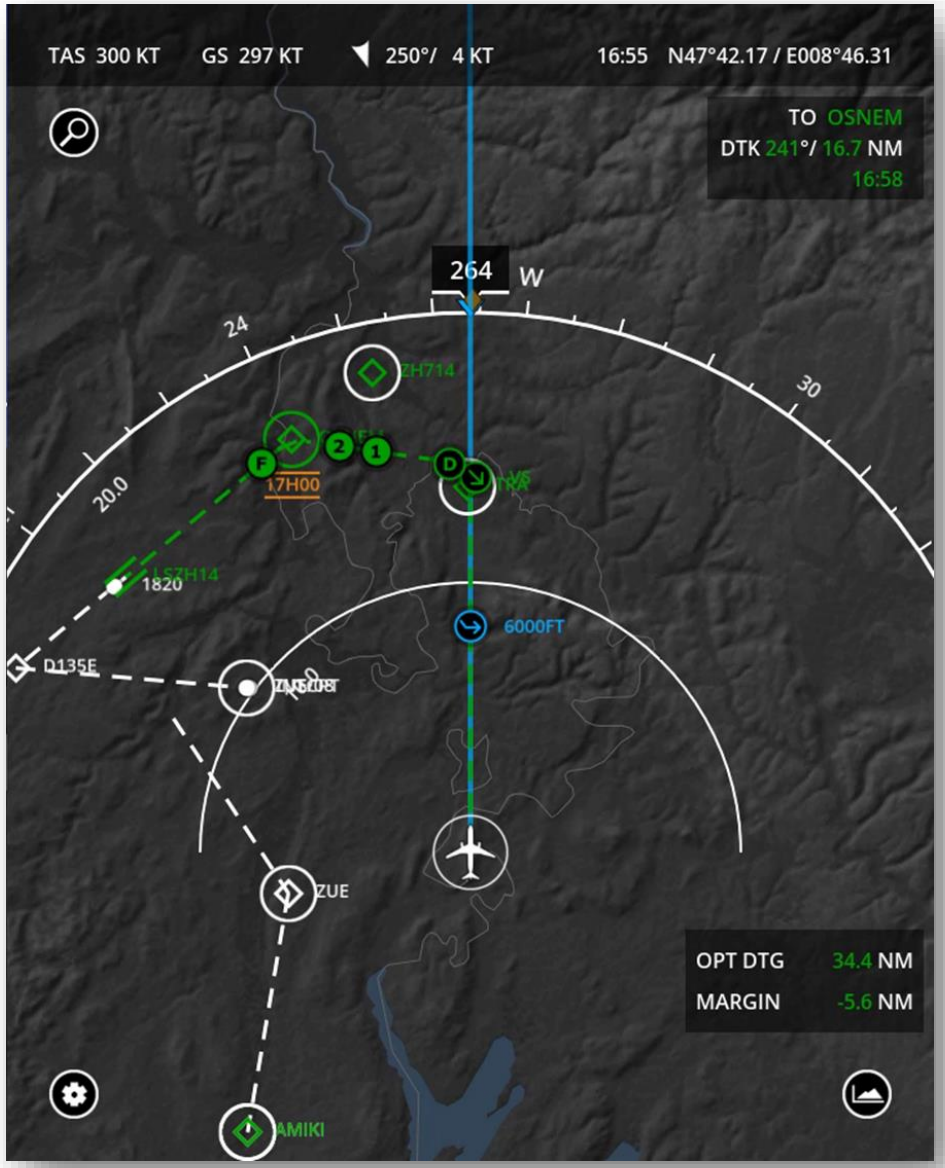
LNAS Concept as Base for DYNCAT's New FMS Function



Credit: DLR / THALES AVS

continuously updated optimal set points

- for <u>energy management</u>
  - descent
  - speed reduction
- for <u>configuration management</u>
  - flaps extension
  - L/G extension

