INTRODUCTION TO AIRCRAFT NOISE ACTIVITIES AT ICAO CAEP WITH ONGOING AND FUTURE CONTRIBUTIONS FROM DLR

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Goethe-Universität, Frankfurt

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DLR

content

- **part 1: ICAO & CAEP**
  - ICAO
  - CAEP
    - aircraft noise activities
    - DLR contribution
- **part 2: DLR aircraft noise simulation**
  - multi-level simulation approach
  - single event noise prediction
  - application example: contribution to dual stringency discussion
- **summary & conclusion**

- ***appendix:*** *ICAO nominated technical experts from DLR*

International Civil Aviation Organization (ICAO)

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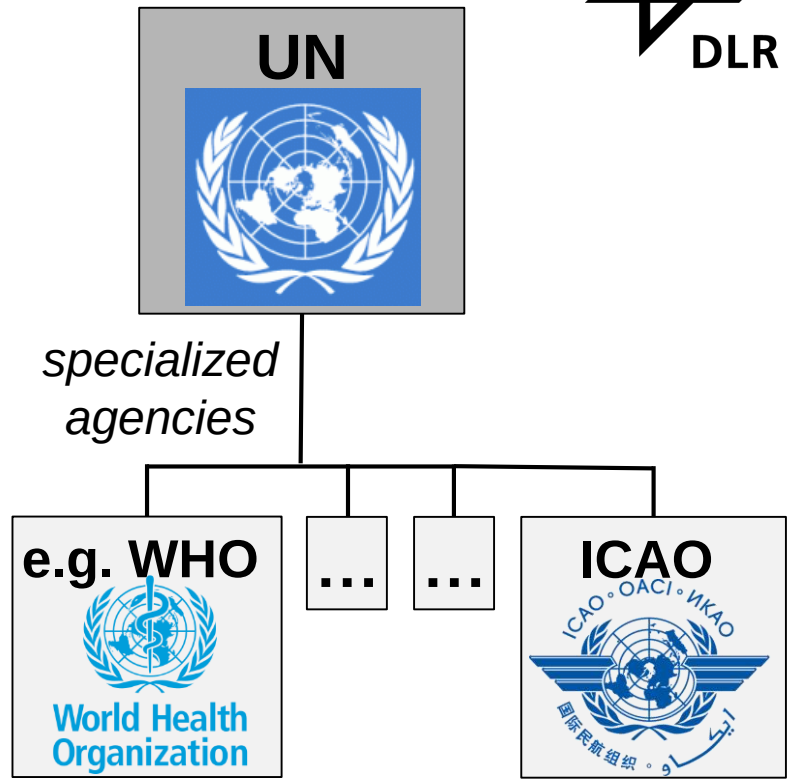
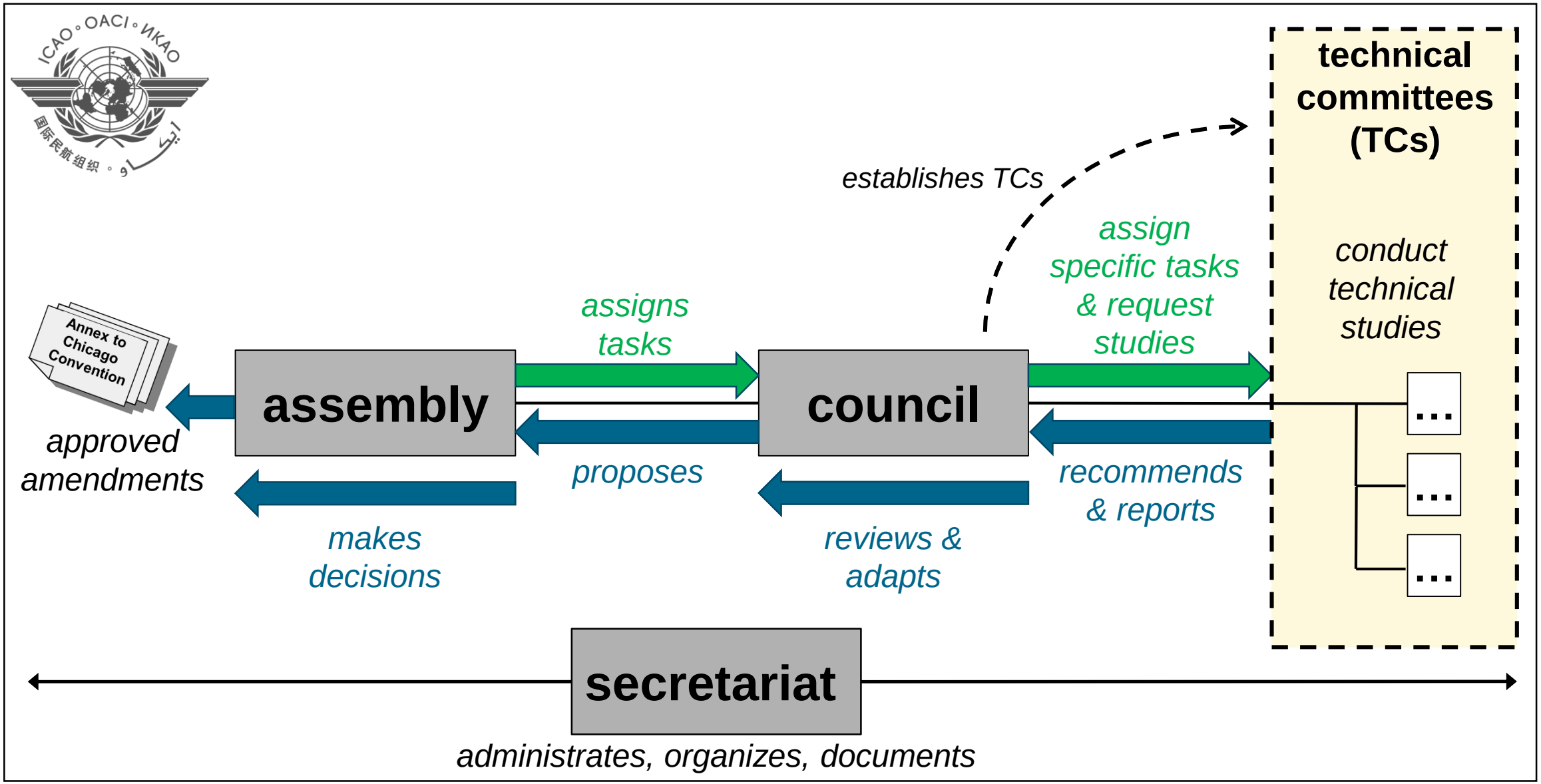
- United Nations Organziation runs specialized agencies



- specialized agency: **ICAO** (est. 1944)
  - member states: 193 national governments
  - supports diplomacy and cooperation in the context of international air transport (based on "**Chicago Convention**")
    - promotes safe & orderly global air transport
    - establishes & maintains regulations and goals: Standards and Recommended Practices (SARPs)
  - **important**: proposals/amendments require approval/ratification by each member state ⚠
- ICAO is comprised of **assembly**, **council**, and **secretariat**
  - **assembly** (all member states): review & overview of all ICAO tasks (also budget); resolutions give direction to council & sets priorities for ICAO; ultimately approves & incorporates amendments to "Chicago Convention"; meets all three years
  - **council** (assembly elects 36 member states: limited to politicians): proposes, maintains, and adopts SARPs; coordinates technical work
  - **secretariat**: administration / documentation / organization (e.g., meetings)

