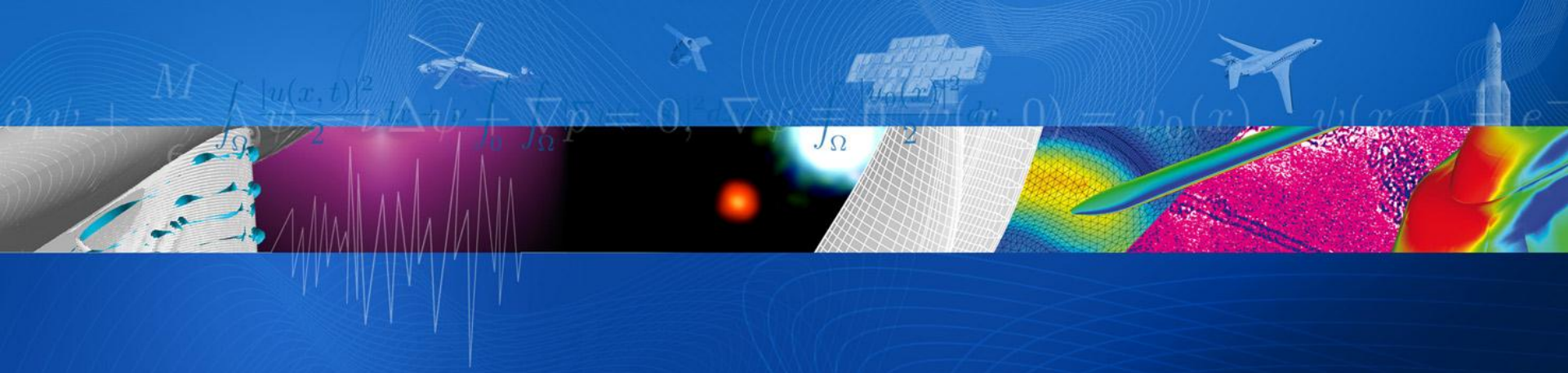


Cluster of simulations
The European project 4DCo-GC

Antoine JOULIA

AirTN-NextGen Seminar

Sept. 25, 2014

Bonn, Germany

ONERA

THE FRENCH AEROSPACE LAB

retour sur innovation

4D Contracts – Guidance and Control

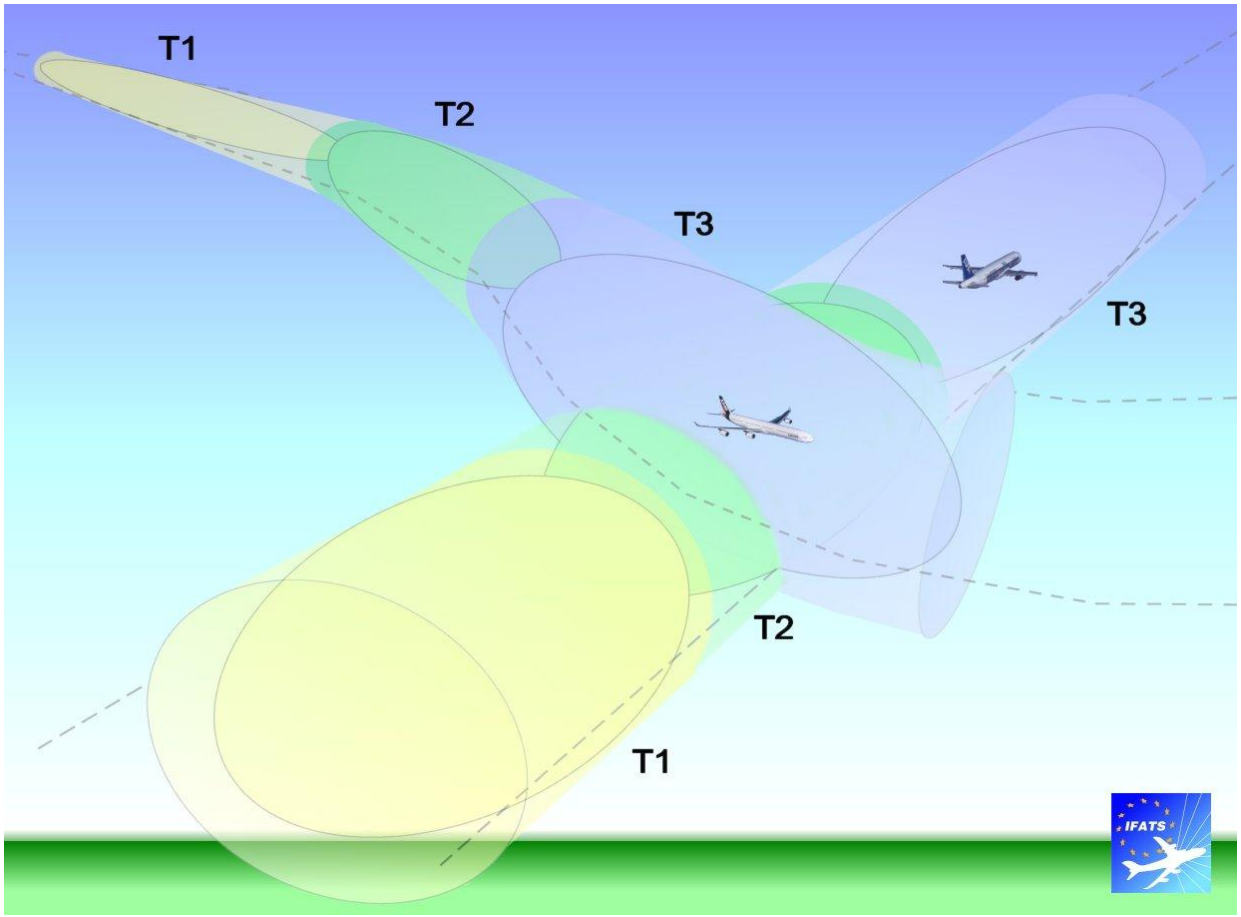
- **7th Framework Programme, 3rd call**
- **Budget: 5.5 M€ (3.9 M€ from EC)**
- **Duration: 36 months**
- **Start date: 1st of November, 2010**
- **Participants**
  - *ONERA, ENAC, Erdyn Consultants, Thales Comm*
  - *Alenia Aeronautica, CIRA*
  - *DLR*
  - *IAI, Technion*
  - *TsAGI, Monitor Soft*
  - *NLR*
  - *University of Patras*

Project objectives

- **Refining the 4D contracts concept definition**
- **Modeling the 4D contracts concept**
  - According to simulation capabilities
- **Simulating a large 4DCo traffic over Europe**
  - 4DCo generation
  - 4DCo execution
- **Assessing the 4D contract concept of operations viability**

THE 4D CONTRACT CONCEPT

“4D tubes” in a “4D airspace”



4D contracts are arranged to avoid any “same time at same position” situation by speed and trajectory adjustments

Bubbles

- **En route, aircraft fly in 4D bubbles**
  - Allowing to modify trajectory without asking for a new contract
  - Allowing ground speed variation
    - In order to follow the optimal Mach number
  - Ensuring separation with other traffic