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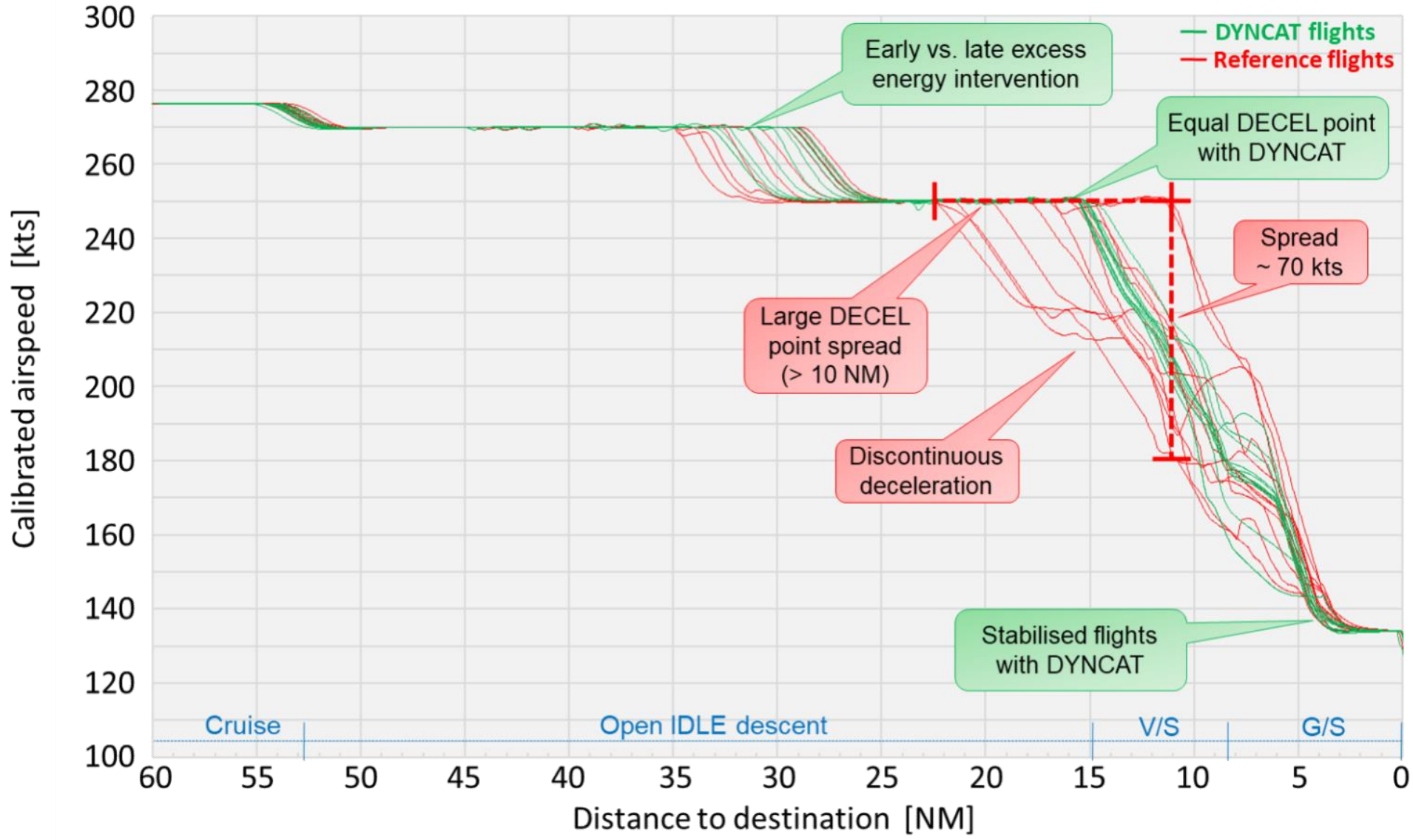
DYNCAT Results
Speed Profiles



