



DER/TA

# Model and robust multidisciplinary design optimization of an airplane in the air transport system

ENAC PhD day - February 10<sup>th</sup> 2022

Nicolas Peteilh

ENAC lab, OPTIM research team and Air Transportation Department

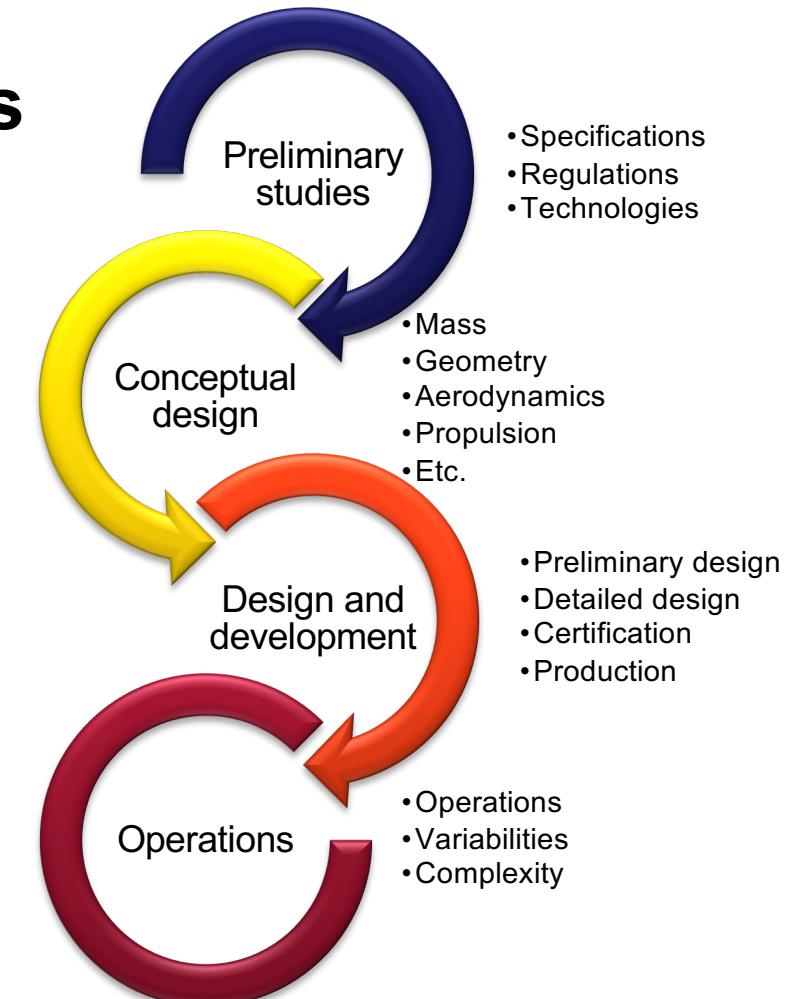
Thesis directors: Christian Bes (ICA), Marcel Mongeau (ENAC)

Supervisor: Thierry Druot (ENAC/Airbus)

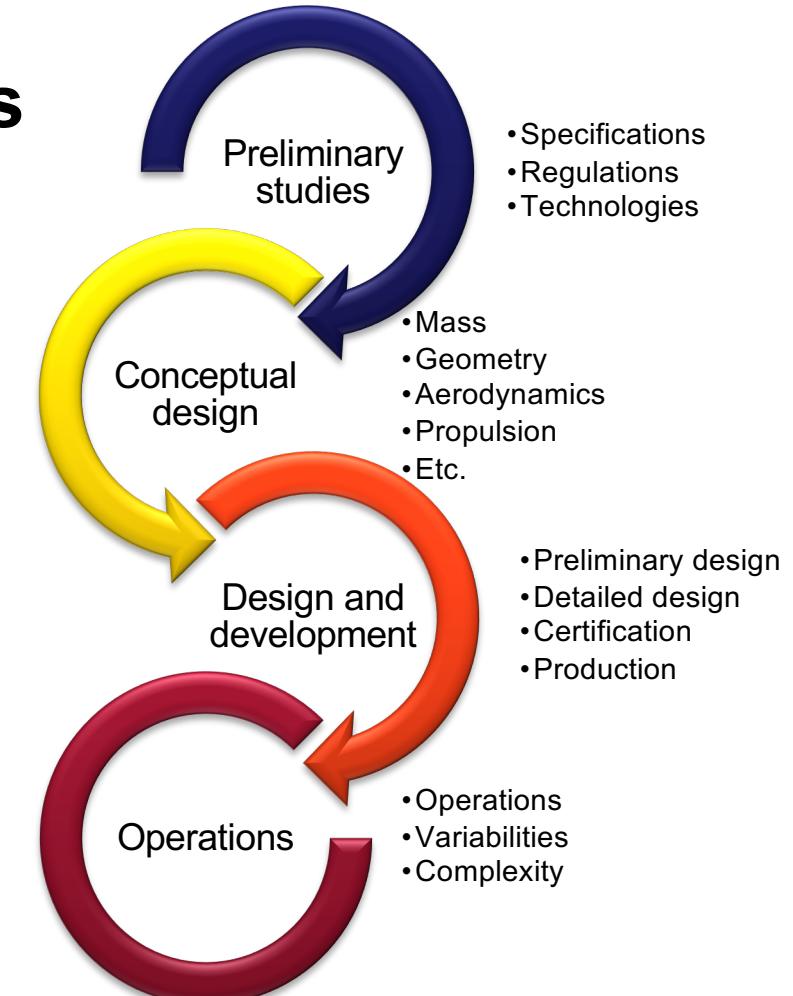
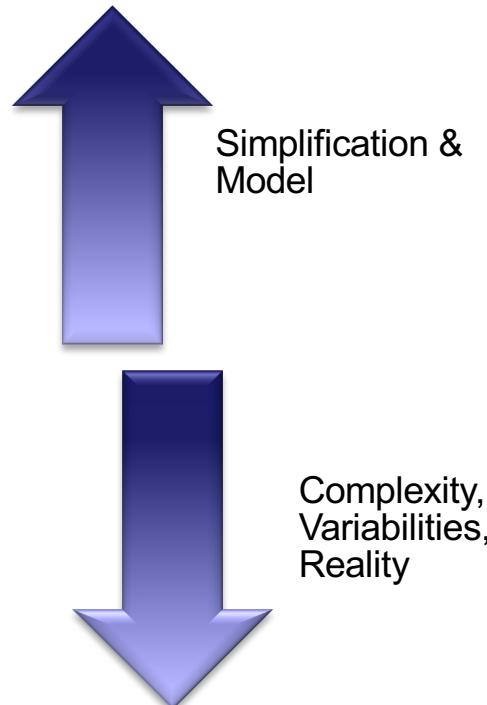