- **Conflict free traffic is guaranteed as long as all aircraft remain within their bubbles**
  - This means that 4D contracts are respected both by aircraft and ATM
  - The aircraft asks for a new contract only when it knows it will fly out of its bubbles

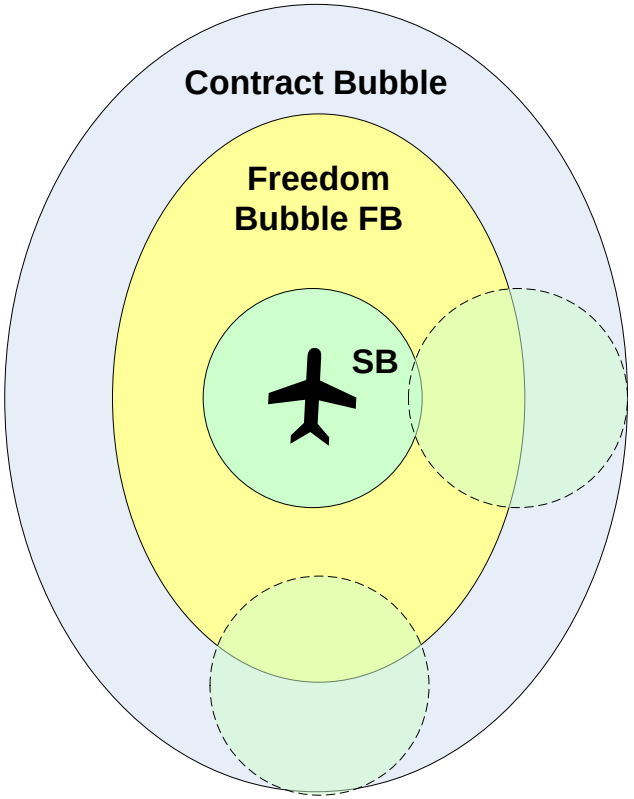
- **Bubble shape and size are function of the neighboring traffic**

4D contract

- **Bone trajectory**

- **Margins around the aircraft**
  - Safety Bubble
    - Linked to the aircraft
    - At any time, 2 SB must not intersect
  - Contract Bubble
    - Calculated by the ATSM to have conflict-free 4D contracts
    - At any time, 2 CB should not intersect
  - Freedom Bubble
    - Calculated by the FMS from CB and SB
    - Area where the CoG of the aircraft can be

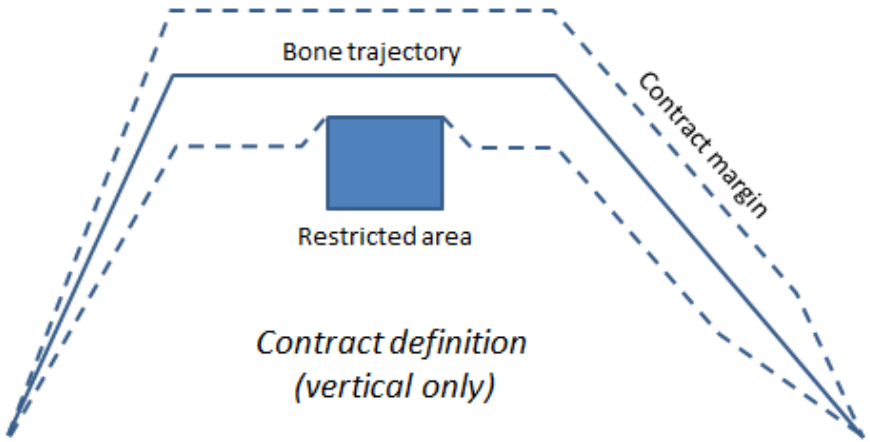
4D contract = Bone + SB + CB

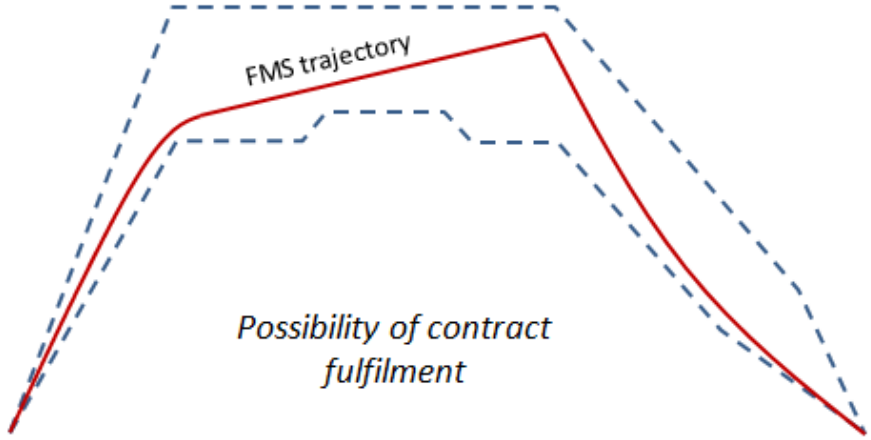


Trajectory management

- **4D contract is assigned to the aircraft by the ATSM**

- **But the trajectory is calculated by the FMS**
  - To comply with the 4D contract
  - To fit the airline priorities





“4D flight” overview

- **4D contracts generation**
  - At a continental scale, based on airlines demand and airports capacity
- **Departure**
  - 4D contract updated just before the flight
  - Take off sequence optimized (aircraft size, weight, performance)
- **En route**
  - Aircraft follow 4D contracts as much as possible
  - If needed 4D contract update requested
    - Computation of a new 4D contract, according to the overall traffic
- **Arrival**
  - Maximized runway throughput

SIMULATION

Simulation high level requirements

- **Modules**
  - 4D contracts generation
  - Global traffic 4D contracts execution
  - Contracts compliance monitoring
  - 4D contract replanning
  - Scenarios management
  - Single aircraft model
- **Constraints**
  - Multiple languages (C++, Matlab, Simulink, Python)
  - Remote simulation (for testing)

Simulation modules

Off-line

- **4DCo calculation**
  - Realistic demand, from DDR
  - City pairs + time of departure
  - Optimized 3D trajectories
  - Deconflicted 4D trajectories
  - 4D contracts