Credit: THALES AVS

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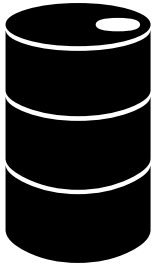
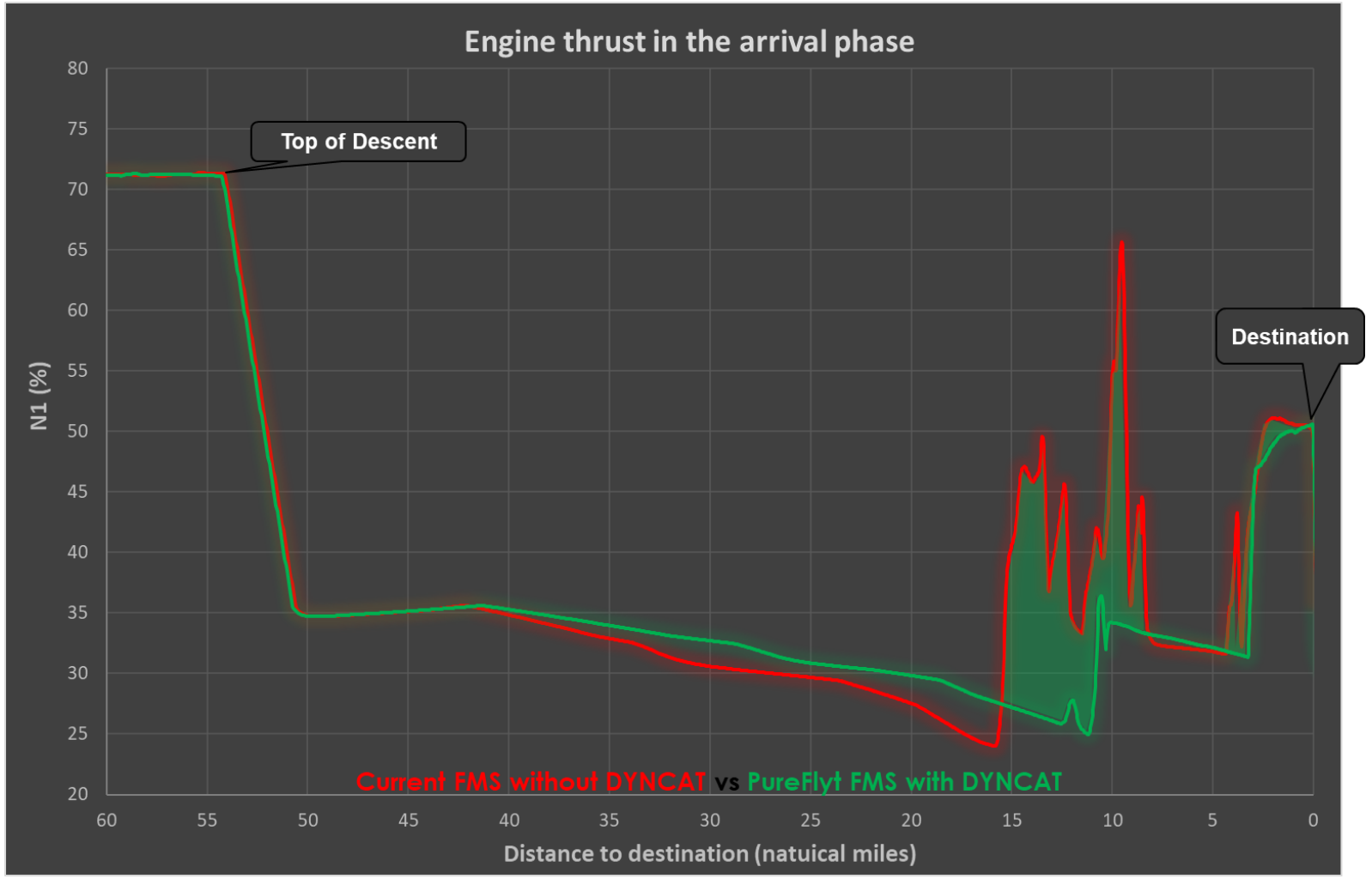
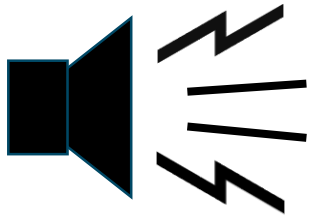
DYNCAT Results
Averaged Engine Usage