# Context – design process and limits

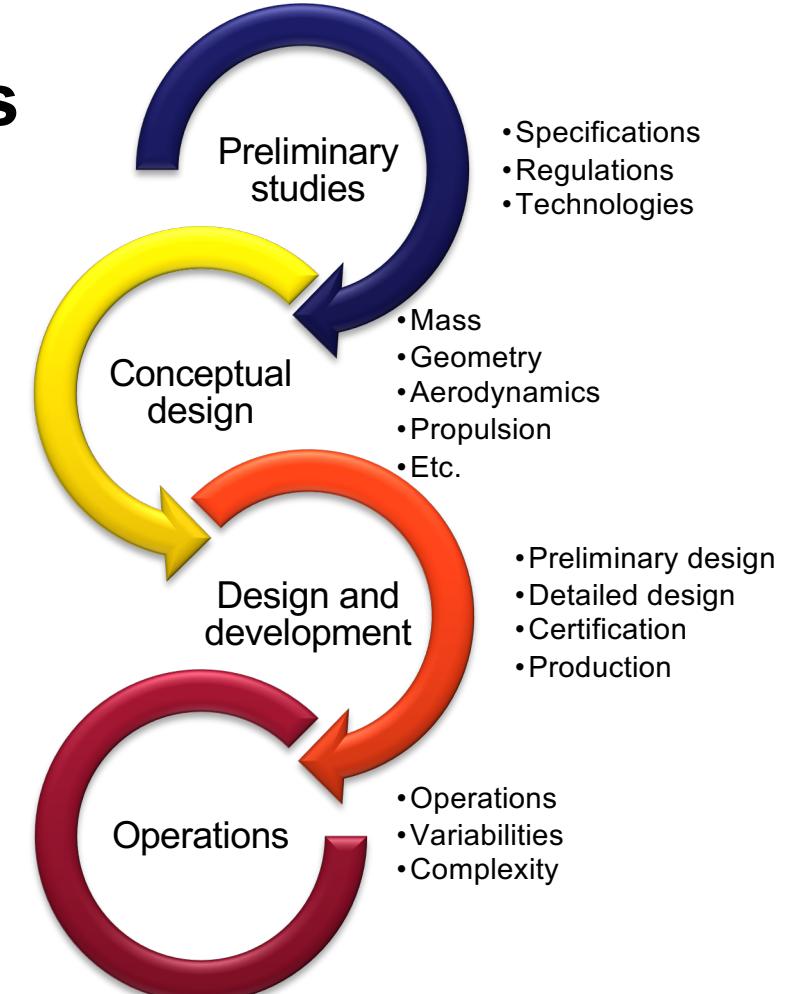
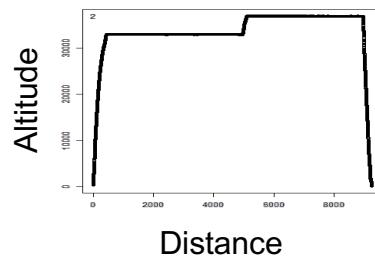
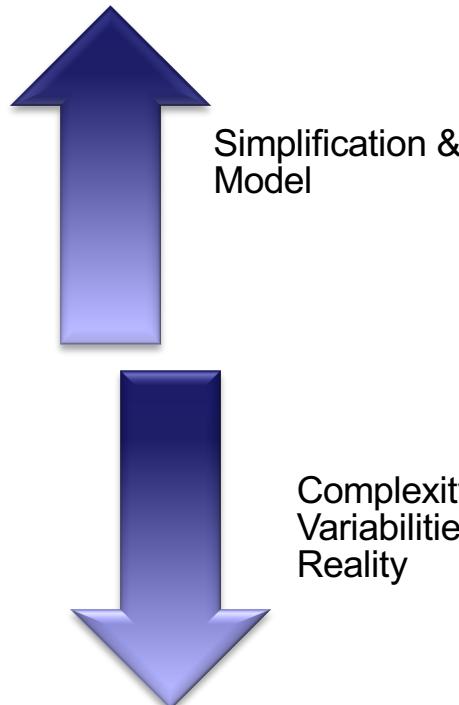
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