Universidad Politécnica de Madrid

Analysis of the geometric altimetry to support aircraft optimal vertical profiles within future 4D trajectory management

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Introduction

Aeronautical business does not permit a fast evolution because of the high safety standard required and huge economic impact that have to be met. However, in the last 50 years almost everything has experienced changes:

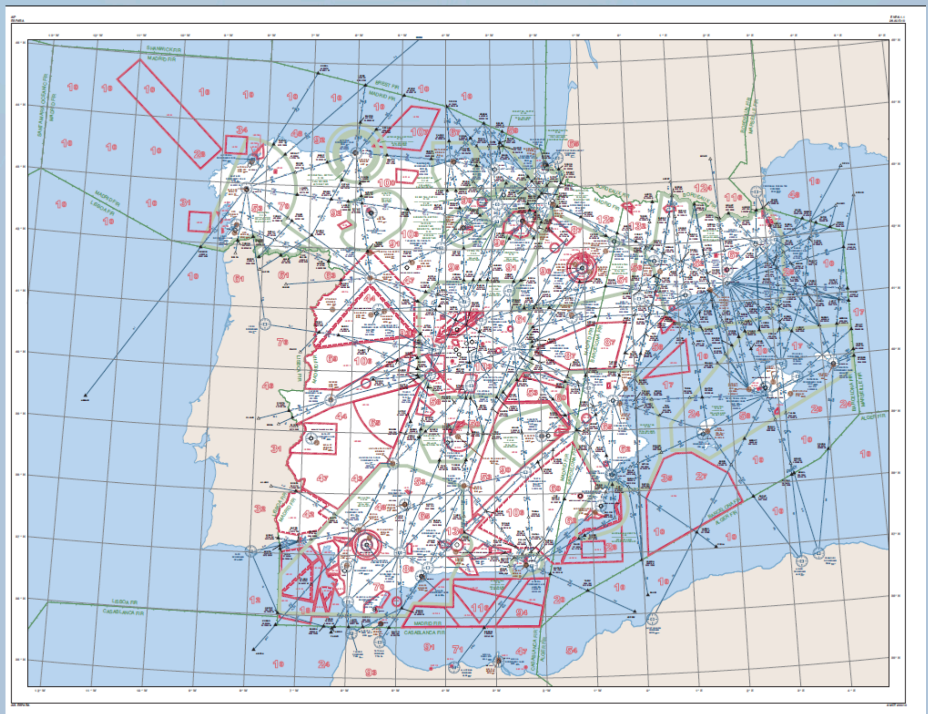
•Aircraft cockpit evolution

Cockpit B314

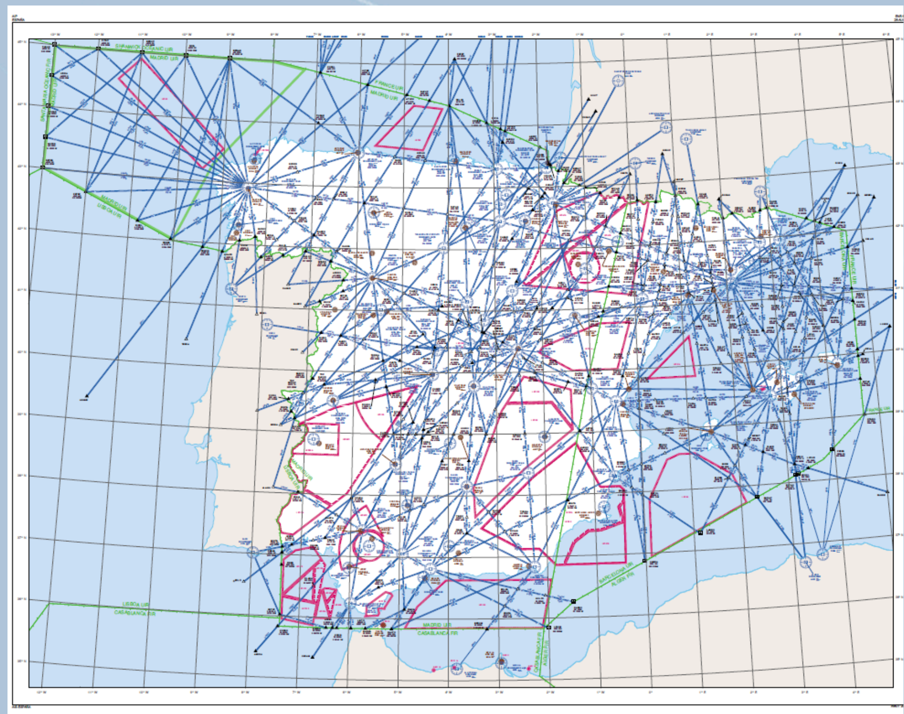
Cockpit B787 Dreamliner

Introduction

- Horizontal Aircraft Movement Evolution



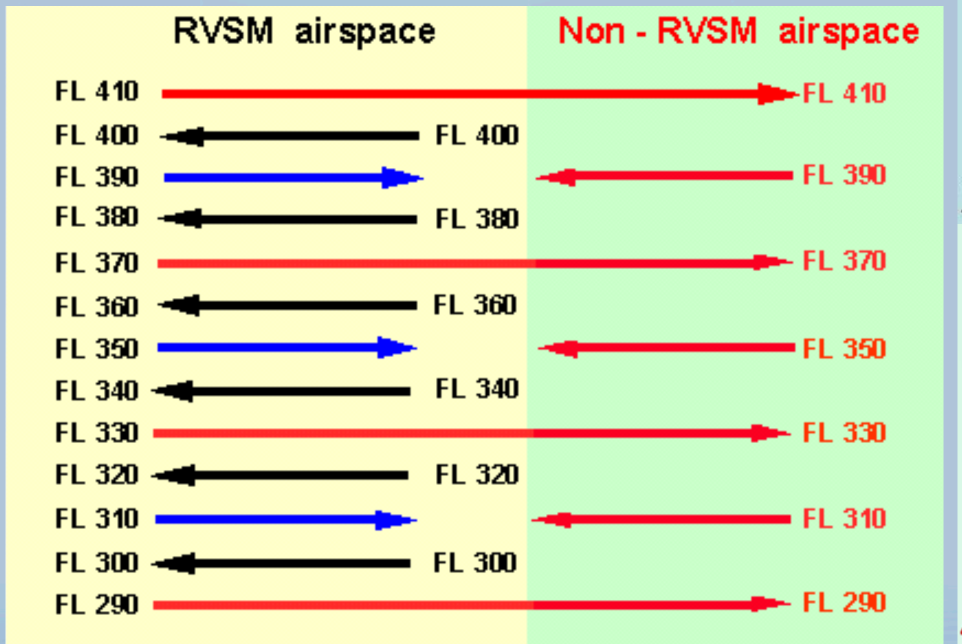
FIR Spain Routes (VOR-DME)

