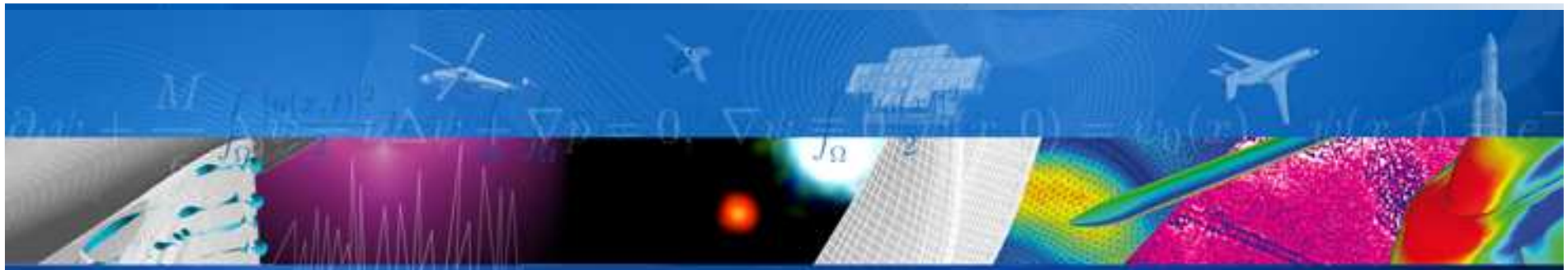

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A model toolbox facility to evaluate innovative solutions for a cleaner airport

ODAS 2008

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Outline

- IESTA platform
- Clean Airport application
- Model toolbox
  - Integration approach
  - Architecture
- Model overview
  - Traffic models
  - Acoustic models
  - Chemistry models
- Conclusions

IESTA platform

- **An infrastructure for evaluating new air transport system concepts including:**

1. Software
   - A distributed simulation framework based on HLA*
   - Simulation management tools / databases
   - A toolbox (library) of models

2. Simulation building
   - A large scale computing and video facility

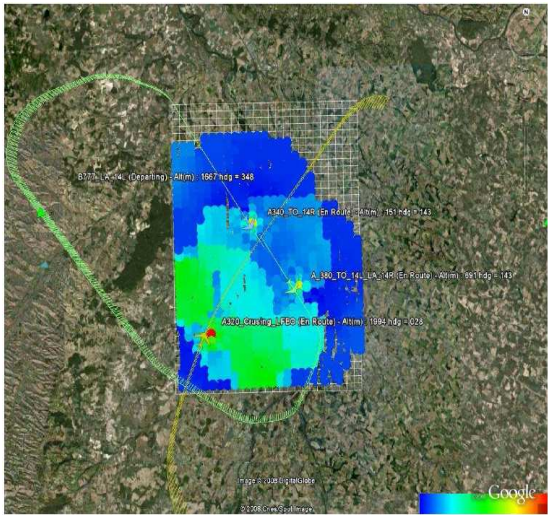
IESTA simulation building

3. People / know-how
   - A dedicated team of multidisciplinary engineers

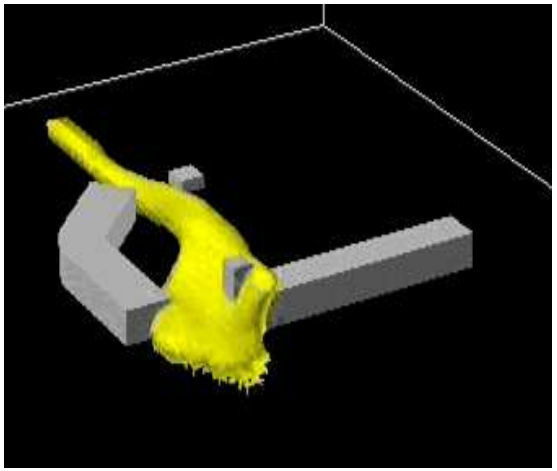
* HLA: High Level Architecture (Interoperability standard)

First IESTA application : Clean Airport

- **To assess potential solutions aimed at reducing the noise and chemical pollution impact of air traffic on airport's surroundings**
  - Changes in aircraft fleet
  - Introduction of new aircraft / propulsion technologies
  - New terminal procedures (CDA*)



- **How:**
  - Building a model toolbox to be integrated into the IESTA platform
  - Adapting platform toolset / databases to manage application-specific scenario data, and results
  - Running simulations to compare scenarios