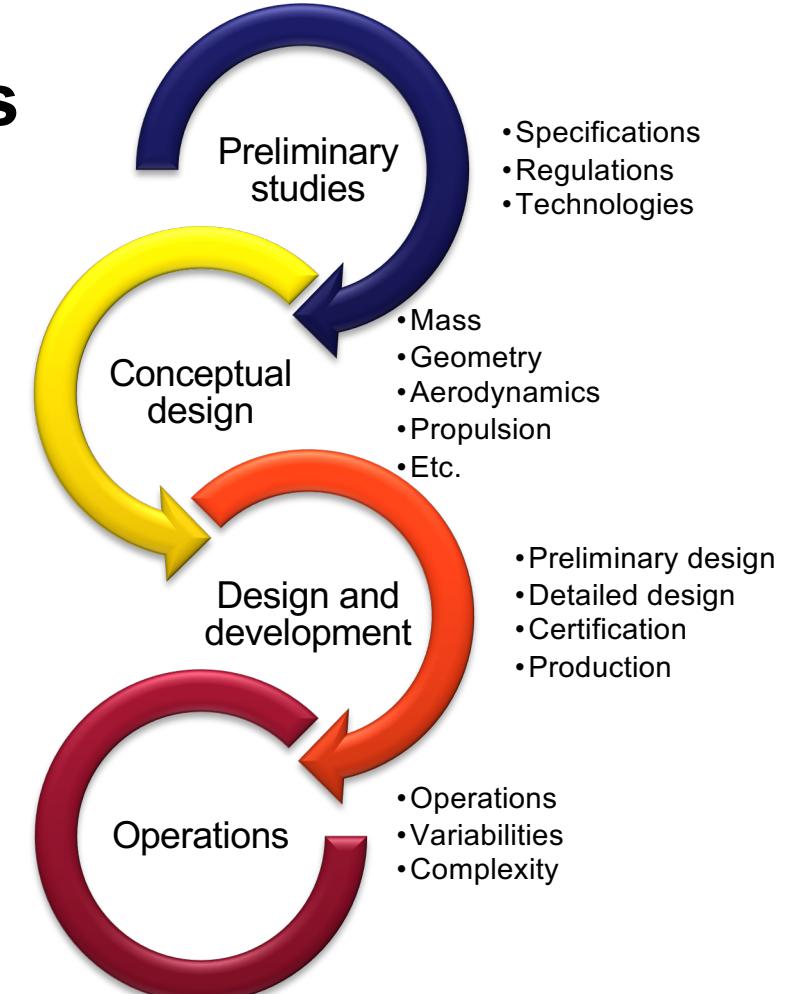
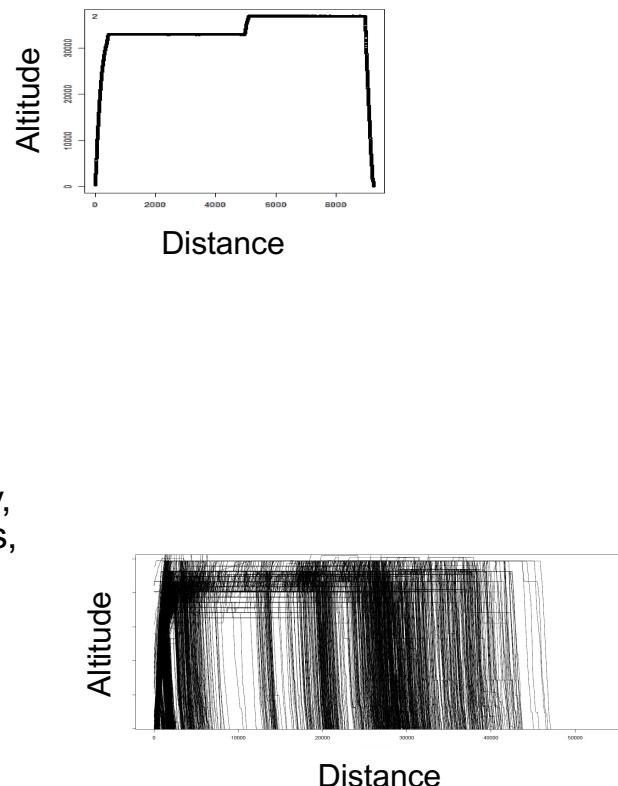
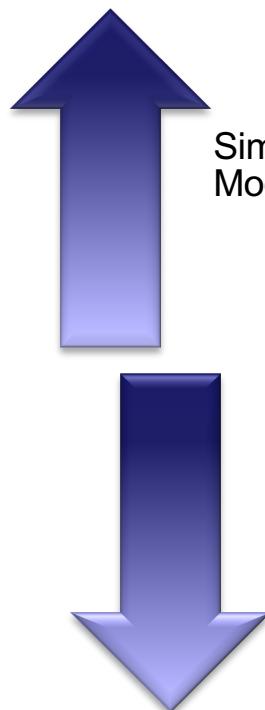
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