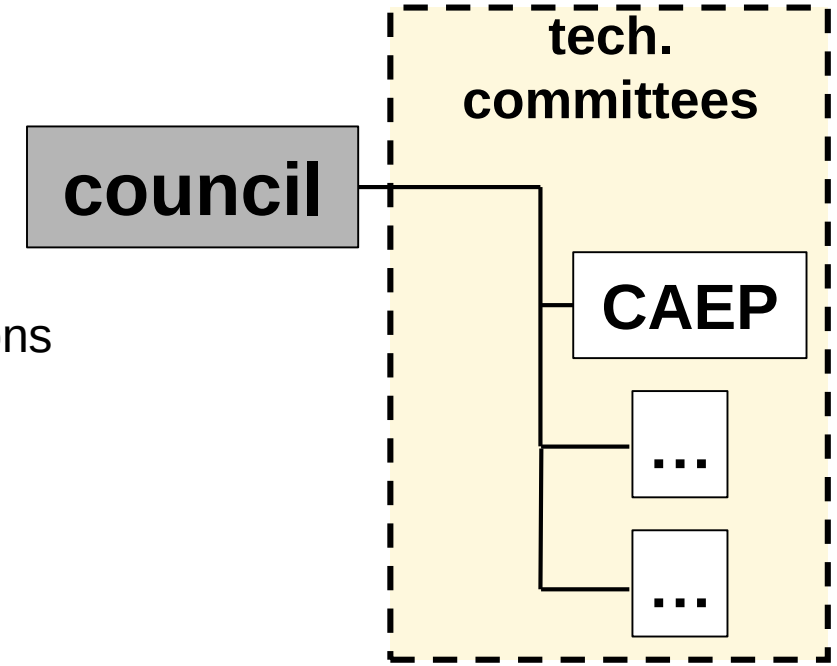
ICAO

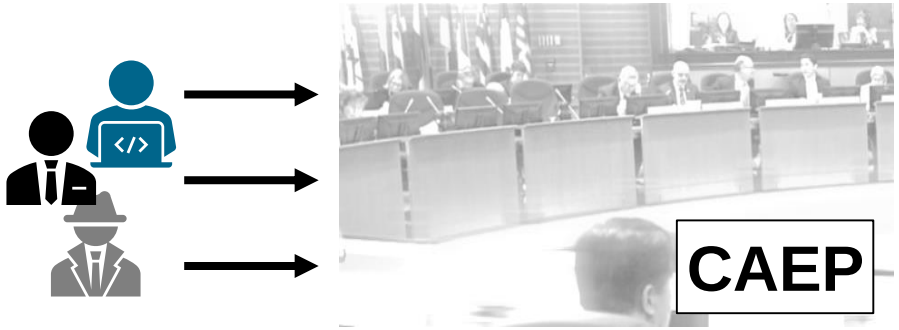
- organization and workflow (*tasks)*:



Committee on Aviation Environmental Protection (CAEP)

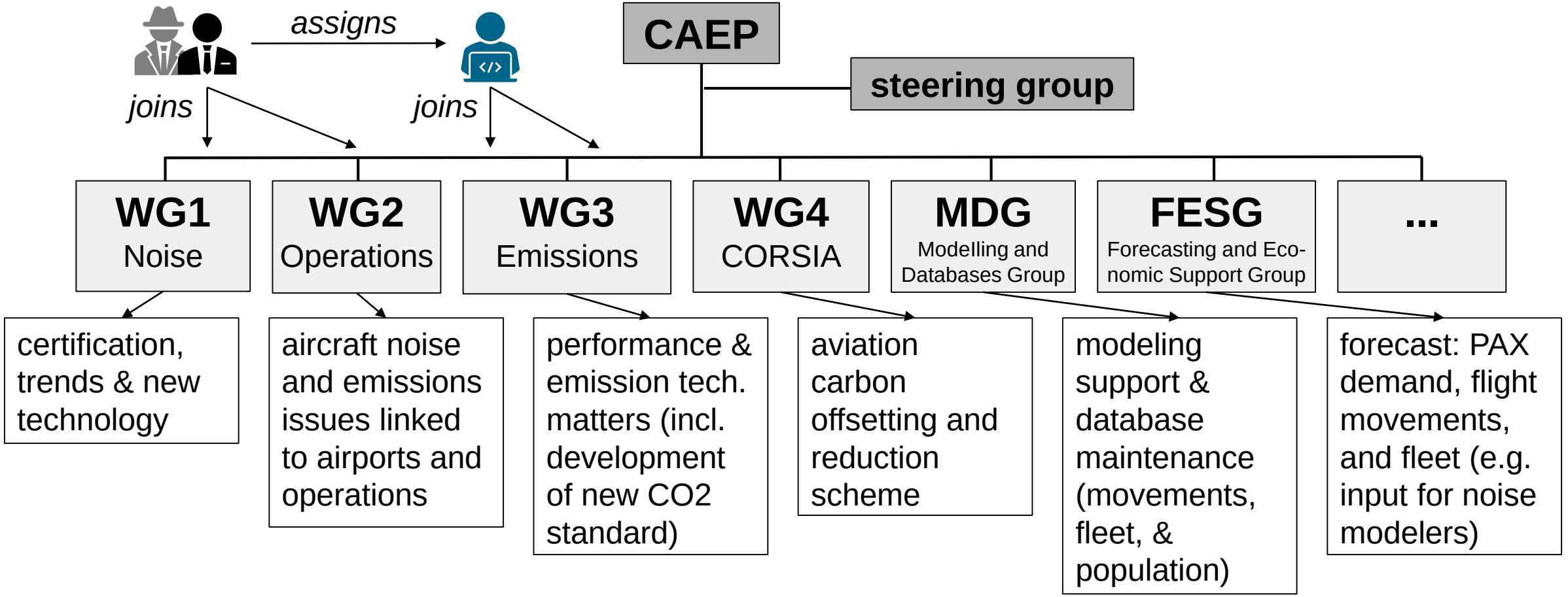
- CAEP to address environmental ICAO goals (since 1983)
  - limit or reduce climate change and aviation emissions
  - limit or reduce adverse impact on local air quality
  - limit or reduce aircraft noise
- specific tasks:
  - conduct studies, formulate new policies & report recommendations
  - comprehensive assessment: from local / airport to global level
- table of measures:
  - aircraft technology
  - operational improvement
  - sustainable aviation fuels
  - market-based measures (CORSIA)
- approx. 600 participants in CAEP (year 2021)
  - 31 **members** w. nominated **technical experts** (not limited)
  - 21 **observers** (6 states and 15 organizations) & **invited organizations** (e.g. industry groups)





CAEP

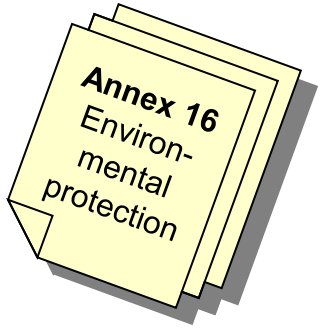
- organization of CAEP in groups (dedicated to specific disciplines and topics)
- members / observers join group(s); technical experts are assigned to group(s)
- coordinated by steering group (SG)
  - collects/reviews reports & approves recommendations (convenes once per year)



