Towards Innovative MEthods for COmbustion Prediction in Aero-Engines

TIMECOP-AE

29-30 March 2011 – Aerodays, Madrid

Coordinator:

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TURBOMECA

PROJECT N° : **AST5-CT-2006-030828**

PROJECT START DATE : **01/06/2006**

DURATION : **48+6 months**

TIMECOP-AE at a glance

- **Towards Innovative MEthods for COmbustion Prediction**
  - Liquid fuel sprays
  - Turbulent combustion
  - Ignition

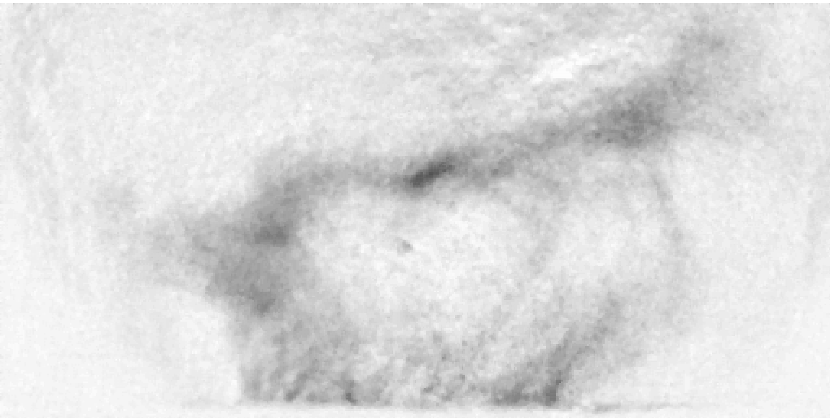
- **Summary**
  - 23 partners from 8 countries (France, Germany, Greece, Italy, Netherlands, Poland, Spain, UK)
  - 4 Work Packages
  - 48 tasks

- **Scientific production**
  - 7 test-rigs
  - 18 CFD codes or modules
  - 94 technical deliverables validated
  - 41 publications produced

- **Simulation results validated**
  - Against experimental data
  - Through code-to-code comparisons

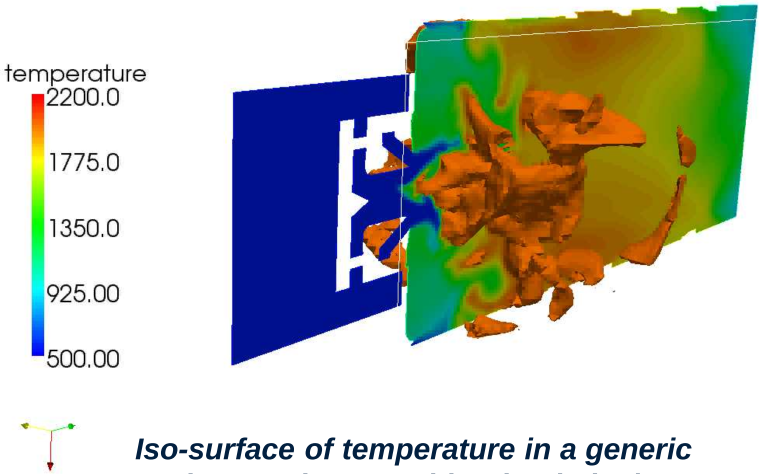
Liquid Kerosene Combustion: 3 Technical Topics

➢Liquid Fuel sprays



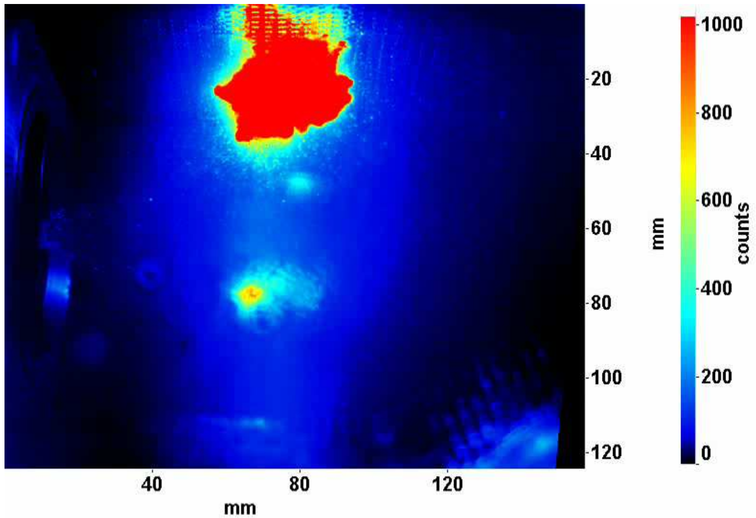
Iso-surface of temperature in a generic burner. (Large-Eddy Simulation)

➢Turbulent combustion



Iso-surface of temperature in a generic burner. (Large-Eddy Simulation)