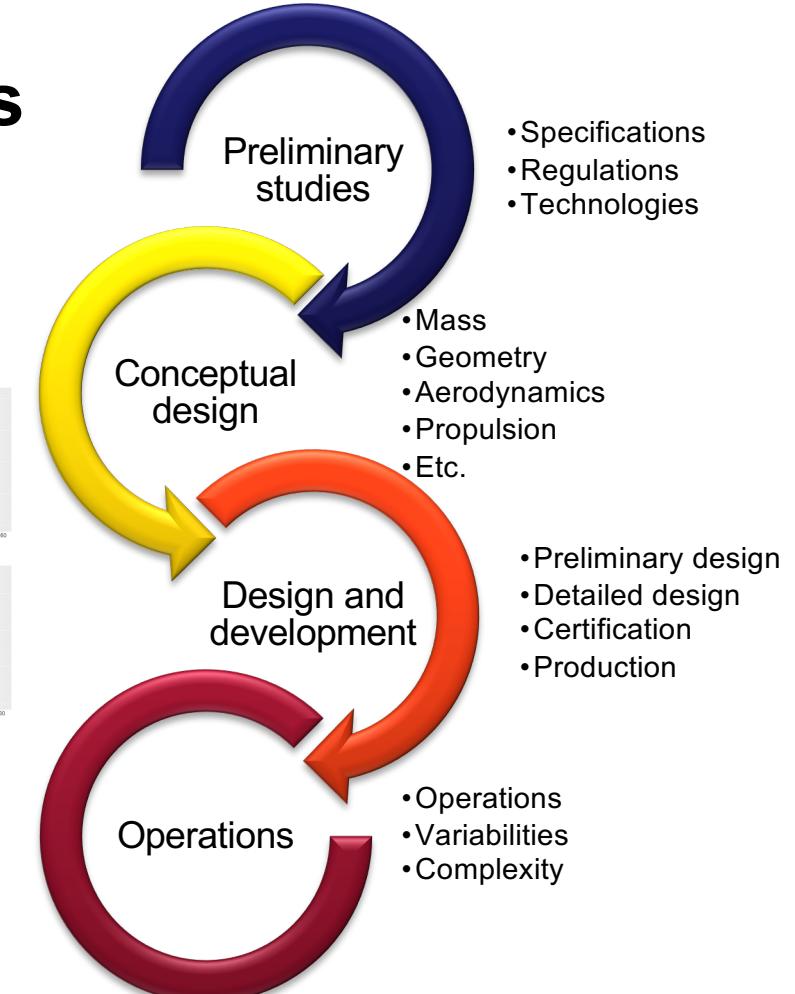
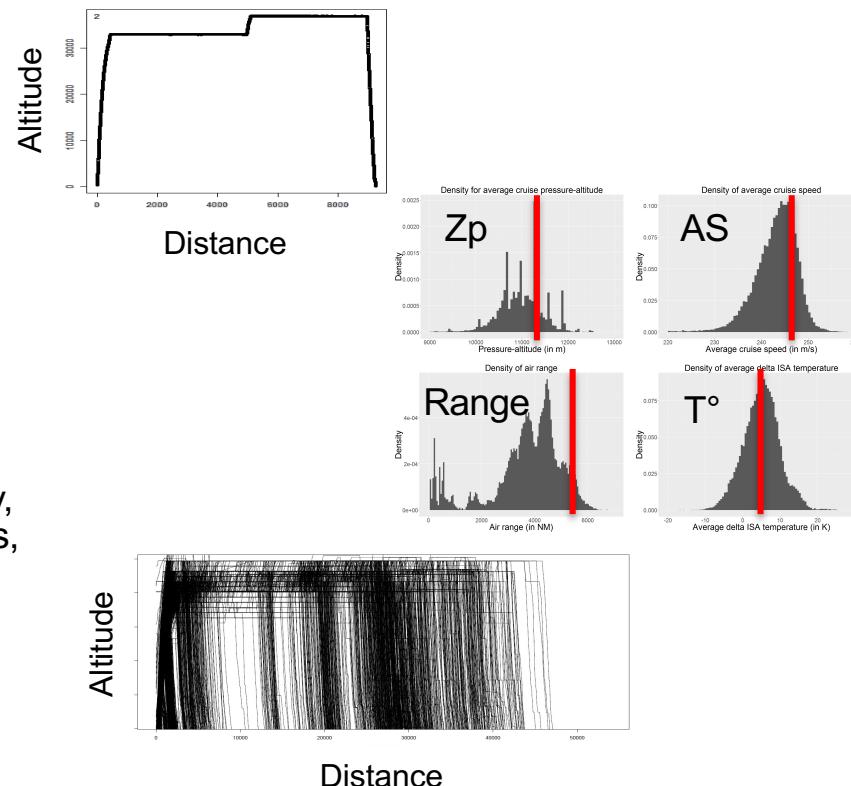
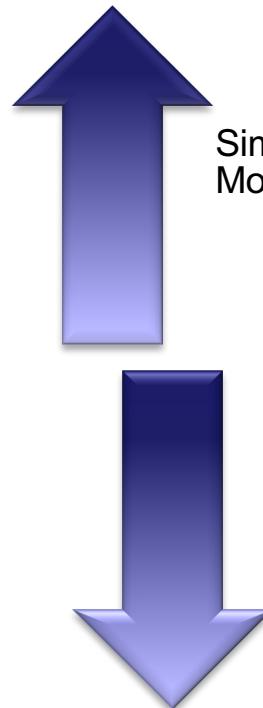
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# PhD objectives