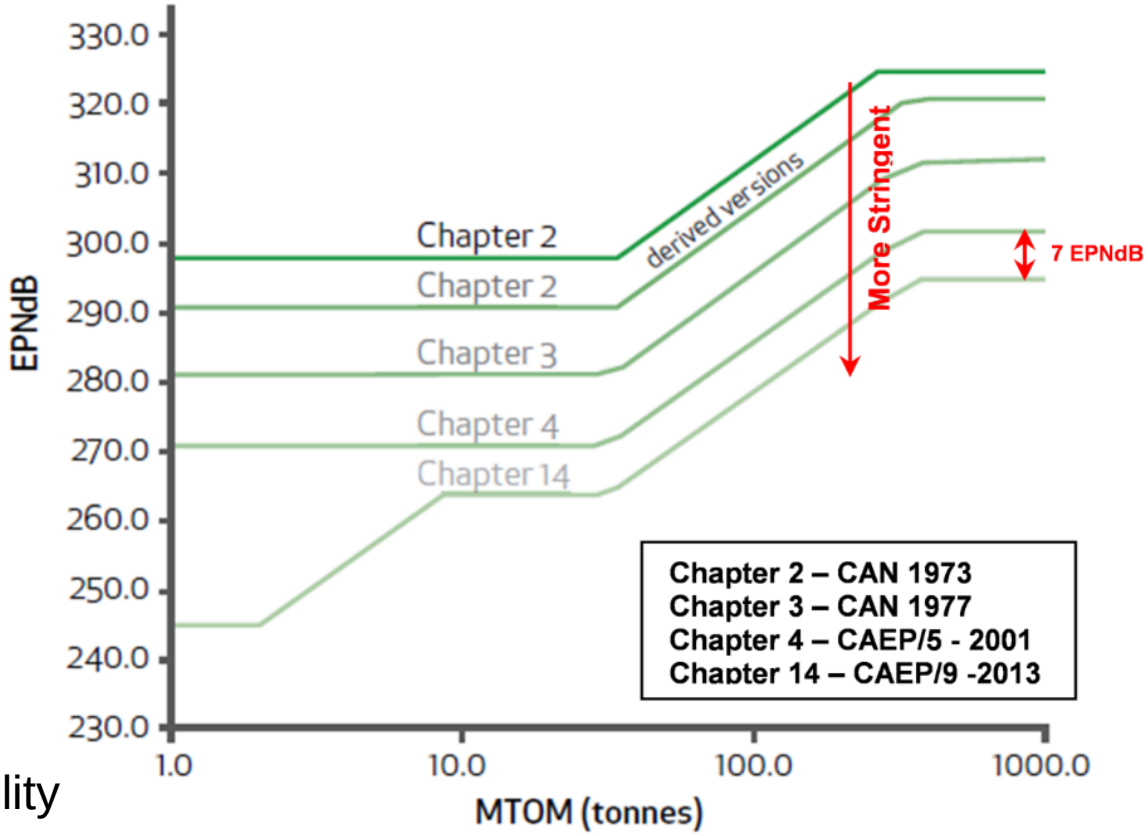
CAEP: a/c noise activities

© Reference: Committee on Aviation Environmental Protection (CAEP) (icao.int)

- today's focus: **aircraft noise activities of CAEP**
- major achievements:



e.g. regulations for aircraft noise certification (Annex 16, Volume I)

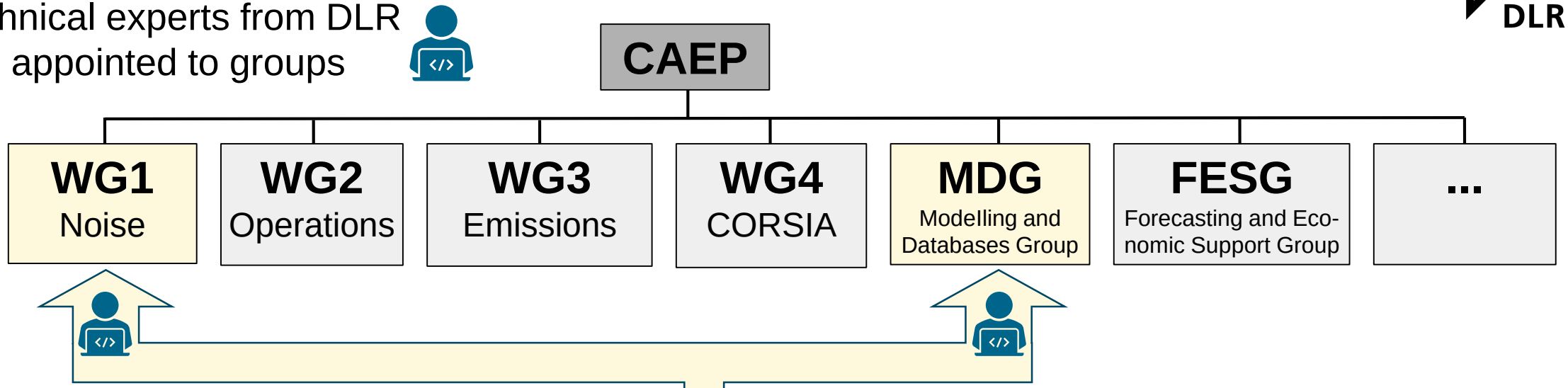


- current CAEP activities:
  - 1 - aircraft noise modeling
  - 2 - noise trends and technology goals
  - 3 - community engagement
  - 4 - new aircraft concepts, e.g. advanced air mobility and drones
  - 5 - supersonic transport (SST) aircraft noise standards development

- *maintenance of public available ICAO Noise Data Bank (NoiseDB)*
- *documentation of results / findings: ICAO Environmental Reports*

CAEP: DLR contribution to a/c noise activities

- technical experts from DLR are appointed to groups



- current CAEP activities:
  - 1 - aircraft noise modeling (**WG1**, **MDG**)
  - 2 - noise trends & technology goals (**MDG**, **FESG**)
  - 3 - community engagement (**WG1**)
  - 4 - new aircraft concepts, e.g. advanced air mobility and drones (**WG1**, **MDG**)
  - 5 - supersonic transport (SST) aircraft noise standards development (**WG1**, **MDG**)

- DLR expertise / contribution:
  - **1 - overall a/c noise simulation**
  - 2 - technology development, traffic forecast, scenario techn. introduction
  - 3 - noise impact research (e.g. auralization)
  - 4 - measurements & simulation (especially: engine installation effects)
  - 5 - SST: a/c design, LTO noise and sonic boom