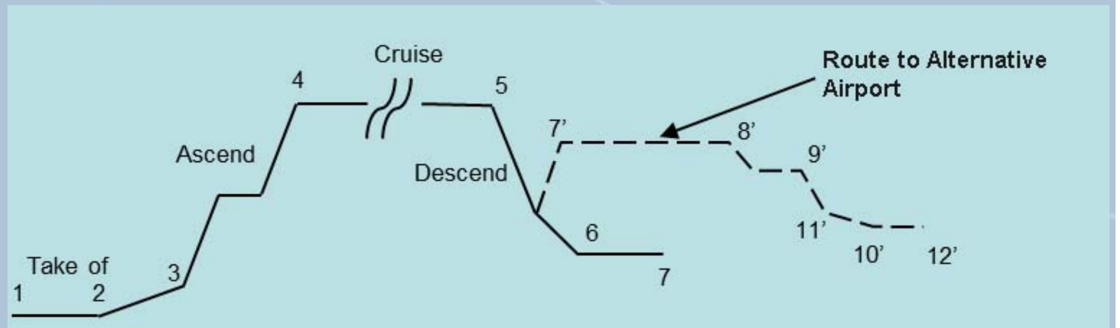


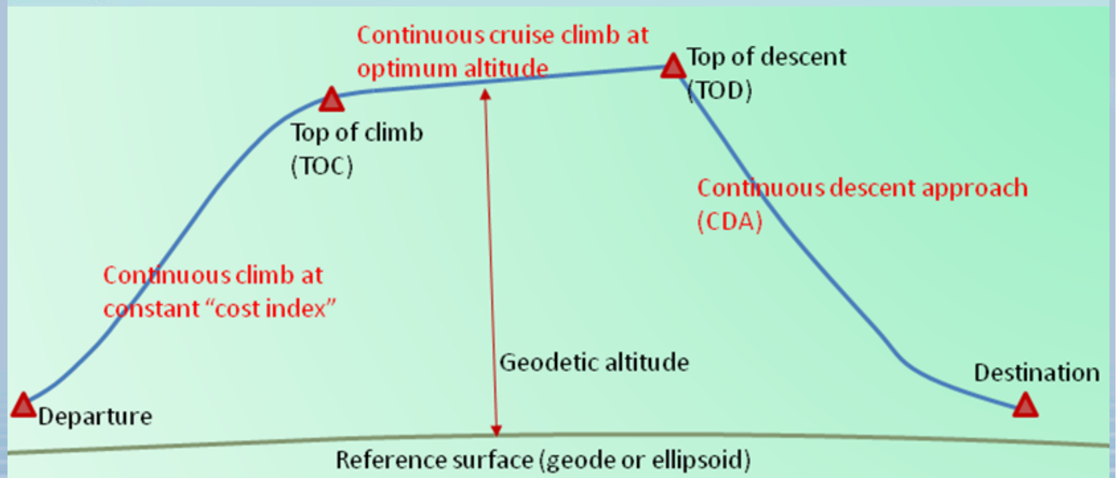
UIR Spain Routes (Way Point)

Introduction

- Vertical Aircraft Movement Evolution, limitations and problems:
  - Specific procedures
  - Steps profiles
  - Altimetry setting (QNH, QNE(FL), QFE), Transition Altitude
  - Controller and Pilot extra workload