On-line

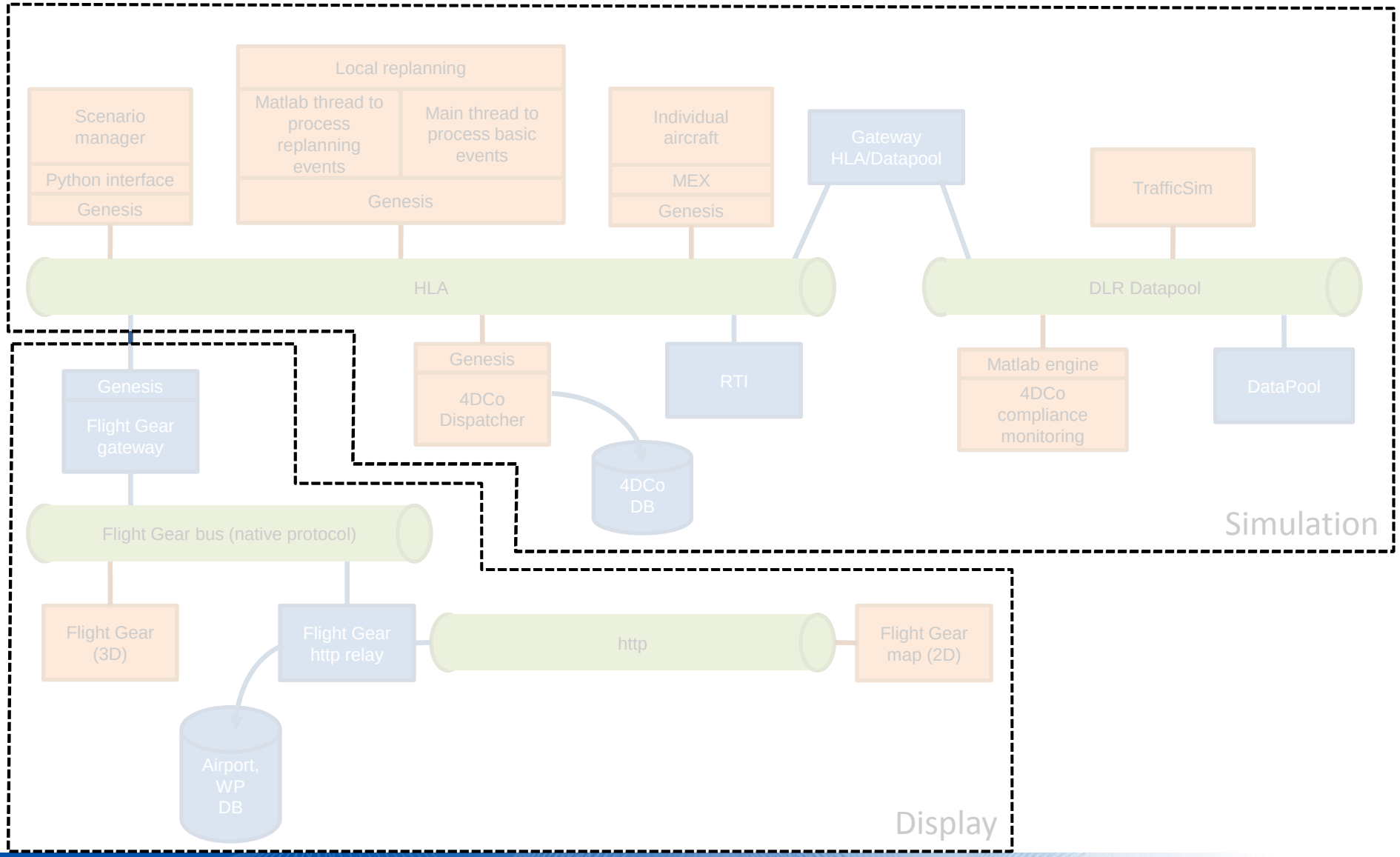
- **4DCo dispatching**
- **Scenarios management**
- **Overall traffic**
- **4DCo compliance monitoring**
- **Replanning**

- **Individual aircraft**

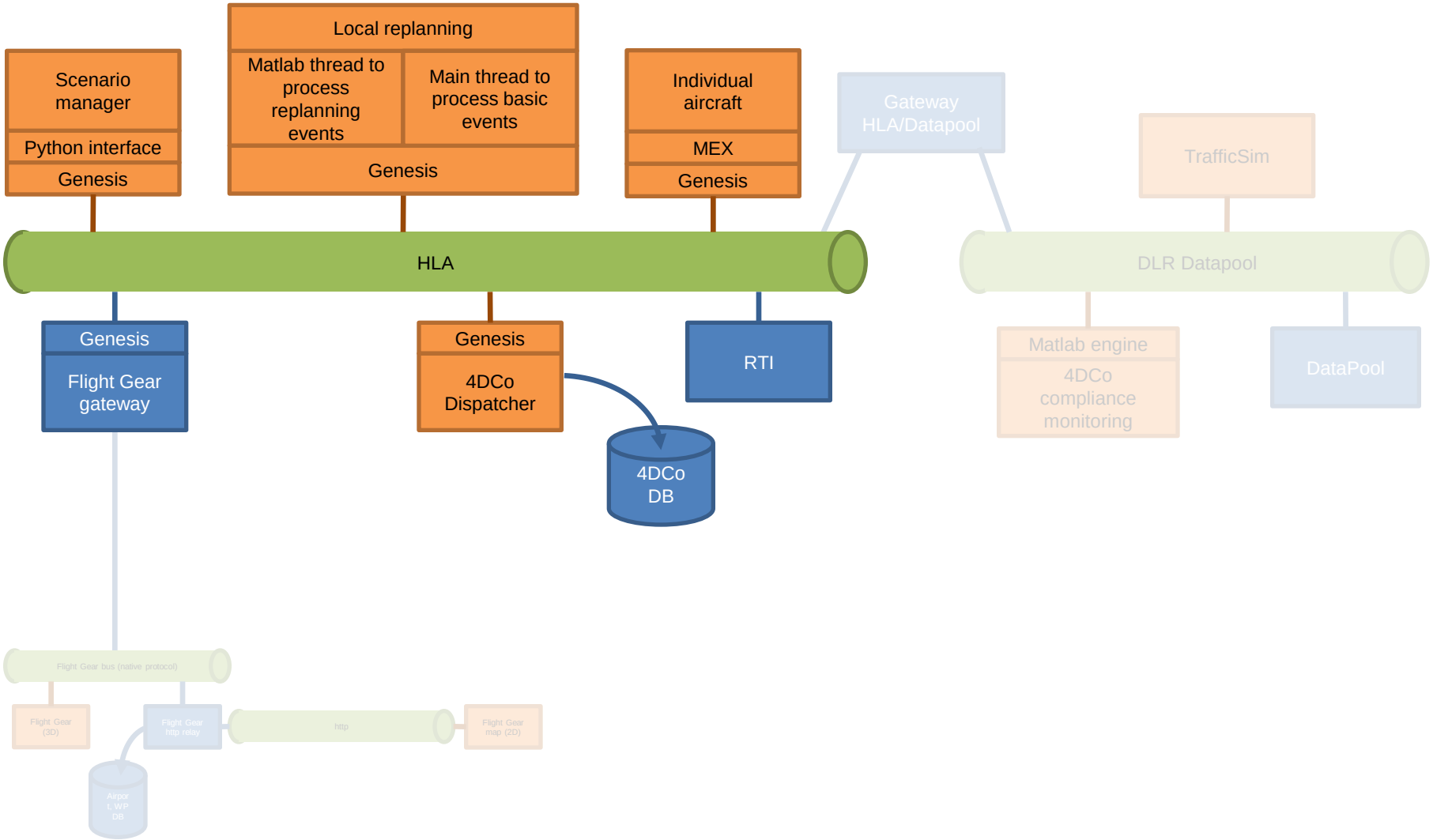
Simulation frame

- **2 simulation infrastructures**
  - IESTA/HLA at Onera
  - TrafficSim/Datapool at DLR
- **Modules plugged to one of the infrastructures**
- **Need for a gateway**