➢Ignition



High speed video visualization of spark ignition and flame luminosity

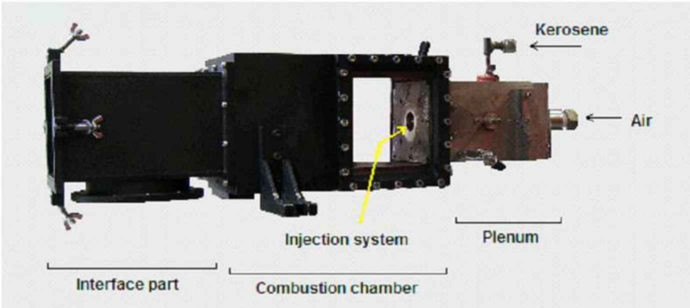
Research Strategy

➢ Objectives of the project

- Understand the physical phenomena associated to liquid fuel combustion in an aeronautical engine
- Develop high-fidelity modelling tools to reproduce these phenomena

➢ Three levels of experimental test rigs

- Experimental facilities aimed at the validation of fundamental works
- Experimental facilities aimed at the validation in complex geometries
- Two-phase flow generic sector combustor

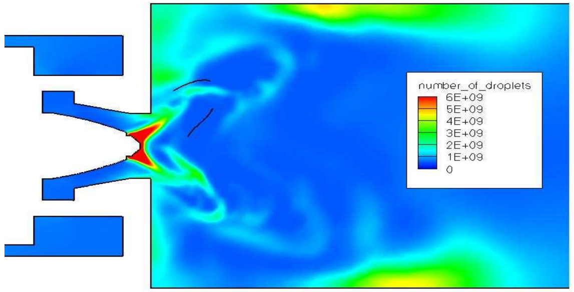


Burner test-rig

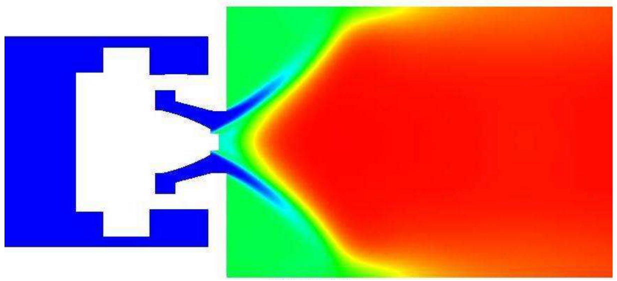
➢ Three levels of numerical tools

- Numerical module
- Research code
- Industrial code

➢ Cross-comparisons



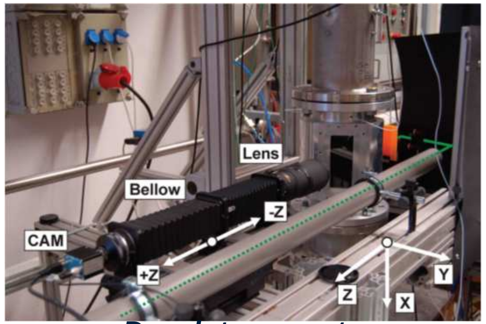
LES calculation (field of liquid kerosene)



RANS calculation (temperature field)

Experimental Facilities

- 3 validation facilities
  - Droplet tracking
  - Detailed flame diagnostics
  - Visualization of ignition sequences

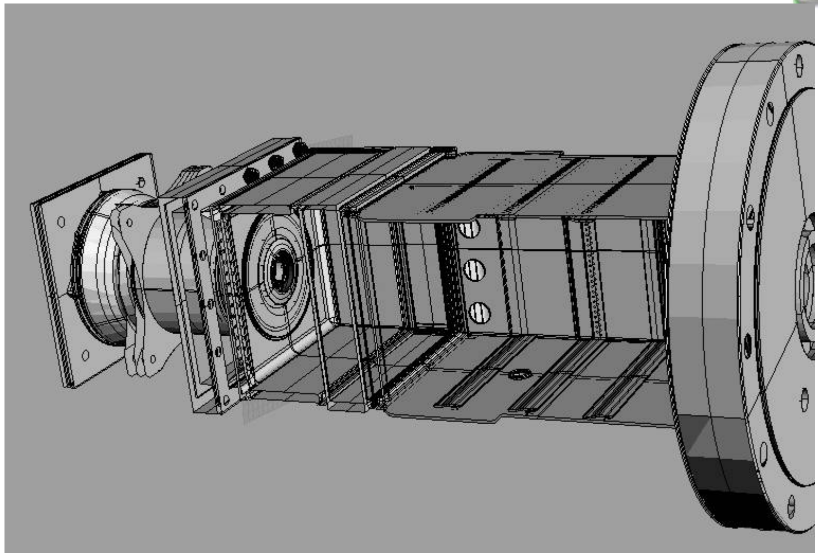


Droplet generator

- 3 complex geometries
  - Liquid fuel spray
  - Swirling flows
  - Optical access