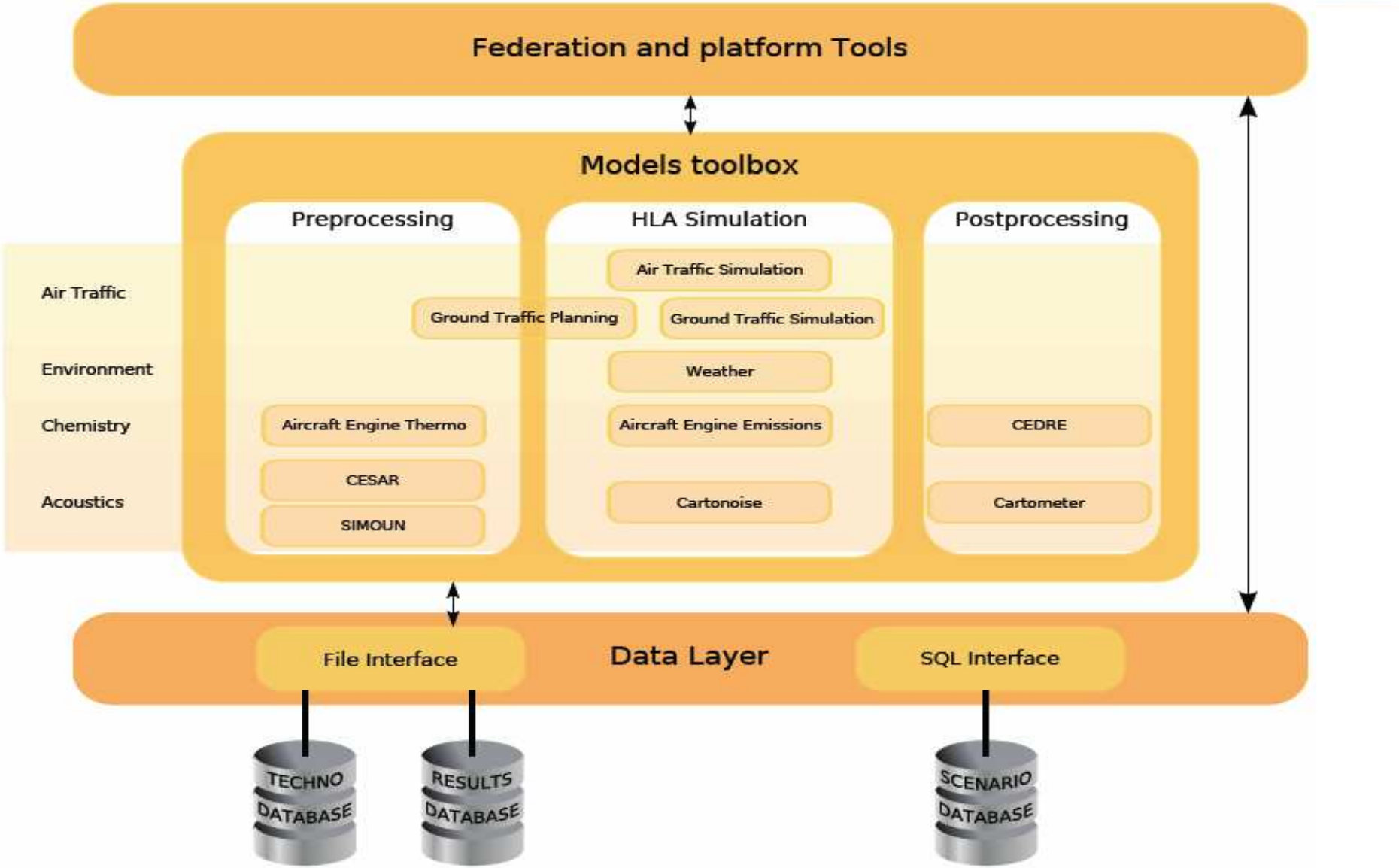
* CDA: Continuous Descent Approach

Model toolbox integration approach

- Challenge
  - Interoperability of a variety of existing time-demanding numerical codes and new fast-time models
  - In a time-constrained simulation environment
  - Minimising the adaptation effort on the existing codes

- Approach
  - Depending on their performance and required input data, models are integrated to operate at:
    - **Pre-processing**: time-consuming numerical codes depending on static data (A/C geometry->Installation effects model)
    - **Simulation**: fast-time models performing “quick” calculations at each simulation time step (ex. Air traffic model)
    - **Post-processing**: time-consuming numerical codes aggregating / exploiting the simulation results (ex. Chemical dispersion model)

Model toolbox architecture



Traffic models

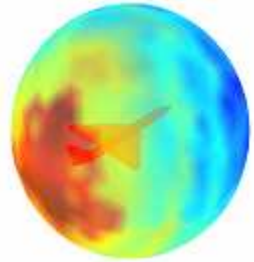
- Air traffic model
  - 4D trajectory generation based on Eurocontrol ***BADA*** model
  - Flight dynamics model, providing extra flight parameters to feed to acoustic and emission models, e.g. Euler angles