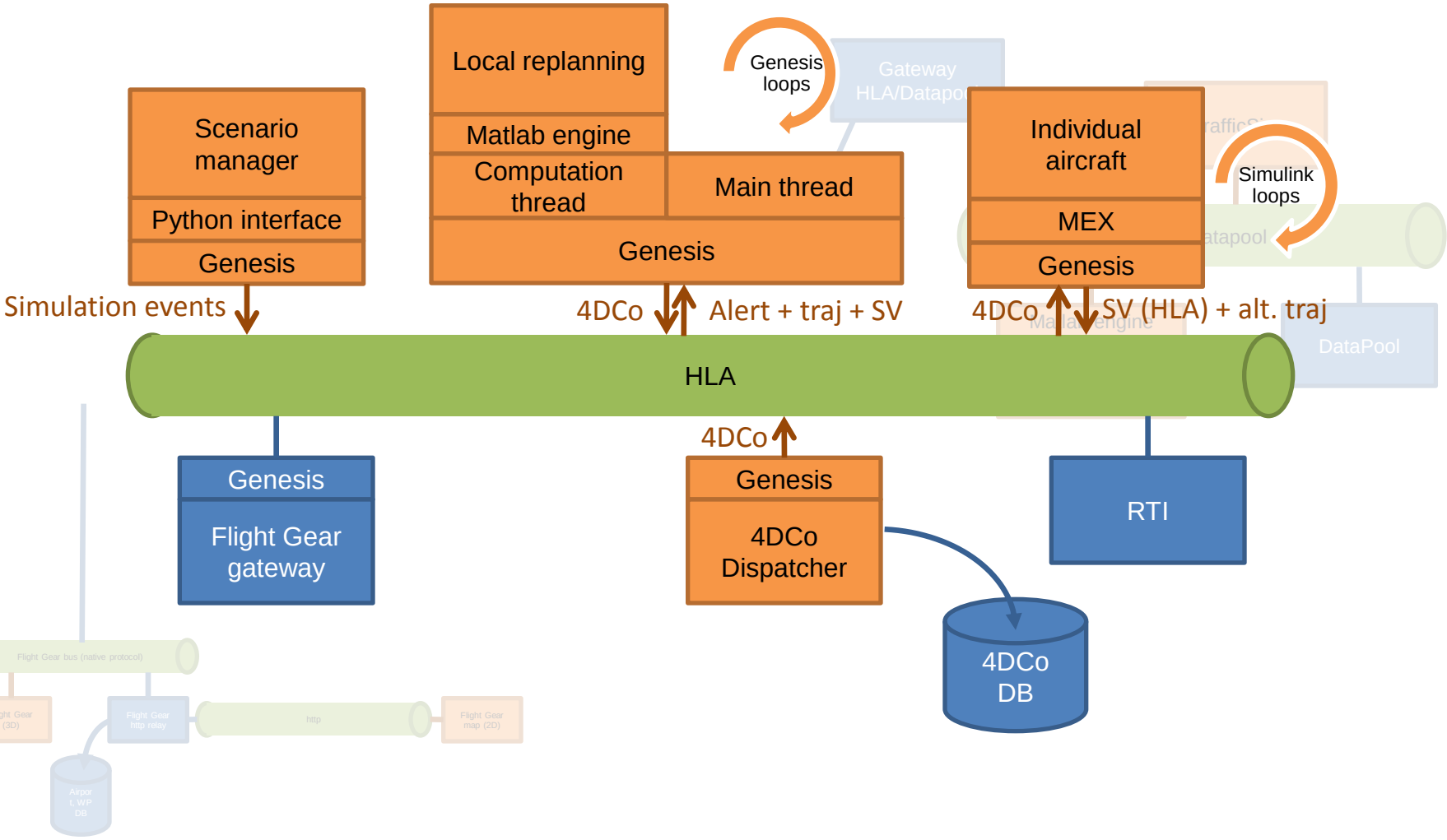
On-line simulation layout



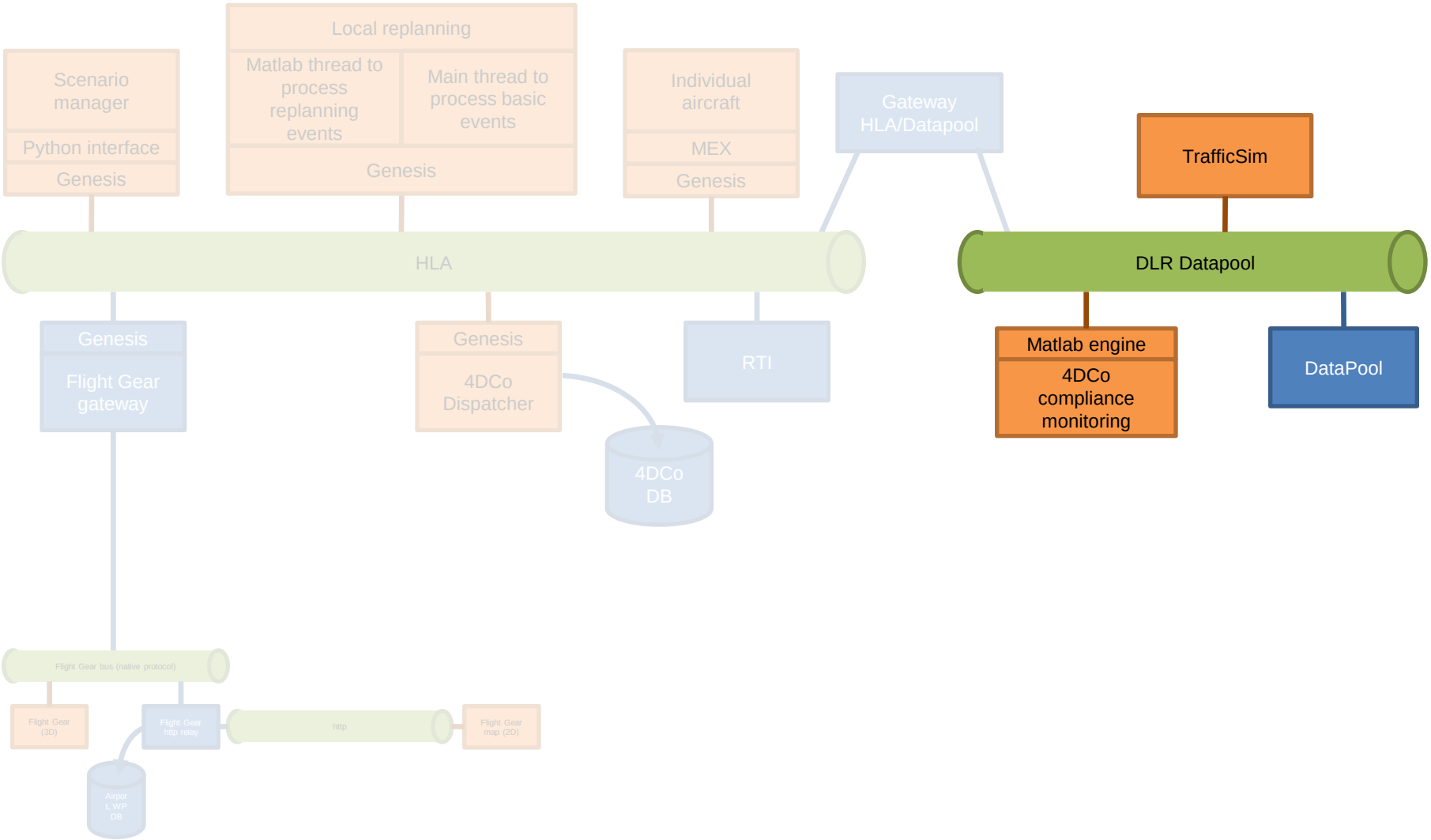
HLA infrastructure