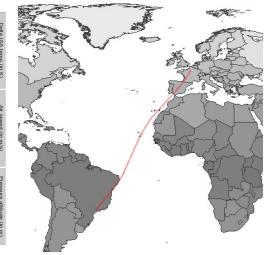
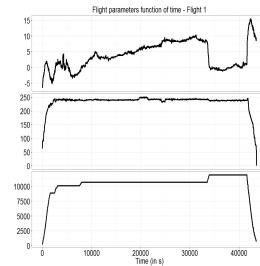
[1]

# PhD objectives

1. Observe real detailed airplane operations – search and find data



Metar  
database



# PhD objectives

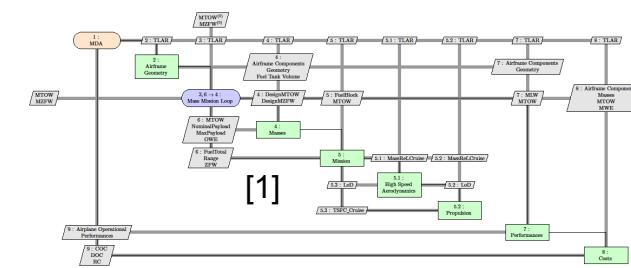
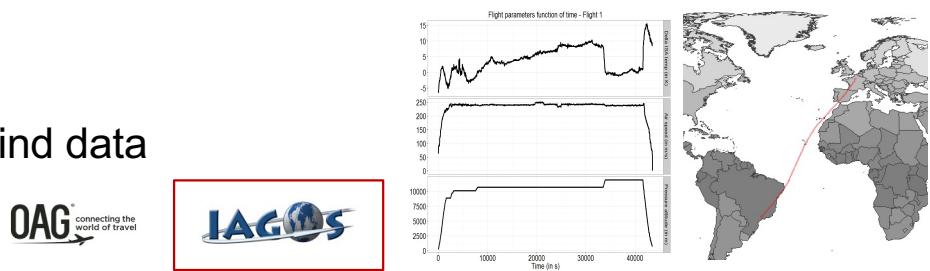
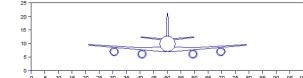
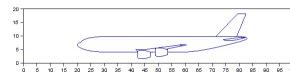
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## Metar database



- ## 2. Set up a realistic airplane conceptual design MDO tool



# PhD objectives

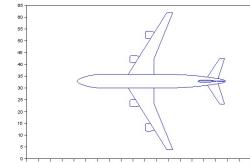
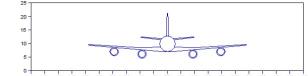
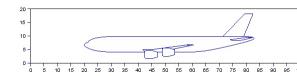
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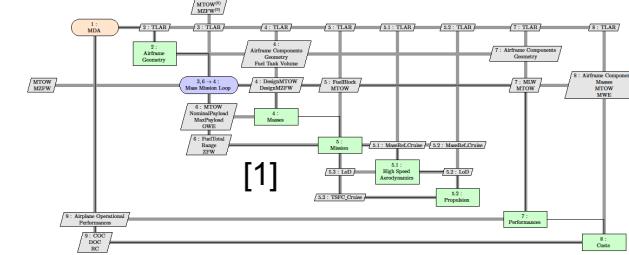
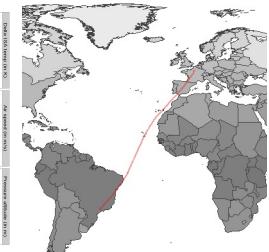
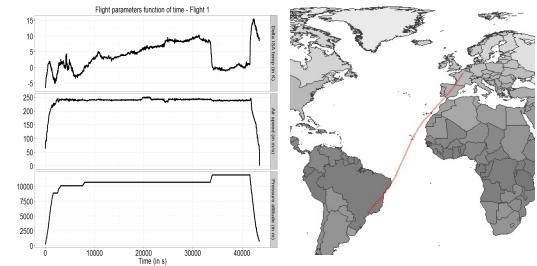
Metar  
database