content

- part 1: ICAO & CAEP
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- **part 2: DLR aircraft noise simulation**
  - multi-level simulation approach
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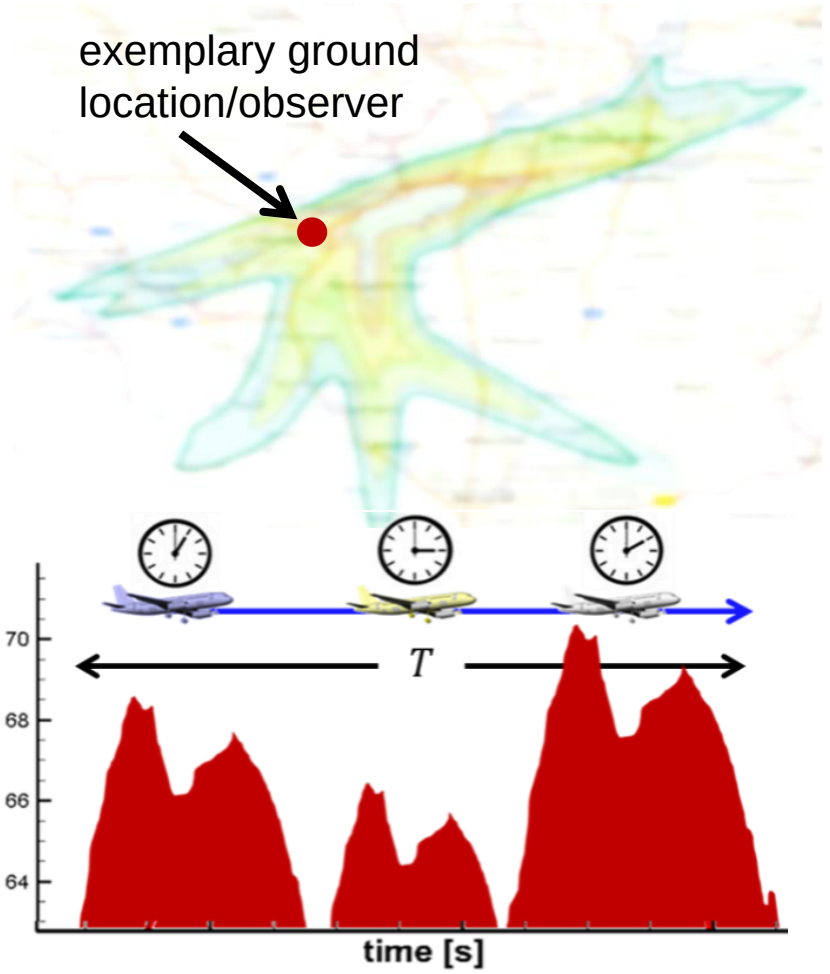
- ***appendix:*** *ICAO nominated technical experts from DLR*

DLR aircraft noise simulation

- requirement: full assessment of **ICAO balanced approach**

$$L_{DEN} = 10 \cdot log10\left(\frac{1}{T}\sum_{i=1}^{N} g_i \cdot 10^{SEL_i/10}\right)$$

- reduce number of flyover events
- traffic routing (distribution) / land development
- avoid/reduce flights during „sensitive“ times
- night flight curfew
- modify noise source (retrofit or new design)
- tailor and adapt flight procedures

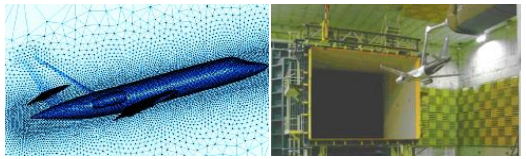


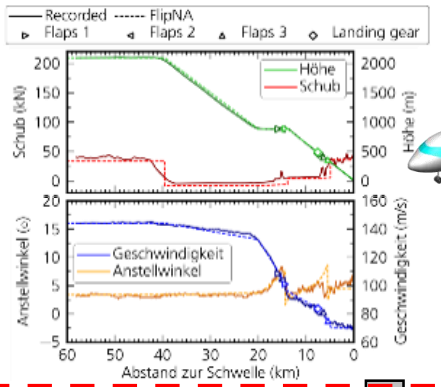
Time dependent weighting g_i

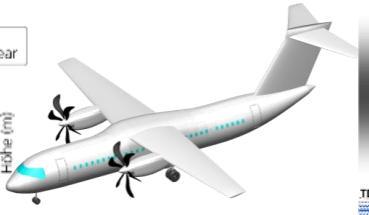
0600-0700	0700-1900	1900-2200	2200-0600
10	1	1	10

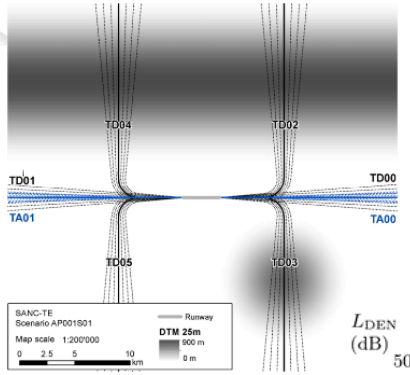
DLR aircraft noise simulation

- ICAO balanced approach captured by **multi-level simulation**

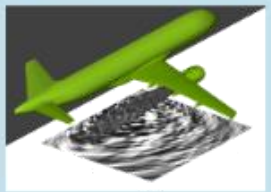






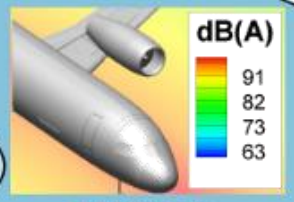


Level 1
Component Level



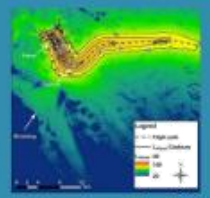
TAU, PIANO*

Level 2
Single Aircraft



PANAM

Level 3
System Scenario

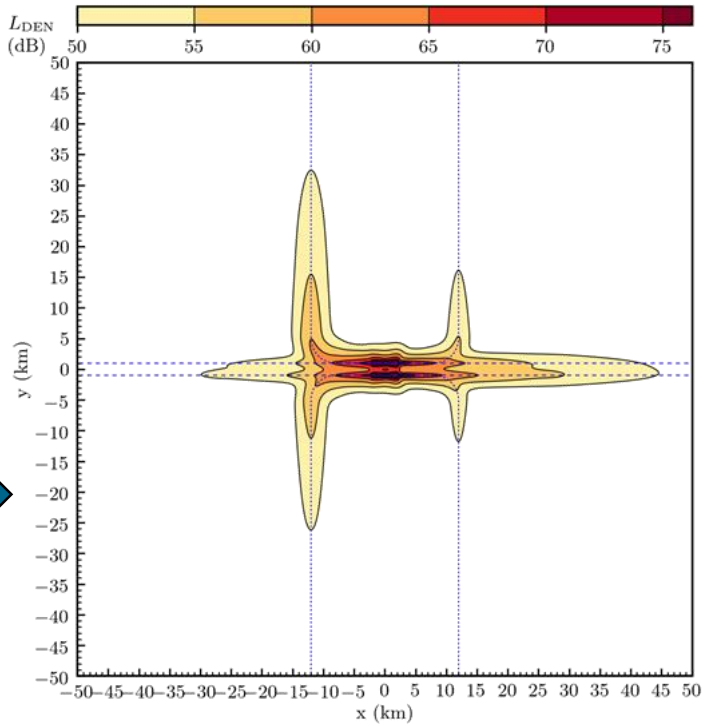


sonAIR*

Sound radiation patterns for separated aircraft components

Noise footprints on the ground for single aircraft of different types

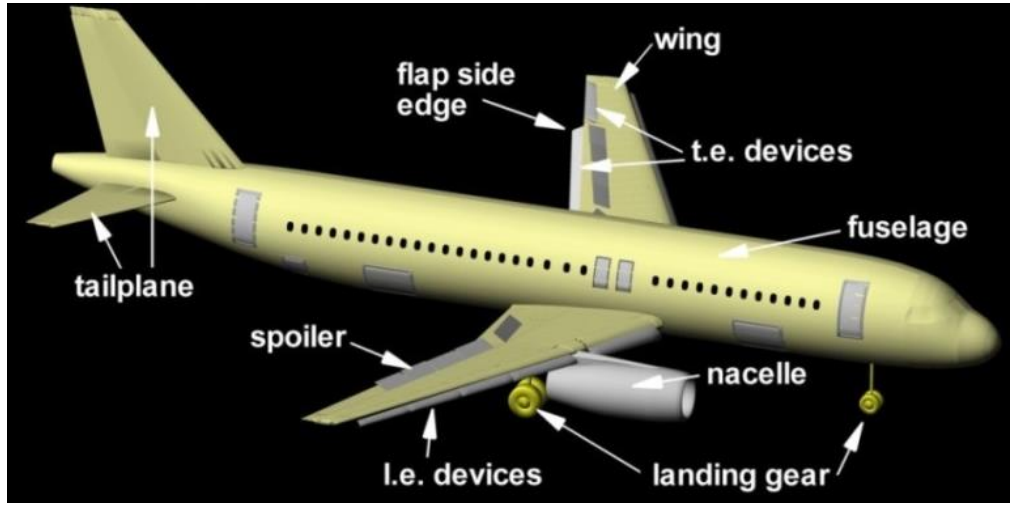
essential capability: connect levels 1 to 3