HLA infrastructure



DLR Datapool infrastructure



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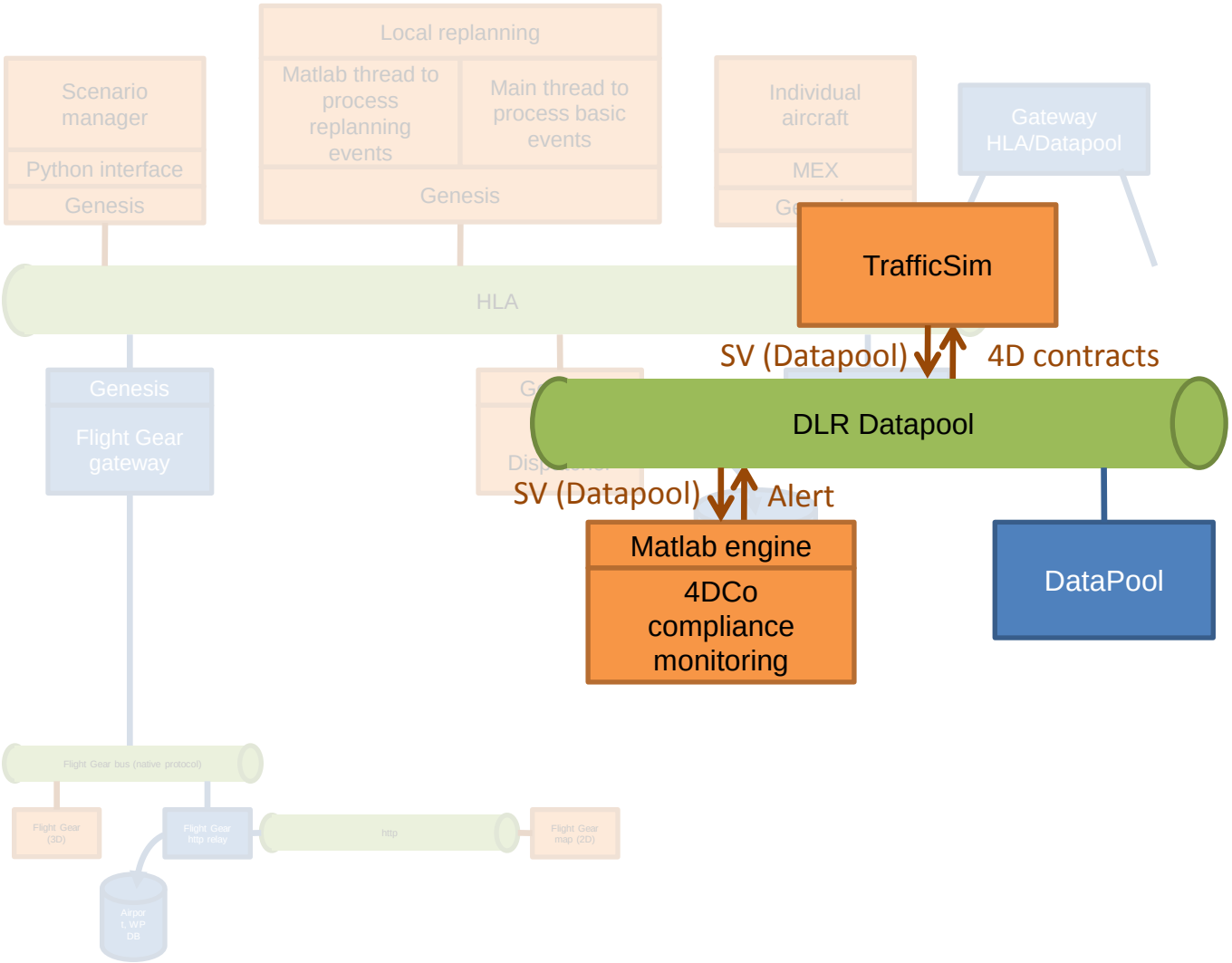