2. Set up a realistic airplane conceptual design MDO tool



3. Model and represent operational variabilities to fit in the design process



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Metar database

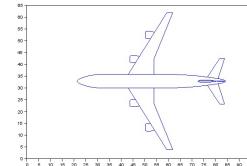
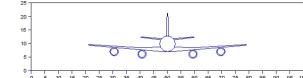
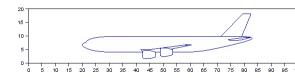
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LIVE AIR TRAFFIC

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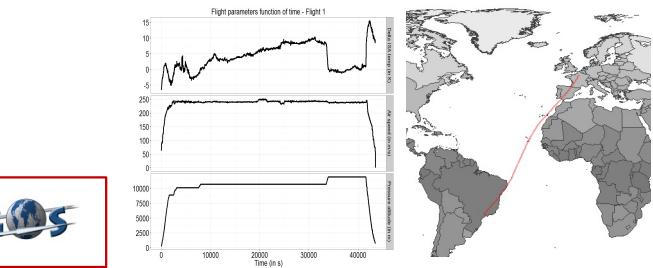
connecting the world of travel



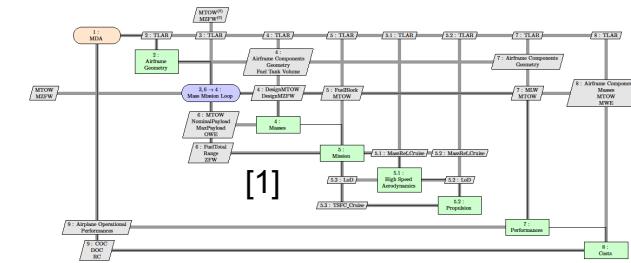
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4. Address 2 applications:



# PhD objectives

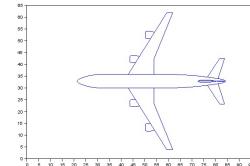
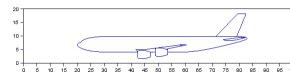
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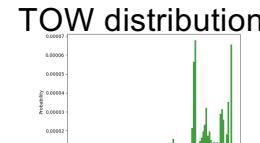
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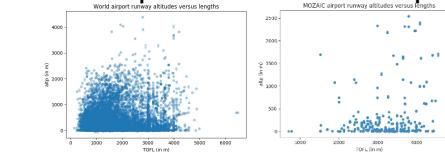
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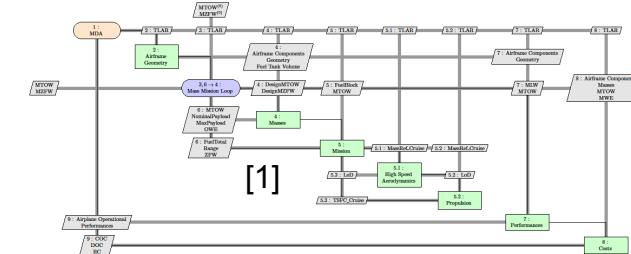
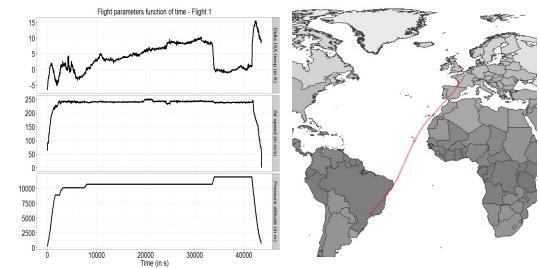


Airports TOFL and altp



4. Address 2 applications:

- A. Low speed performances → challenging take-off requirements



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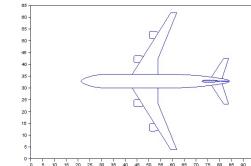
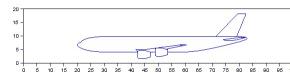
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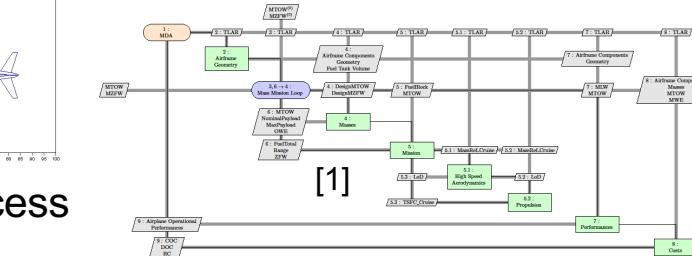
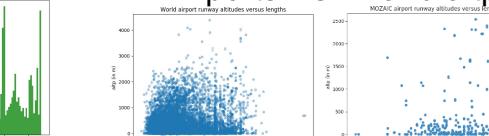