- Ground traffic planning model
  - Needs a graph representing the airport
  - Based on shortest-path graph algorithms to generate a set of conflict-free ground plans (gate<->runway)
  - Pre-processed ground plans are updated at simulation time for the aircraft initiating the descent phase or for those due to push-back

- Ground traffic simulation model
  - Executes the ground plans generating the ground trajectories including runway acceleration / deceleration during aircraft take-off / landing

Acoustic models - Pre-processing

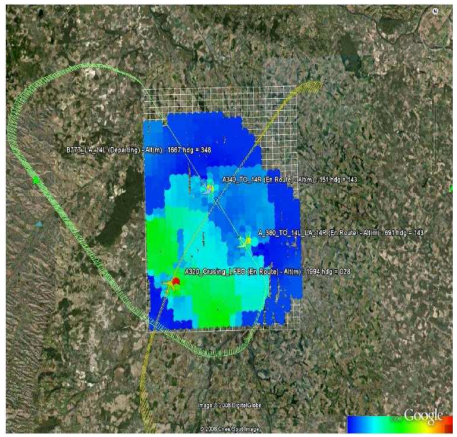
- CESAR
  - Input: aircraft geometry model (IGES)
  - Computes local noise propagation coefficients for different:
    - Frequencies
    - Aerodynamic configurations (landing gear / high-lift devices on / off)
    - Points on a sphere surrounding the aircraft
  - Installation effects (diffraction, reflection) considered

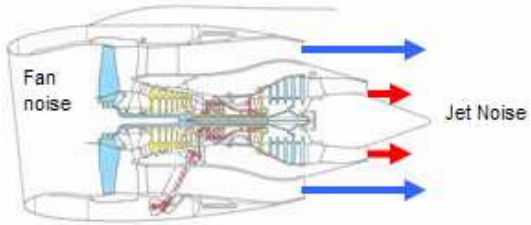


- SIMOUN
  - Input: stratified atmosphere model (ALADIN) for the airport, with wind profiles and temperature gradients for each altitude layer
  - Based on ray tracing, computes the atmospheric propagation effects as well as their subsequent ground reflections (multiple bounding)

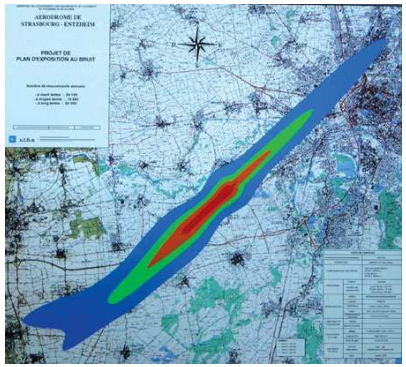
Acoustic models - Simulation/post-processing

- Cartonoise
  - At each simulation time step, computes the noise footprint on the ground for all traffic
  - Noise sources are computed using analytical models
    - Airframe: slaps/flaps, landing gear (on/off)
    - Engine: jet, fan
  - Noise propagation is done by applying the pre-processed CESAR and SIMOUN coefficients





- Cartometer
  - Computes noise metrics by post-processing noise grids generated at simulation
    - LAeq: A-weighted SPL* of a noise fluctuating over a period of time T
    - Lden: A 24 hour LAeq value weighted for night and evening