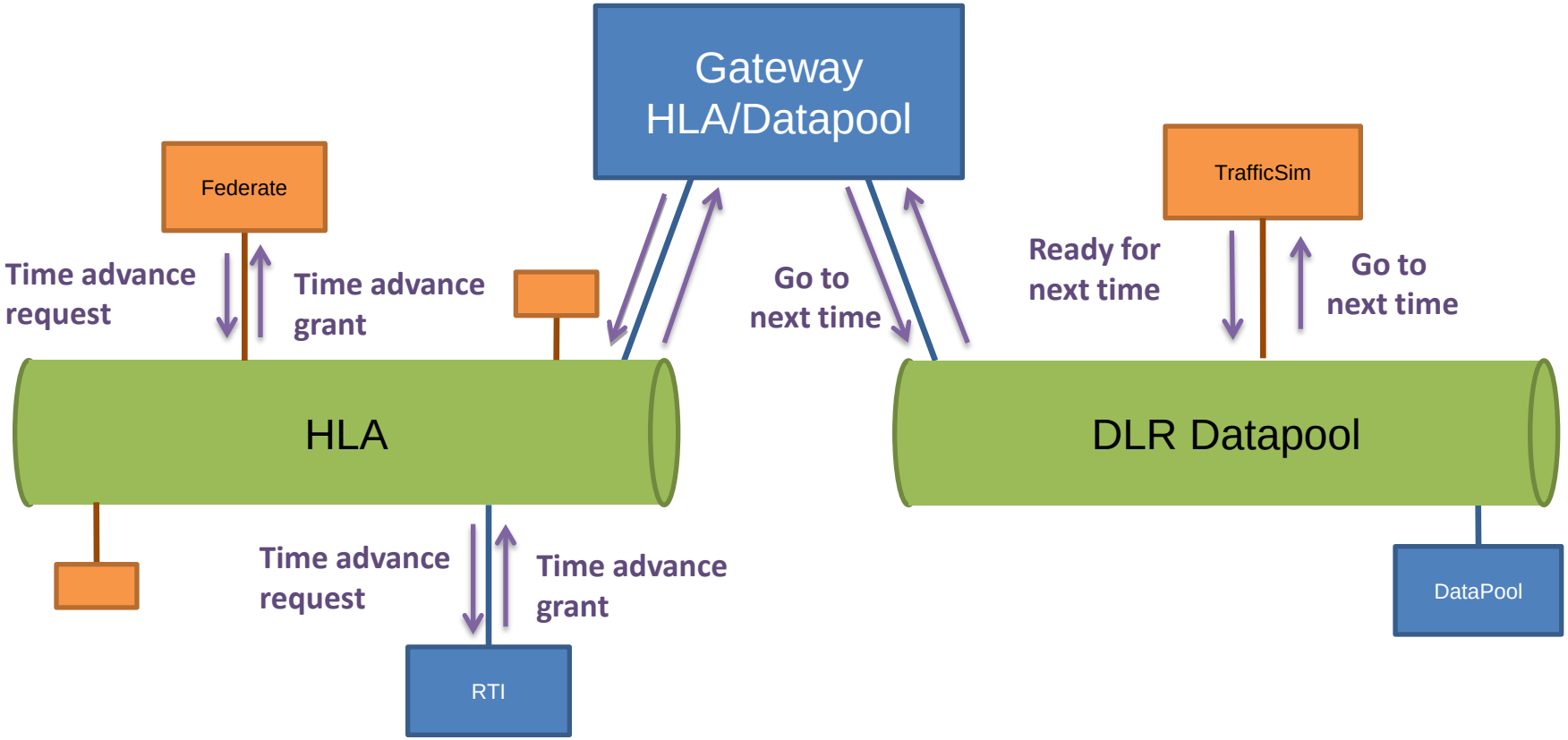
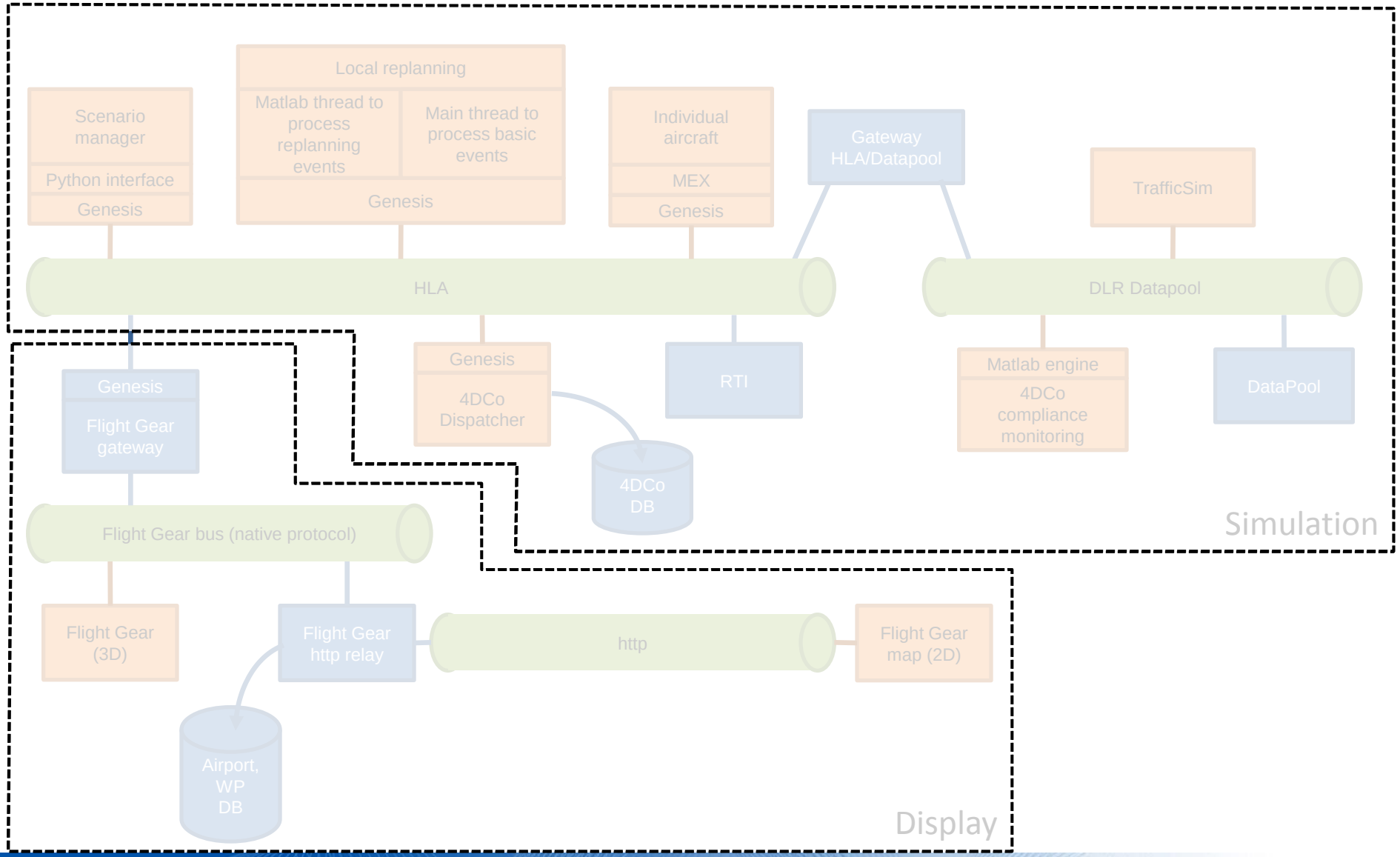
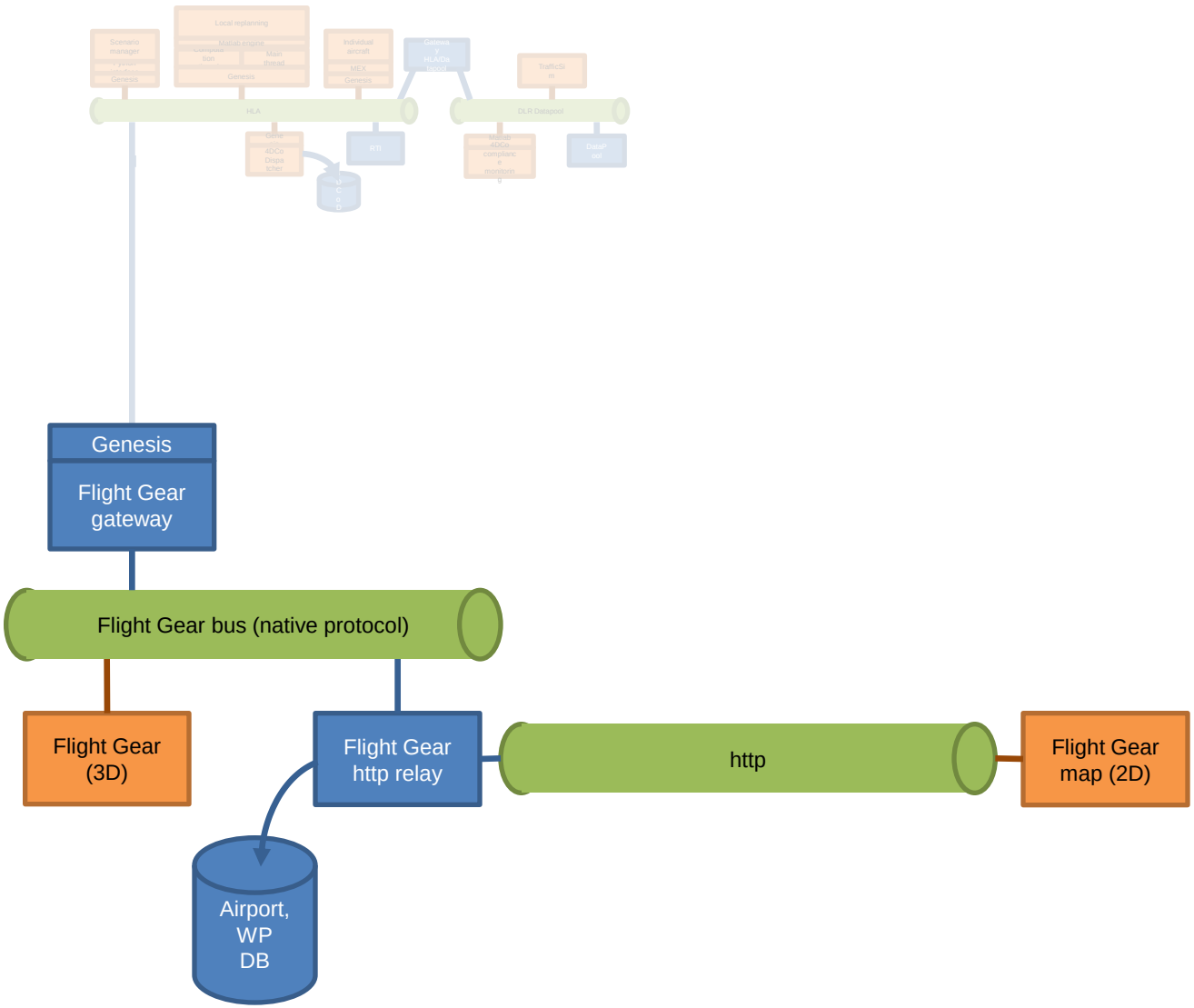