3. Model and represent operational variabilities to fit in the design process

TOW distribution



Airports TOFL and altp

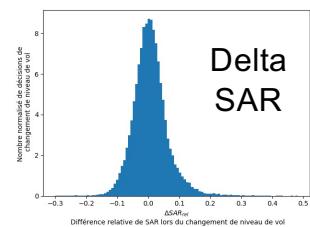
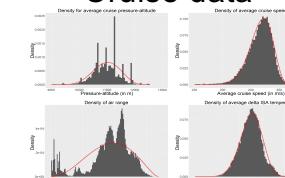


4. Address 2 applications:

A. Low speed performances → challenging take-off requirements

B. High speed performances → accounting for cruise variability

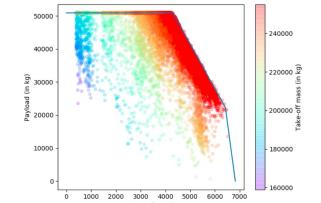
Cruise data



# PhD main results

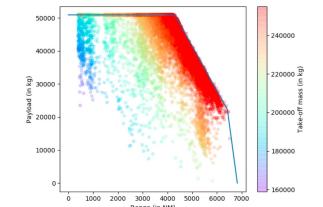
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1. Data enrichment : take-off mass estimation from flight profile using random forest<sup>[2]</sup>



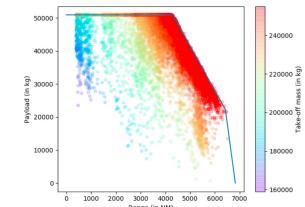
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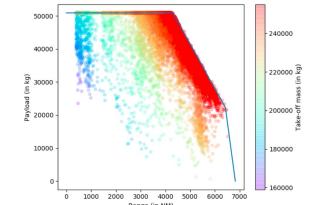
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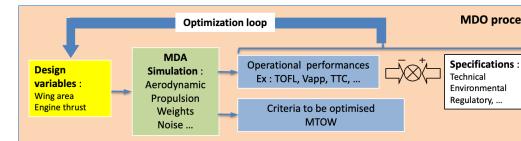
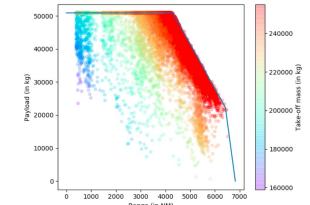
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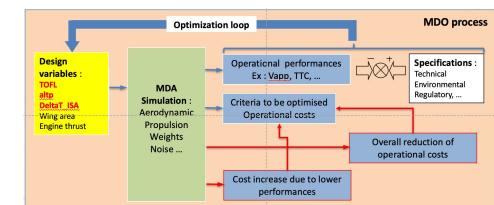
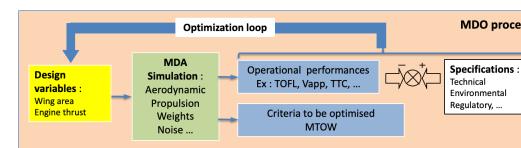
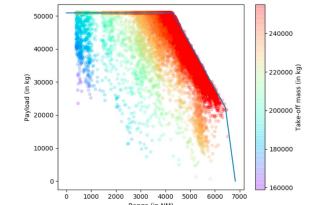
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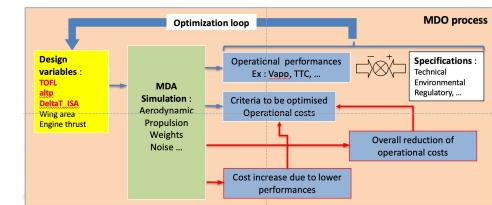
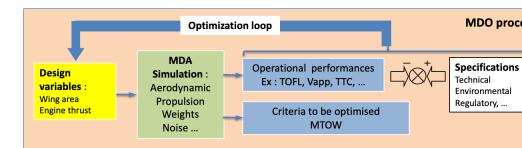
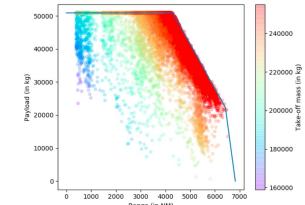
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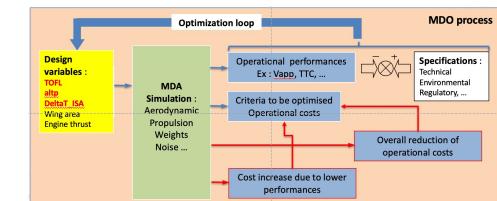
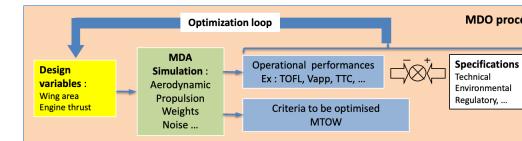
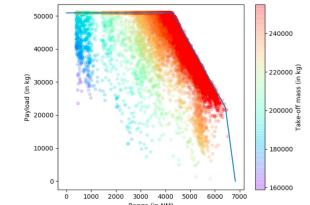
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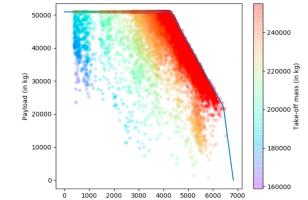
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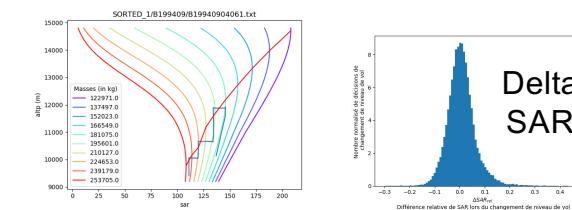
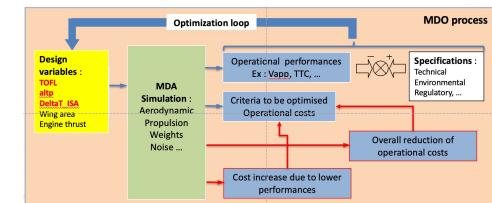
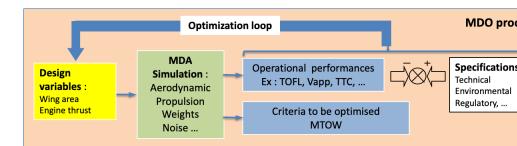
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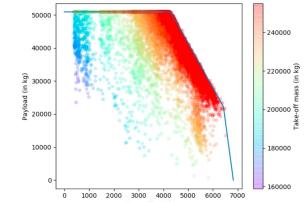
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- a. New approach to model flight profile variability based on the decision to change flight level