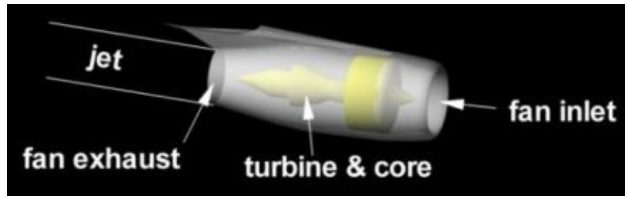


*) exemplary tools

DLR aircraft noise simulation

- essential simulation capability: **connect level 1 - 3**
  - predict overall a/c noise (immission is relevant!)
  - capture different a/c, engines, flight procedures, and technology upgrades (ICAO Balanced Approach)
- DLR tool PANAM
  - **componential** (source by source)
    - captures relevant sources & effects
    - (semi-) empirical and analytical methods
  - **parametric**: geometry & operation
  - simulation output:
    - detailed emission assessment (component level)
    - detailed immission assessment (component and aircraft level):
      - single observers and large arrays
      - common noise descriptors ($L_{A,max}$, $SEL, EPNL$ …)



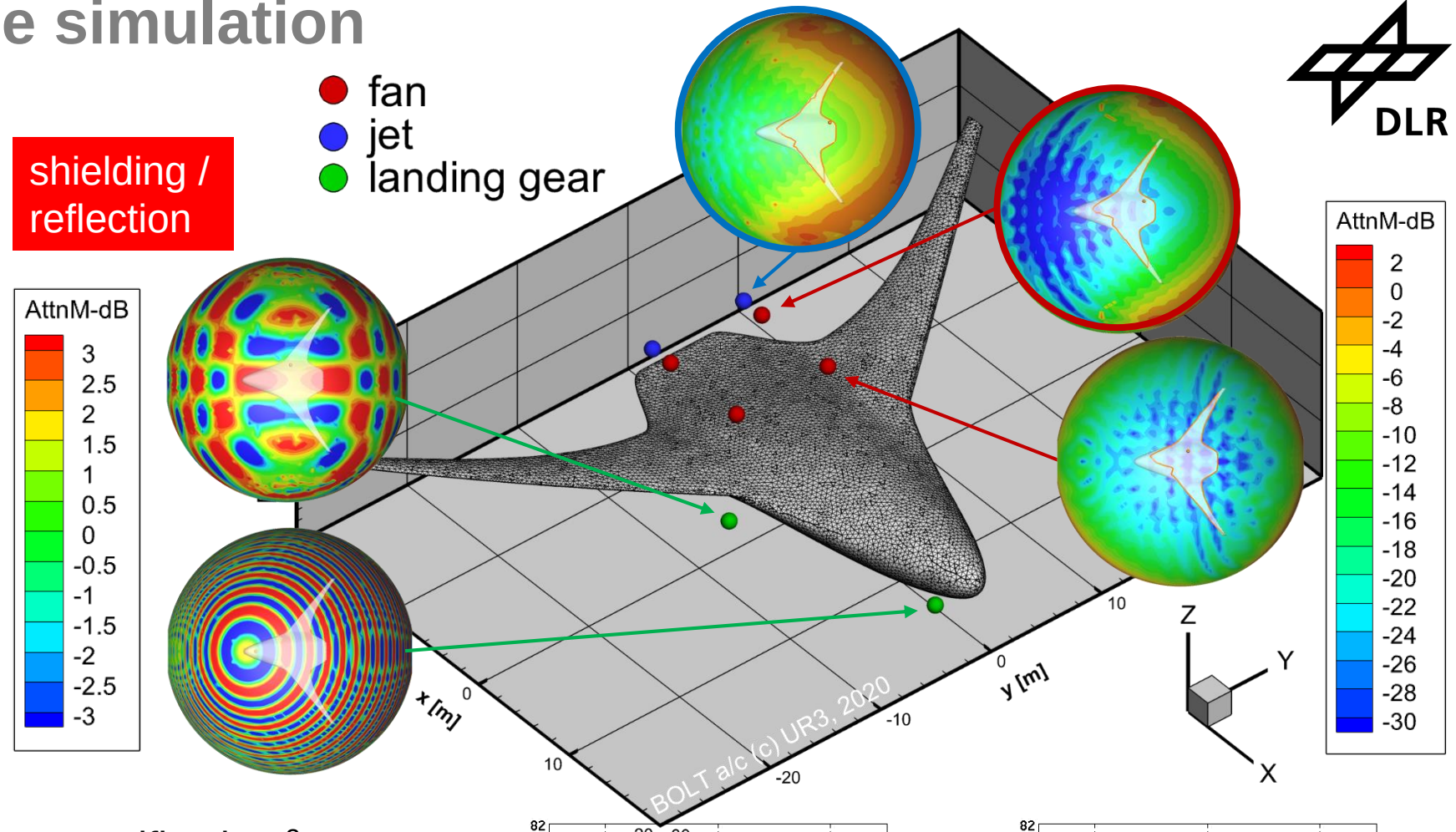


DLR aircraft noise simulation

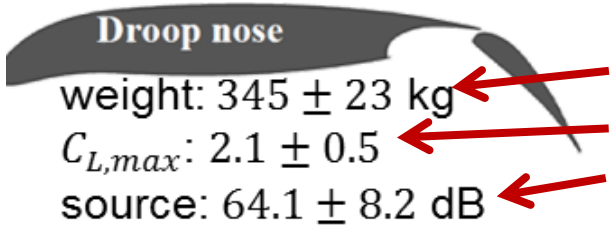
- additional essential features:
  - **mixed-fidelity**: input from experiment or numerical high-fidelity assessment [1]

shielding / reflection

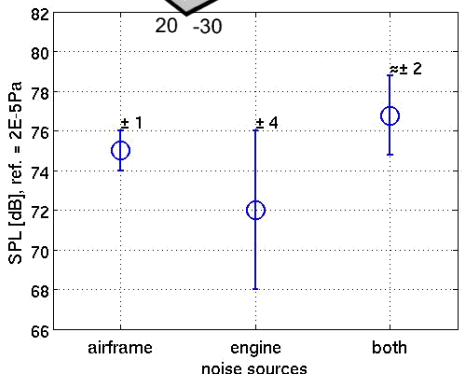
fan
jet
landing gear

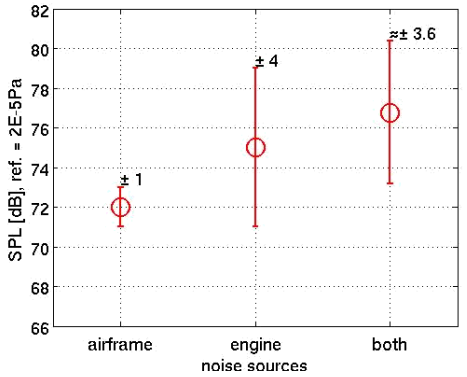


- simulation **uncertainty** quantification [2]