Credit: THALES AVS

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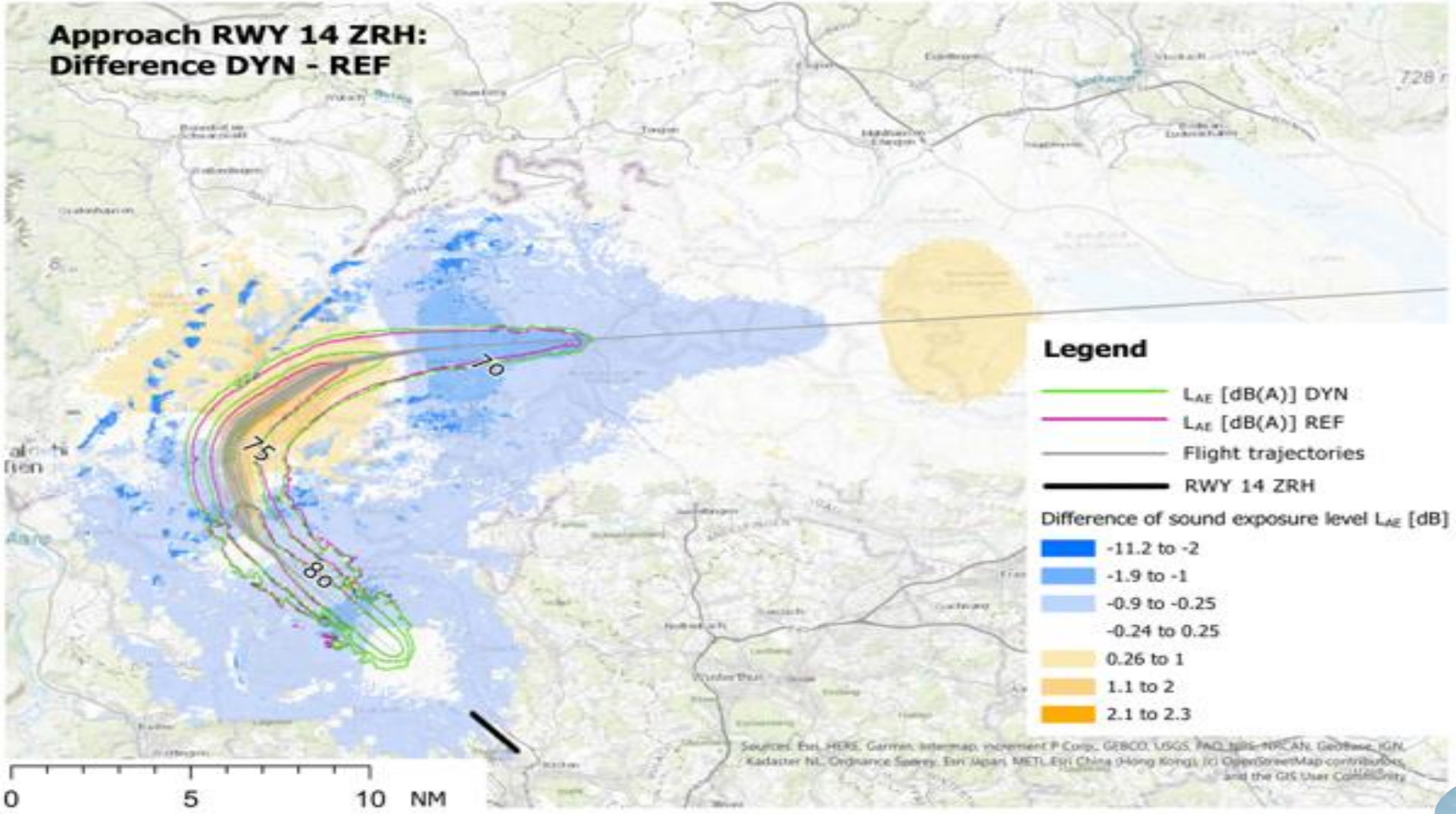
DYNCAT Results
Noise Footprint