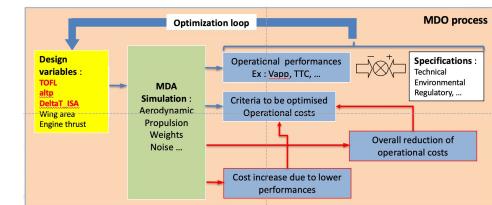
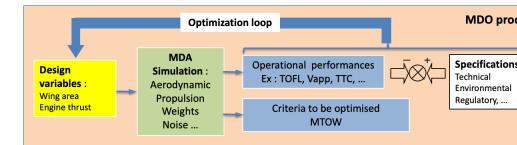


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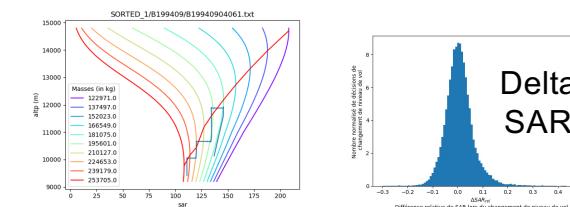


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3. Application 2 : Accounting for cruise variability

- a. New approach to model flight profile variability based on the decision to change flight level
- b. Focusing on flight profile variability : 0.2% over consumption



# References, conferences, publications

N. Peteilh. Towards a robust multidisciplinary design optimization model for the airplane in the air transport system. In *AEGATS '16, Advanced Aircraft Efficiency in a Global Air Transport System*, April 2016.

Peteilh, N., Mongeau, M., Bes, C., Druot, T., & Conderolle-Lestremau, M. (2017). Modeling Operational Variability for Robust Multidisciplinary Design Optimization. In *18th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference* (p. 4328).

T. Y. Druot, M. Belleville, P. Roches, F. Gallard, N. Peteilh, and A. Gazeix. A multi-disciplinary airplane research integrated library with applications to partial turboelectric propulsion. In *AIAA Aviation 2019 Forum*, page 3243, 2019.

Peteilh, N., Klein, T., Druot, T. Y., Bartoli, N., & Liem, R. P. (2020). Challenging Top Level Aircraft Requirements based on operations analysis and data-driven models, application to takeoff performance design requirements. In *AIAA AVIATION 2020 FORUM* (p. 3171).

Druot, T. Y., Peteilh, N., Roches, P., & Monrolin, N. (2022). Hydrogen Powered Airplanes, an exploration of possible architectures leveraging boundary layer ingestion and hybridization. In *AIAA SCITECH 2022 Forum* (p. 1025).

[1] A. B. Lambe and J. R. Martins. Extensions to the design structure matrix for the description of multidisciplinary design, analysis, and optimization processes. *Structural and Multidisciplinary Optimization*, 46(2) :273–284, 2012.

[2] Breiman, L., *Classification and regression trees*, Routledge, 2017 .

[3] Sobol, I. M., “Sensitivity estimates for non linear mathematical models,” *Mathematical modelling and computational experiments*, Vol. 1, No. 4, 1993, pp. 407–414.

[4] Gamboa, F., Klein, T., and Lagnoux, A., “Sensitivity analysis based on Cramér von Mises distance,” *SIAM/ASA Journal on Uncertainty Quantification*, Vol. 6, No. 2, 2018, pp. 522–548.

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