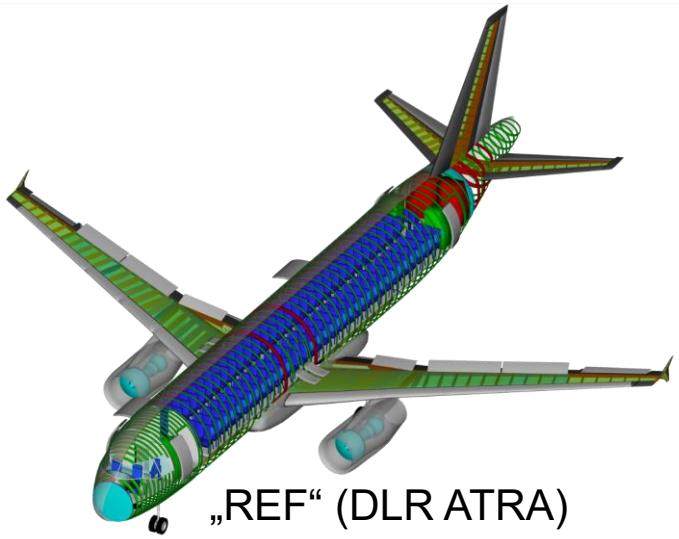
experiment
HiFi simulation
best guess



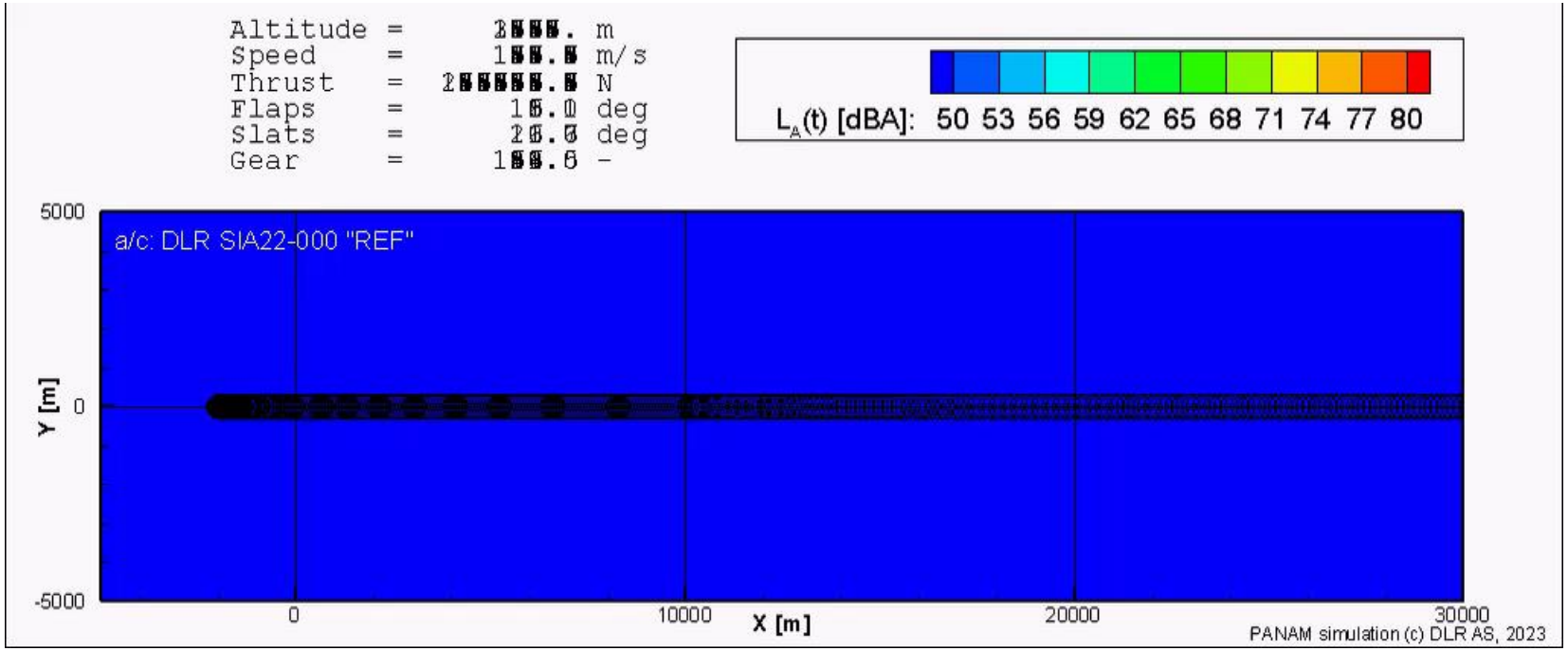


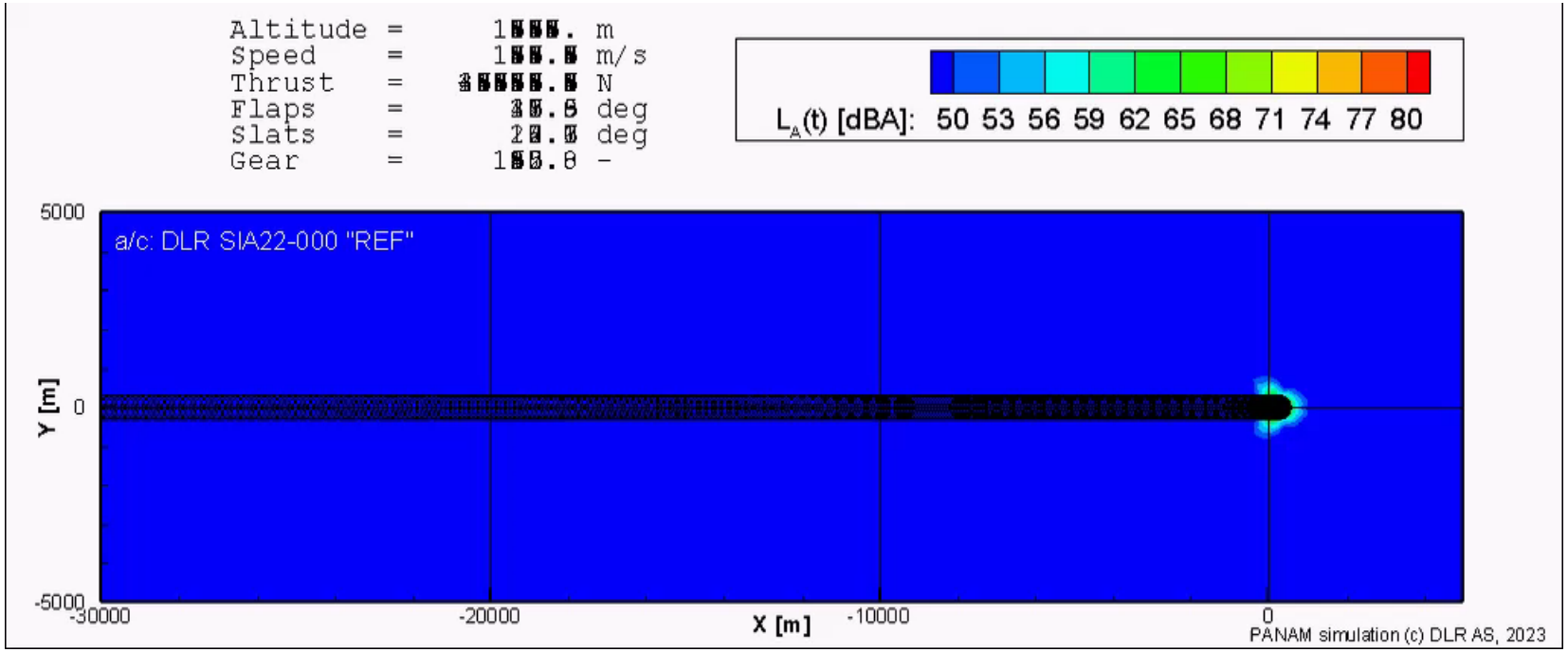
DLR aircraft noise simulation

- output of componential & parametric simulation



„REF“ (DLR ATRA)