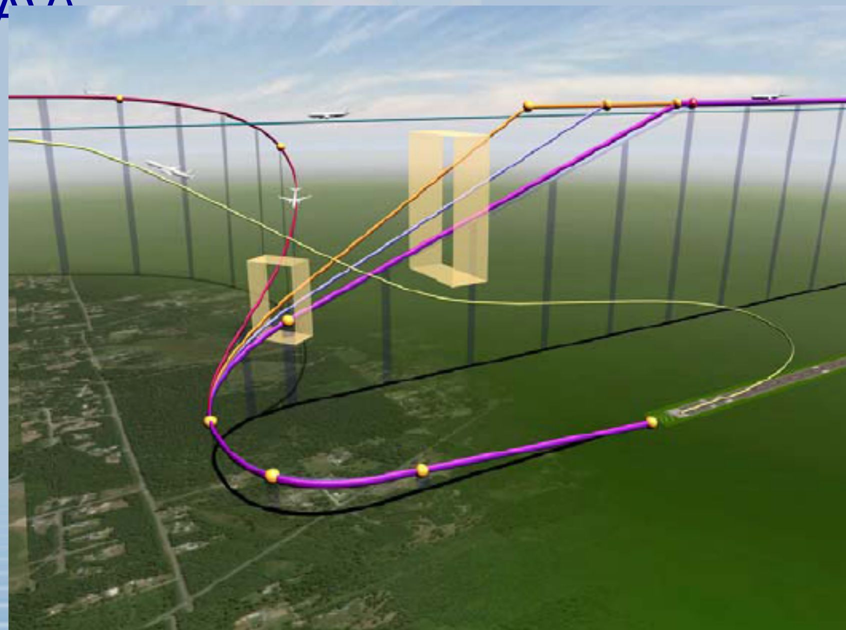






Objective

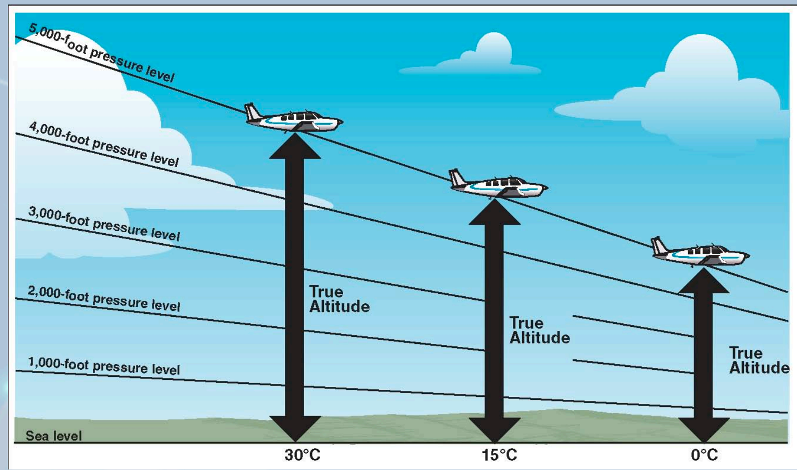
1. To assess if geometric altitude fulfils the aeronautical requirements through the existing sensors (INS, GNSS/GPS, Radar Altimeter, Air Data Computer).
2. To show advantages of geodetic altitude over the barometric altitude in terms of efficiency for vertical navigation.
3. To show evidences that geometric altitude could be the best choice for 4D trajectories management (RNP/VNAV).



Current Situation: Atmosphere Study

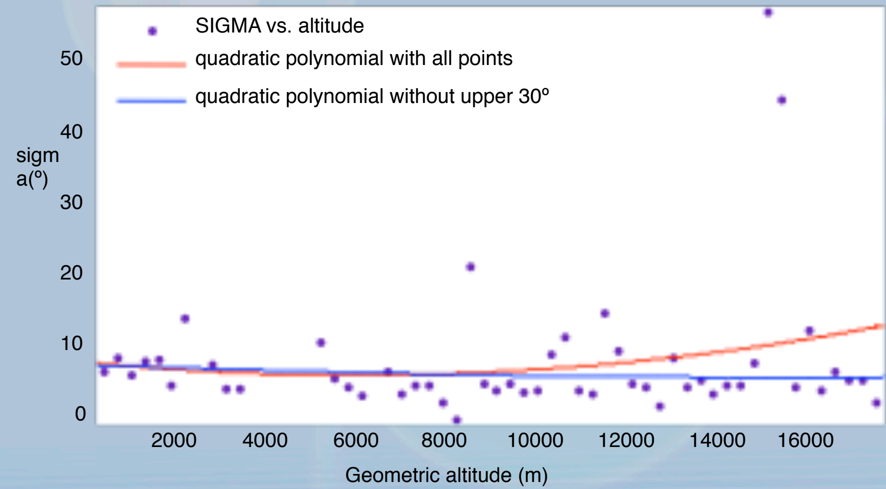
•Barometric Altimetry:

- Is based on International Standard Atmosphere
- Actual Temperature makes it varies



Statistical study using 95 radiosondes stations of World Meteorological Organization (WMO):

- To estimate the Temperature deviation from ISA
- A quadratic second order polynomial approximation
- A 60K maximum deviation