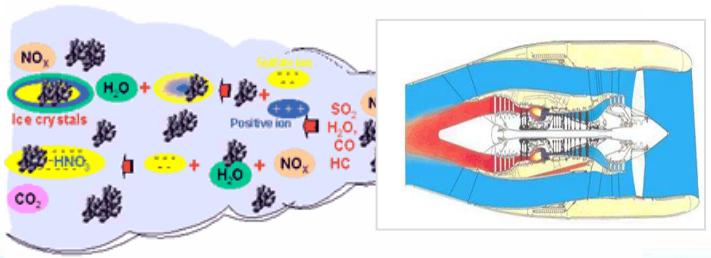


* SPL: Sound Pressure Level

Engine emissions model

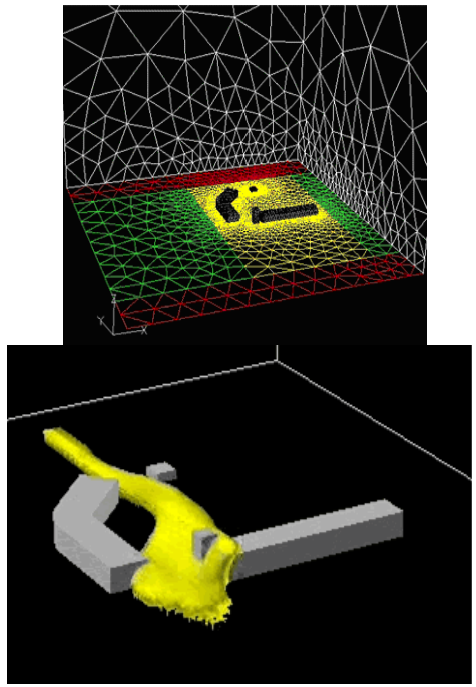
- Estimates at each simulation time step:
  - Exhaust emission rates of CO, CO2, NOx, HC, SOx, soot
  - Other engine parameters for ***Cartonoise*** like Jet/Fan blades Mach Number

- By interpolating:
  - Engine thermodynamic parameters computed by the ***Engine Thermo*** model at pre-processing
  - One of the following emission databases:
    - Turbofans: ICAO Engine Exhaust Emissions Data Bank
    - Turboprops: Swedish Defence Research Agency
    - Pistons: Federal Office of Civil Aviation (Swiss confederation)



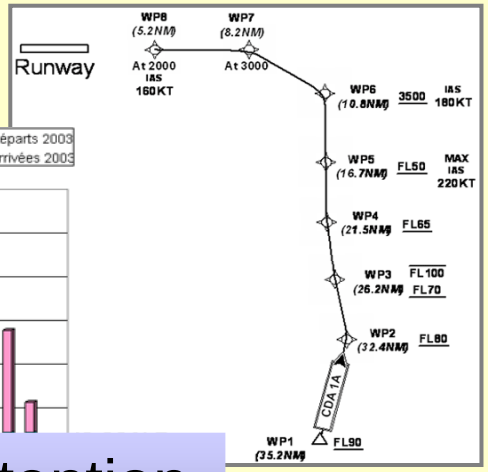
CEDRE - Chemical dispersion model

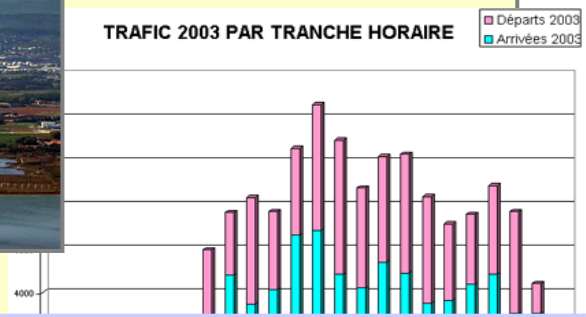
- Existing CFD numerical code being adapted to support emissions from mobiles sources (aircraft)
- Computes at post-processing the atmospheric dispersion of the exhaust emissions generated at simulation
- Needs careful 3D modelling of the airport by means of a mesh, whose resolution has an important impact on the model performance and fidelity
- Requires meteorological conditions and initial concentration of pollutants in the atmosphere
- Results can be exported to TECPLOT or other tools to illustrate the evolution or final concentration of pollutants on maps



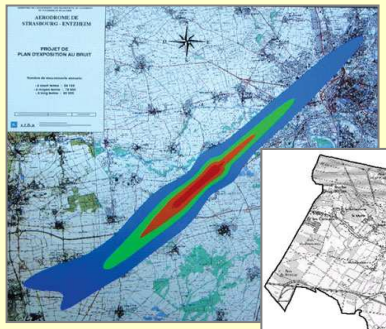
Conclusions

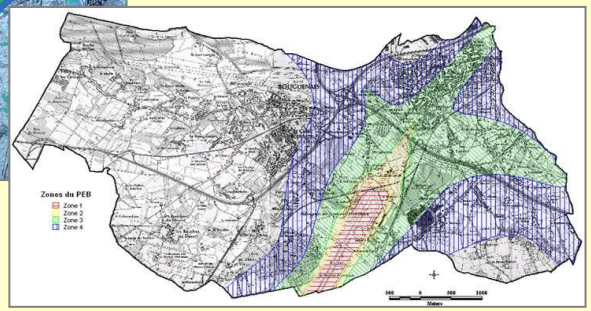
- The proposed approach enables us to build a model toolbox capability by combining existing and new models with different levels of performance and fidelity
- The resulting model toolbox is designed to assess the impact of potential solutions on the noise and chemical pollution
- Integration of the model toolbox into the IESTA platform is underway
- A demonstration of Clean Airport is due in Jan'09
- First operational version of Clean Airport scheduled by June'09





Thank you for your attention.
Any questions?





Enregistrer les résultats