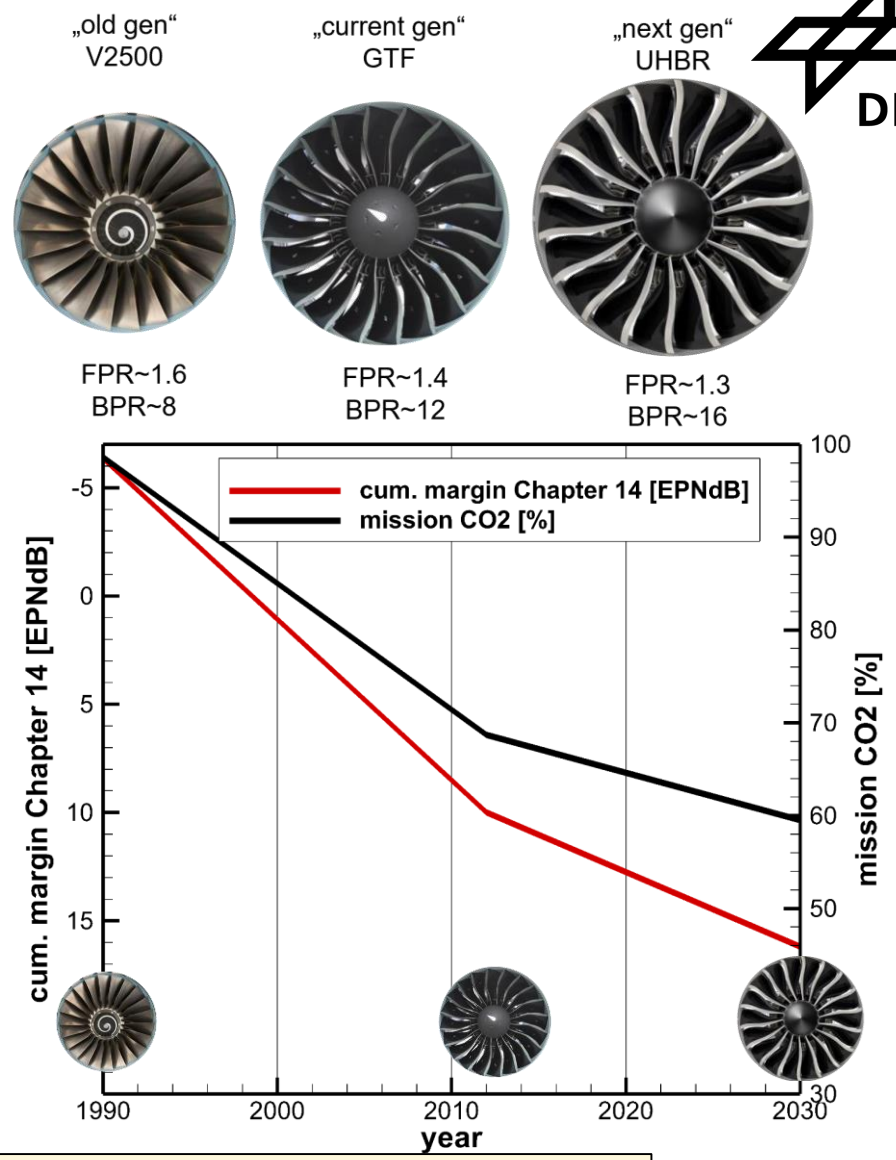


DLR aircraft noise simulation

- application: toward an **integrated CO_2 / noise stringency**
  - impact of ultra-high-bypass-ratio engine (CO_2 and noise)
  - technology may reach TRL8 between 2025 and 2030
  - CO_2: input from high-fidelity simulation (DLR tool GasTurb)

eng	app	flyover	sideline	cum.	margin ch. 14	sideline	cert. chapter
„old gen“	97.8	88.5	93.3	279.6	-7.1	2700 m	4
„current gen“	91.0	81.7	89.9	262.5	10.0	2600 m	14
„next gen“	90.2	78.4	87.7	256.3	16.2	2600 m	14

eng	3000 km mission		LTO	
	fuel [kg]	CO2 [kg]	fuel [kg]	CO2 [kg]
„old gen“	9206	29065	1032	3262
„current gen“	7354	23217	710	2243
„next gen“	6361	20083	614	1940



- additional noise reduction possible (other DLR presentations)
  - **airframe** (M. Fischer) / **engine** (L. Enghardt) / **novel aircraft** (R. Schmidt & M. Fischer)