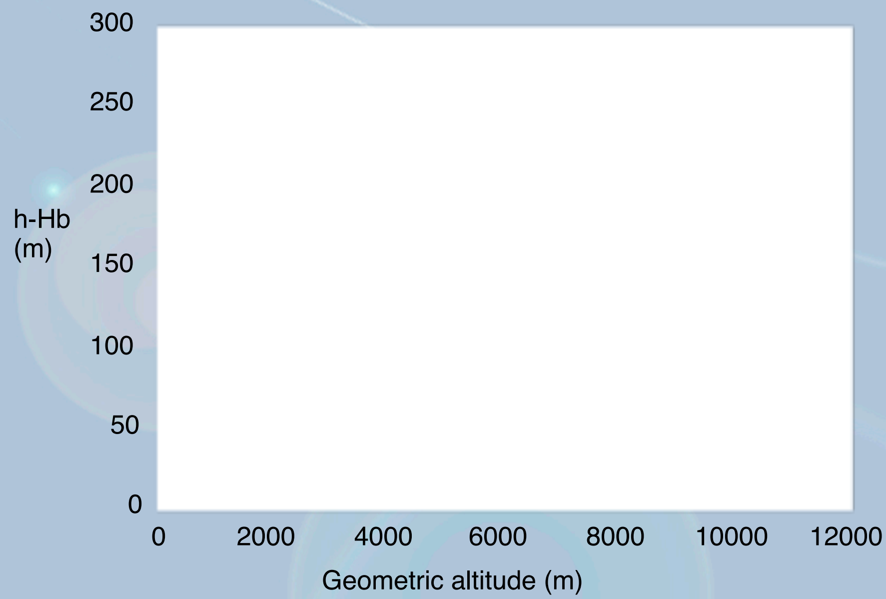


Current Situation: Atmosphere Study

A continuous relationship between Geometric and Barometric altitude was achieved using the following hypothesis:

- Ideal gas
- Without dust, humidity and water vapour
- Stable relative to the Earth
- The pressure at mean sea level equal to the ISA.

$$\frac{dH_b}{dh} = \frac{T_{ISA}}{T_{ISA} + T_{Dev}} \simeq 1 - \frac{T_{Dev}}{T_{ISA}}$$



Where:

- Hb is the barometric altitude
- h is the geometric altitude
- TISA is the ISA temperature
- TDev is the temperature deviation form ISA

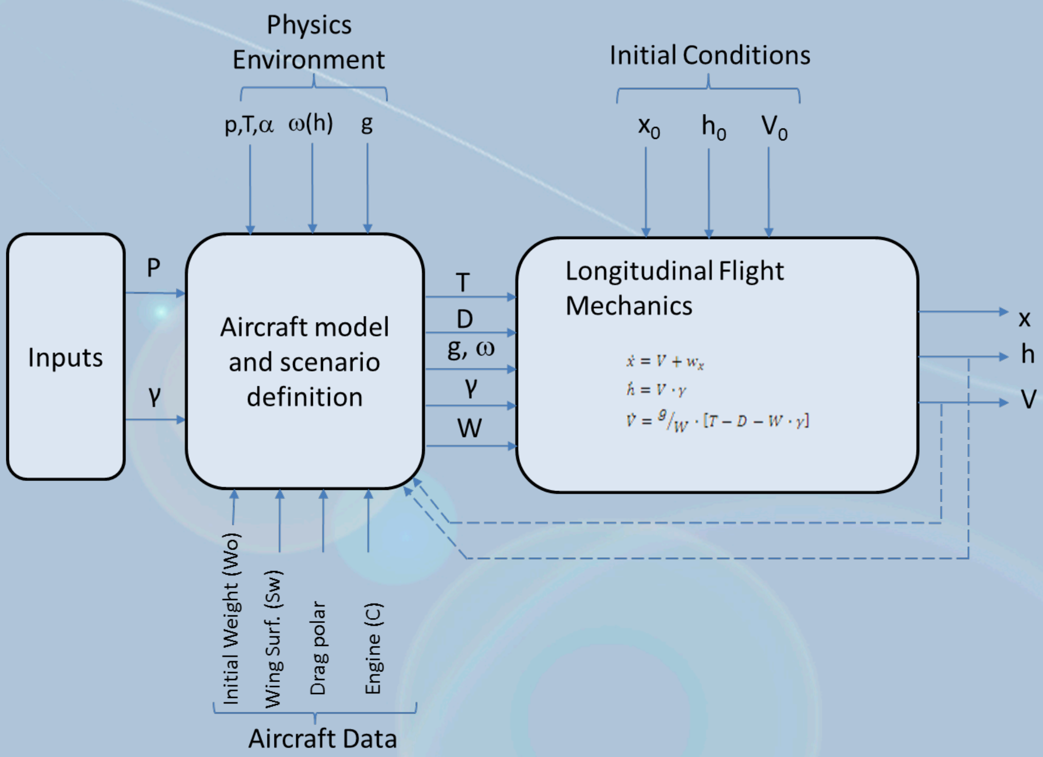
Current Situation: Aircraft Trajectory (Vertical Profile) Model

A Three Degrees of Freedom (3DOF) model.