Time stepped simulation




Local replanning
Matlab thread to process replanning events
Main thread to process basic events
Genesis
Scenario manager
Python interface
Genesis
Individual aircraft
MEX
Genesis
Gateway HLA/Datapool
TrafficSim
HLA
DLR Datapool
Genesis
4DCo Dispatcher
RTI
Matlab engine
4DCo compliance monitoring
DataPool
Genesis
Flight Gear gateway
4DCo DB
Simulation
Flight Gear bus (native protocol)
Flight Gear (3D)
Flight Gear http relay
http
Flight Gear map (2D)
Airport, WP DB
Display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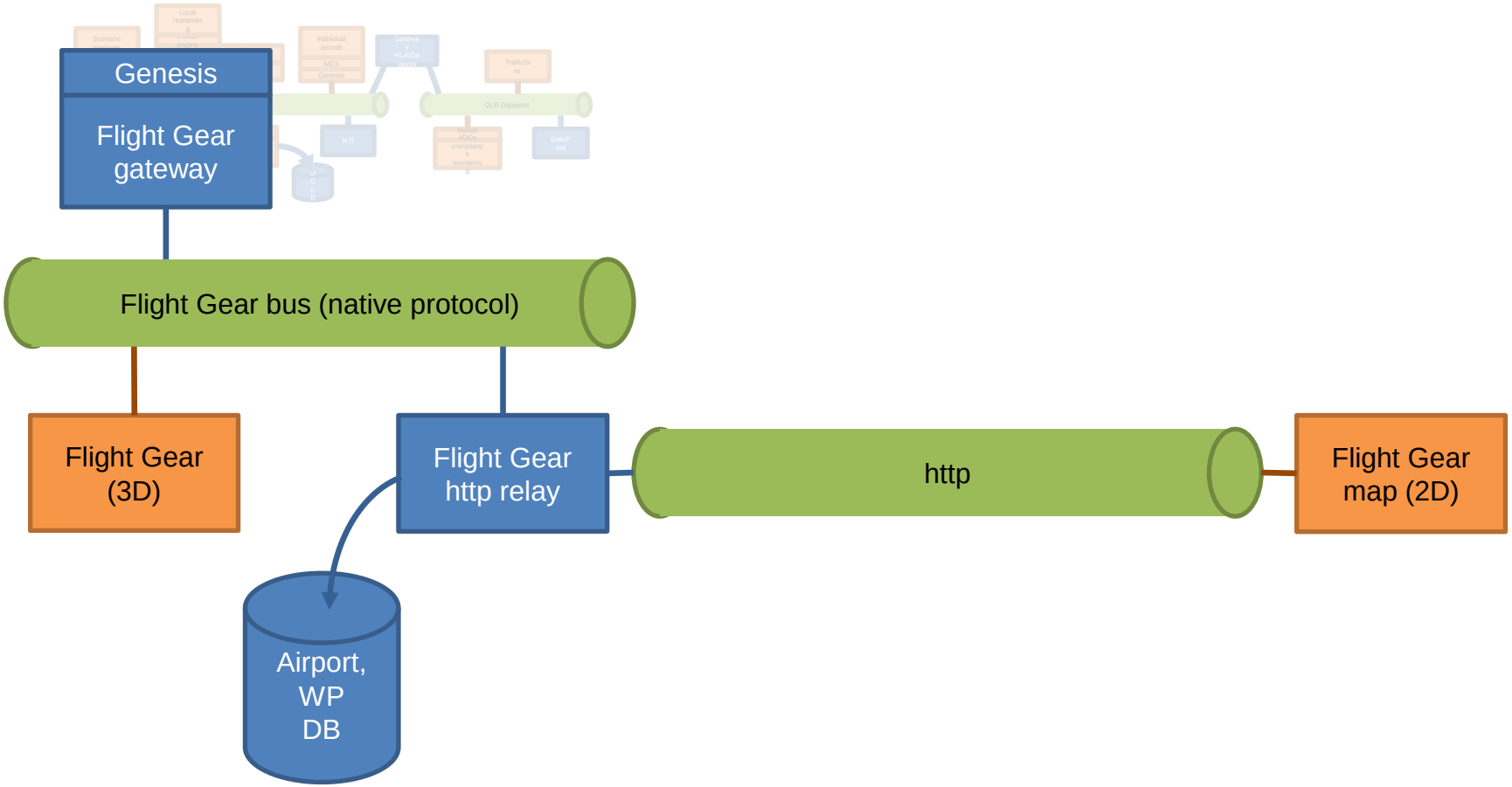
Genesis
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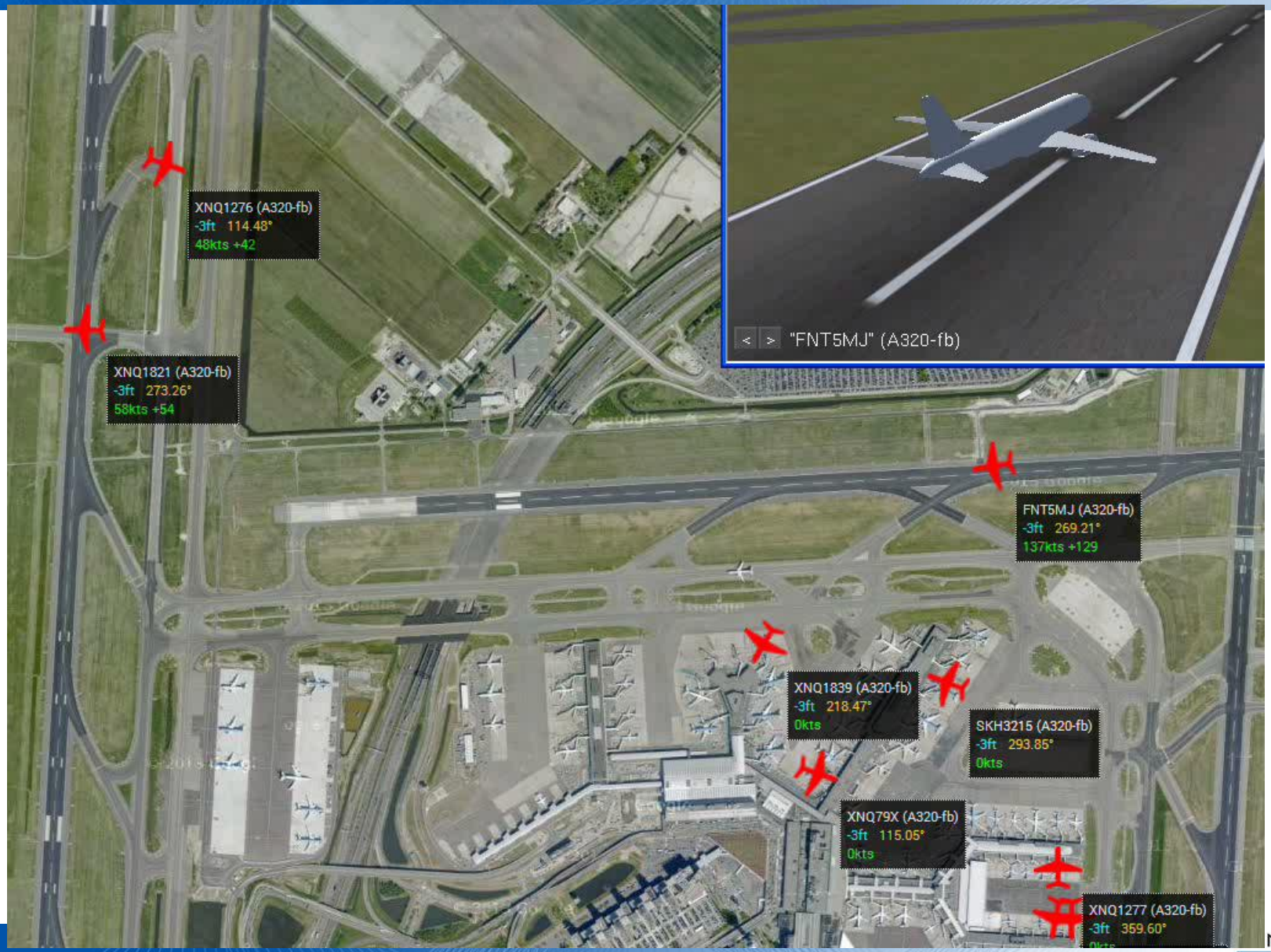
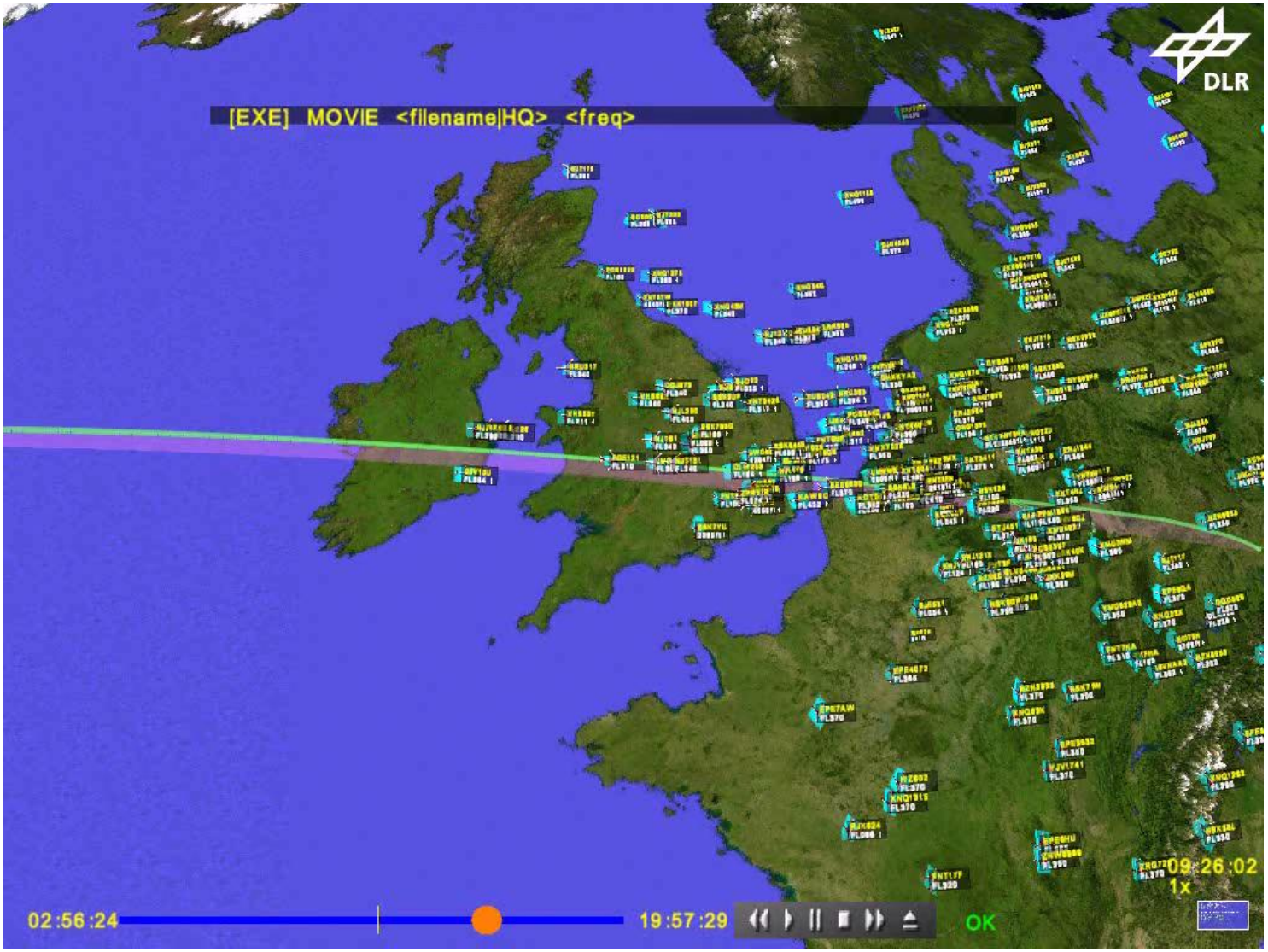
Flight Gear Display



Results, nominal scenario

Results, airport closure

Results, emergency



THANK YOU
FOR YOUR ATTENTION!

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