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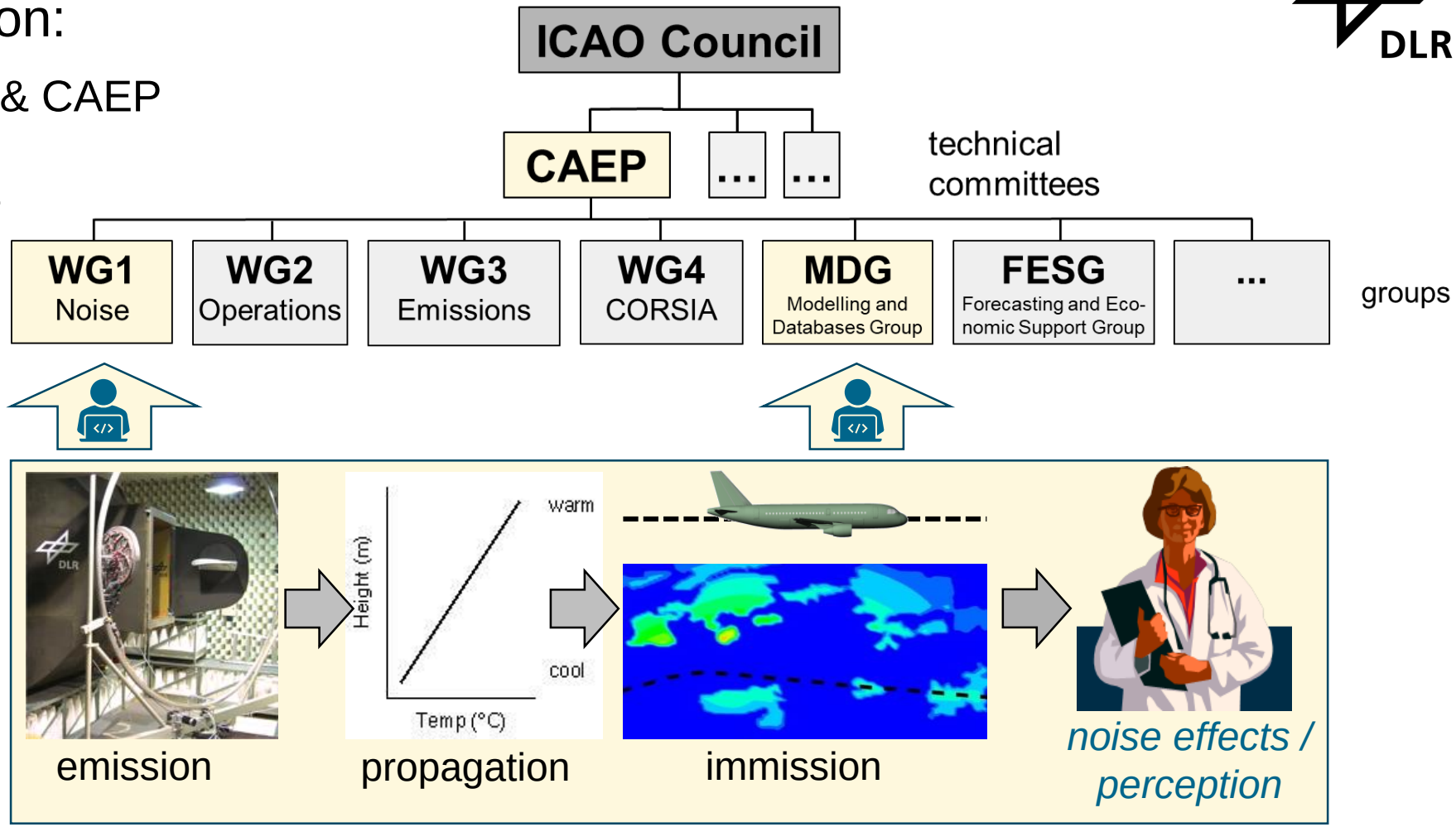
summary & conclusion

- goals of presentation:
  - introduction ICAO & CAEP
  - highlight of aircraft noise activities in CAEP
  - overview of DLR a/c noise envolvement: **comprehensive assessment capability**
  - detailed presentation of single event aircraft noise prediction as **essential capability** (**links** components to overall immission / scenario)



Questions?

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Institute of Aerodynamics and Flow Technology, DLR Göttingen

appendix
nominated technical experts from DLR (CAEP/13)

name	DLR institute	expertise	group
Berghof, Ralf *	Air Transport and Airport Research, Köln	traffic forecast, scenarios	MDG, FESG
Bertsch, Lothar	Aerodynamics and Flow Technology, Göttingen	acoustics (overall a/c), SST (LTO)	MDG, WG 1
Delfs, Jan	Aerodyn. and Flow Technology, Braunschweig	acoustics (airframe, installation)	WG 1
Gelhausen, Marc *	Air Transport and Airport Research, Köln	traffic forecast, scenarios	FESG
Grewe, Volker	Atmospheric Physics, Oberpfaffenhofen	climate effects	ISG
Jaron, Robert	Propulsion Technology, Berlin	acoustics (engine), SST (LTO)	WG 1
Kirz, Jochen	Aerodyn. and Flow Technology, Braunschweig	SST (design, boom)	WG 1
Liebhardt, Bernd	Air Transportation Systems, Hamburg	flight performance, CO2 emissions	WG 3
Linke, Florian	Air Transportation Systems, Hamburg	air transport, flight operations	LTAG
Plohr, Martin *	Propulsion Technology, Köln	engine, CO2 emissions	WG 3
Wicke, Kai	Maintenance, Repair, and Overhaul, Hamburg	product lifecycle management	MDG, FESG
Zill, Thomas *	System Architectures in Aeronautics	aircraft design	MDG

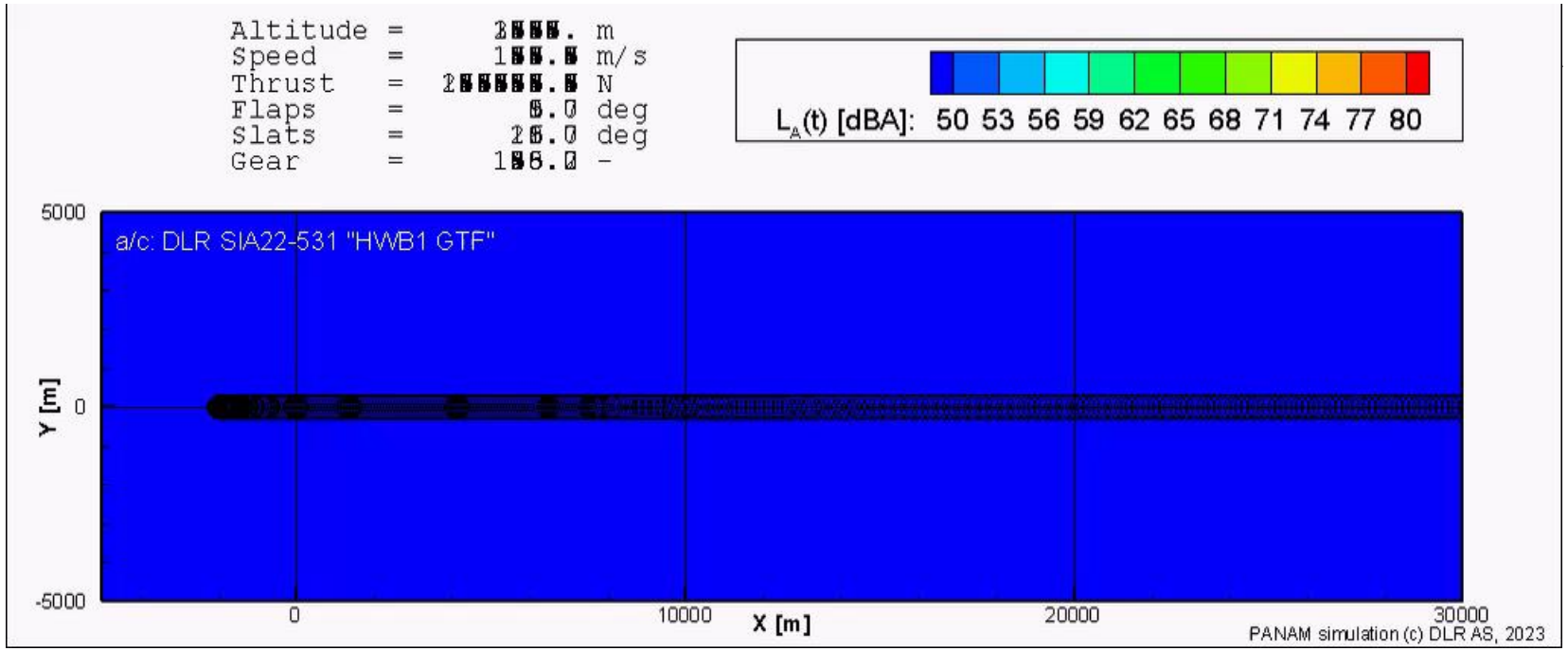
SST = Supersonic Transport, LTO = Landing and Take-off

*) experienced / long-time CAEP participant

backup

- output of componential & parametric simulation

„HWB1 GTF“: DLR design w. Ultra- High-Bypass engines
(fig.: M. Mößner, DLR, 2023)



approach