•To study the vertical profile routes.

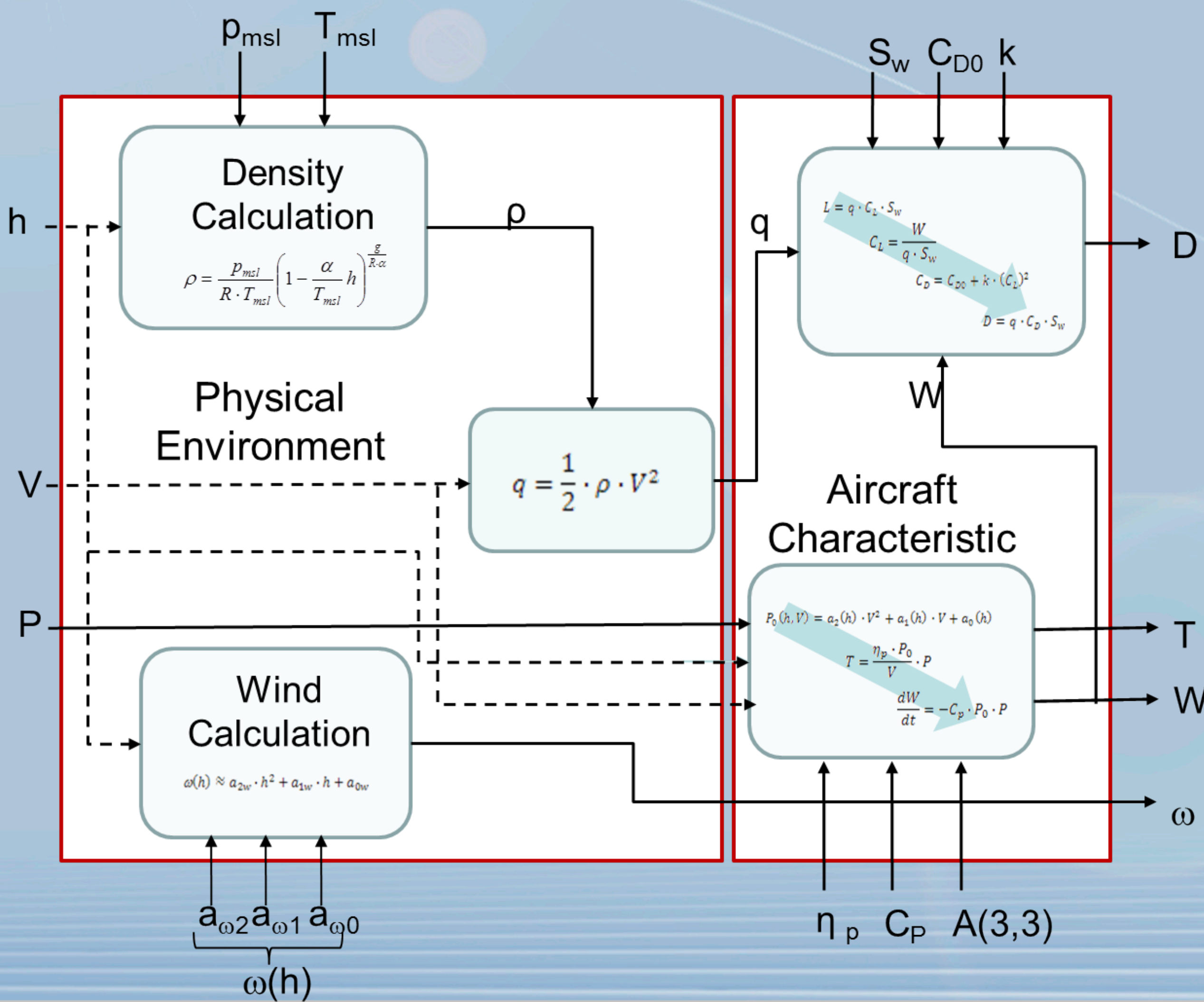
•It has 3 main sections:

- Inputs
- Aircraft model and Scenario definition
- Longitudinal flight mechanics



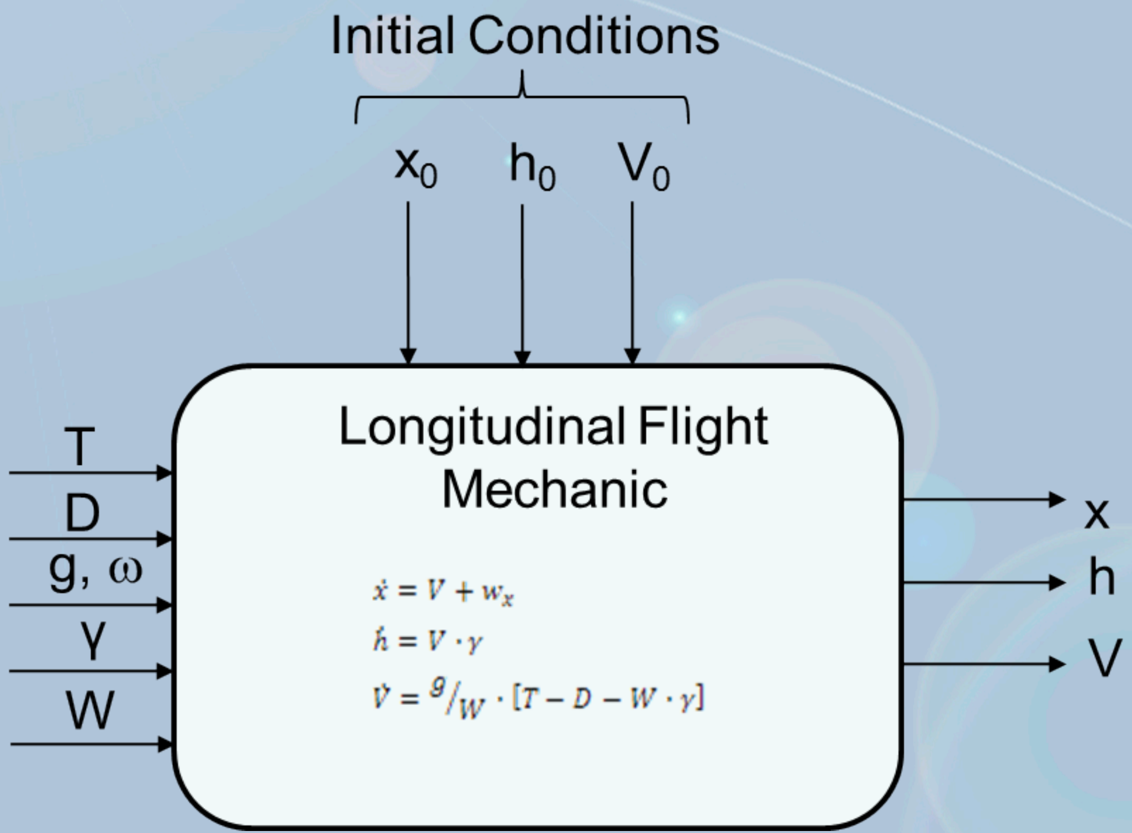
Current Situation: Aircraft Trajectory (Vertical Profile) Model