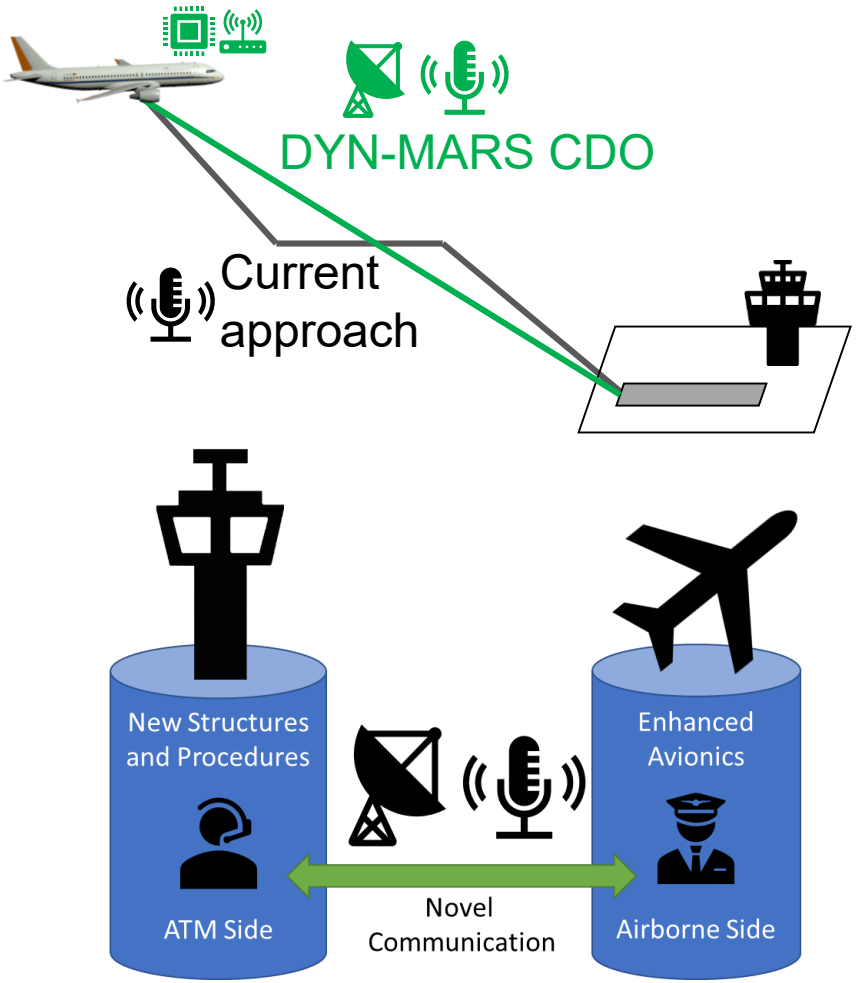


Credit: EMPA

HORIZON-SESAR-2022 DYN-MARS

Dynamic Management Of Aircraft Configuration And Route Structures

- **DYNCAT** follow-up project, start **Sep. 2023** (36M)
- **8 European partners**, total budget **7.3M€**
- <u>Goal</u>: **environmentally friendly TMA operations through combined dynamic management of aircraft (DYNCAT) and route structure**
- **OBJ1:** dynamic optimization of descent trajectory to significantly **enhance the efficiency of the descent and approach phase per aircraft**.
- **OBJ2**: Dynamically adjusted Performance Based Navigation (PBN) route structures to **optimize network flight efficiency and improve environmental performance**
- **OBJ3:** evaluation of impact of FMS-defined arrivals to the ATM operation



Credit: DLR

Disclaimer

Topic:	**Leiser Fliegen durch Energieoptimale Flugbahnen mit dem DLR Low Noise Augmentation System (LNAS)**
Date:	May 23rd, 2023
Series:	DGLR L6 Workshop, Manching, Germany
Authors:	Dr. Christoph Deiler (christoph.deiler@dlr.de)
	Dr. Fethi Abdelmoula (fethi.abdelmoula@dlr.de)
	Falk Sachs (falk.sachs@dlr.de)
Institute:	Institute of Flight Systems, Braunschweig

THANKS FOR YOUR ATTENTION !