Aircraft model and Scenario Definition



Current Situation: Aircraft Trajectory (Vertical Profile) Model

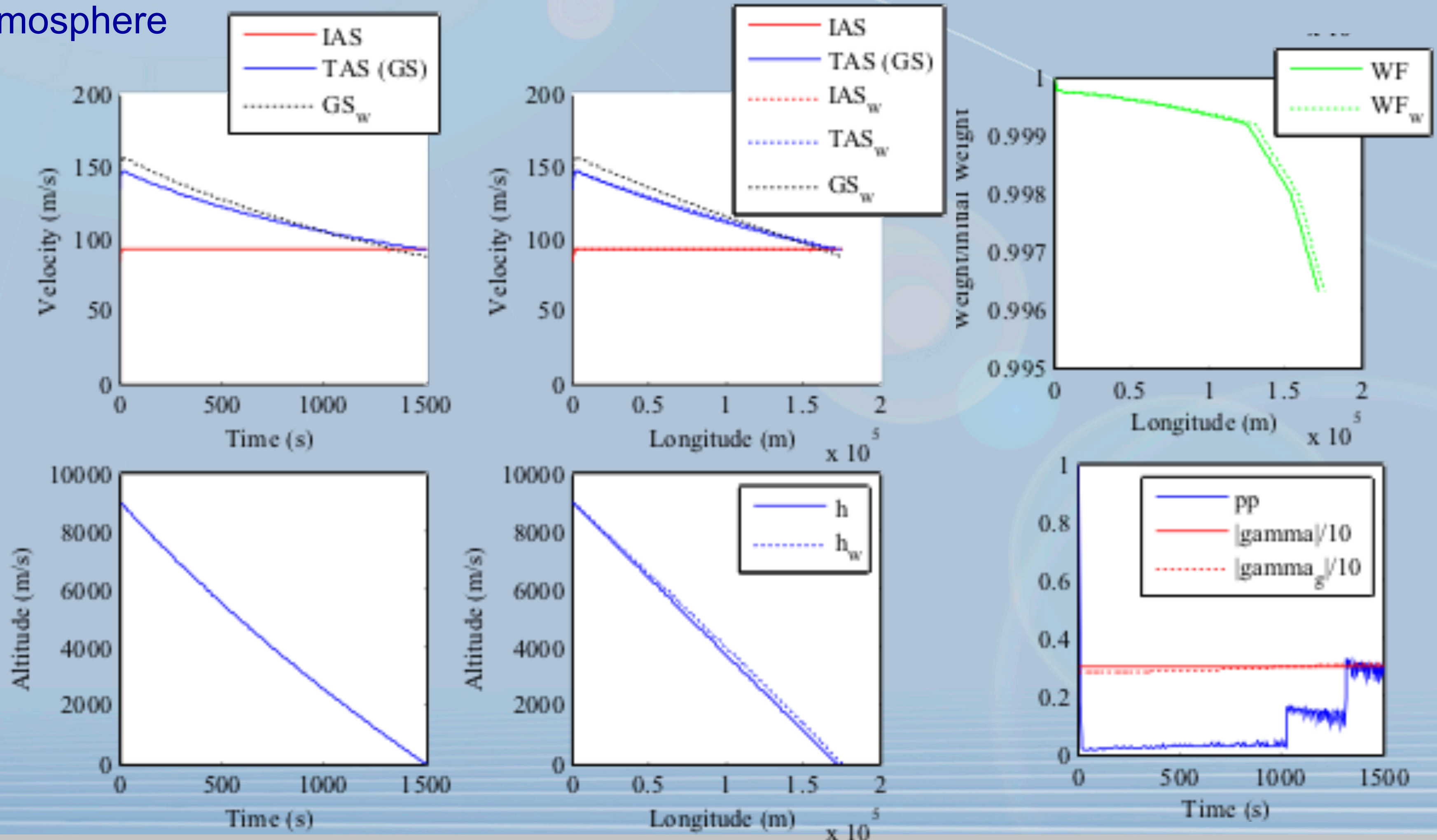
Longitudinal Flight Mechanic



Example Continuous Descent Approach Boeing 737

Characteristics:

- IAS control (IAS=92.6m/s) (Acting on the throttle lever position)
- Flight path angle (γ) equal -3º
- ISA Atmosphere
- Wind



Future Work

1. Assessment of the impact on aircraft when they follow geometric predefined vertical routes in terms of flight feasibility and efficiency.
2. Assessment of its impact on the vertical airspace organization to provide separation assurance within the ATM/ATC.
3. Assessment of the robustness of the candidate sensors (safety issues, accuracy, integrity and availability).
4. Evaluation of enhancement in terms of 4D trajectory management applied to the predictability and efficiency of flights.

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