Swirler-nozzle combustion test-rig

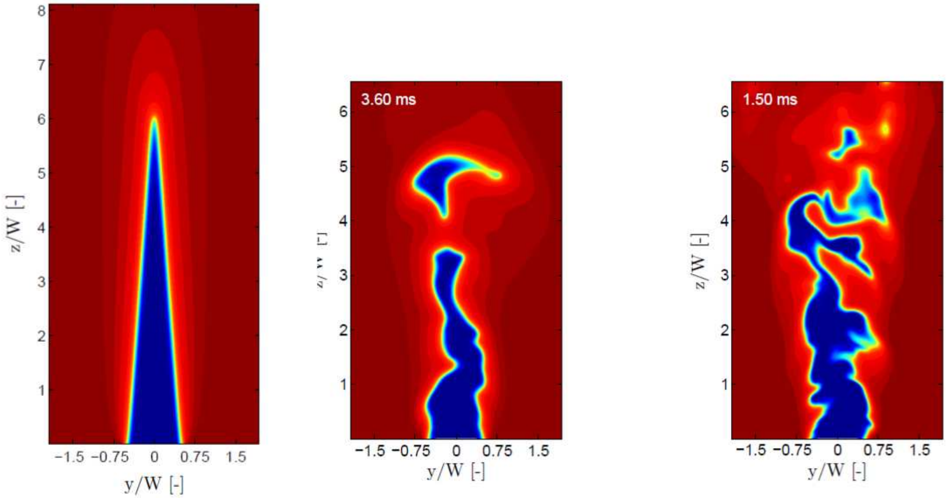
- 1 Generic sector combustor
  - High-pressure facility



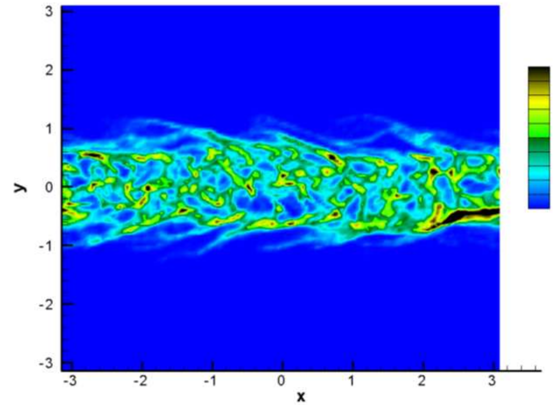
High-pressure Generic combustor sector

Numerical tools

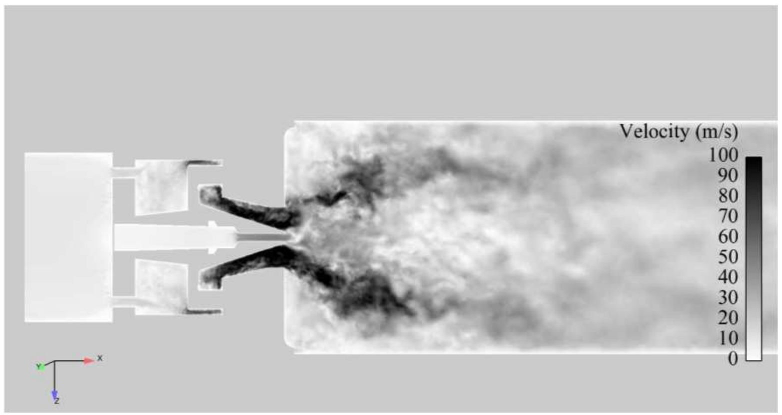
- **5 code modules**
  - Droplet tracking
  - Detailed chemistry calculations
  - Combustion models



- **7 research codes**
  - Experimental facilities aimed at the validation of fundamental works
  - Experimental facilities aimed at the validation in complex geometries
  - Two-phase flow generic sector combustor



- **6 industrial codes**
  - RANS and LES
  - Commercial or private codes



Main Advances in Liquid Fuel Spray Modelling

	Before TIMECOP	After TIMECOP
Experimental Level	lack of accurate measurements of droplet size and velocity in industrial swirling flows	detailed gaseous and liquid phase databases in industrial burner flows
Numerical Level	Lagrangian and monodisperse Eulerian methods available but not tested on industrial configurations	Polydisperse Eulerian and Lagrangian methods tested on industrial configurations. Assessment of the advantages and drawbacks of each method

Advances in Turbulent Combustion Modelling

	Before TIMECOP	After TIMECOP
Experimental Level	lack of details in measurements on industrial configurations of reacting swirling flows (e.g. elevated pressure) . Difficult to validate numerical models (boundary conditions)	detailed flame visualizations and measurements in industrial configurations (e.g. fuel/flame interaction)
Numerical Level	Lack of validation of chemistry schemes (reduced chemistry, tabulated chemistry)	Assesment of several chemistry schemes, pdf methods, pollutant formation methods

Advances in Ignition Modelling

	Before TIMECOP	After TIMECOP
Experimental Level	➢Lack of experimental evidence to describe the ignition phenomenon ➢No knowledge on stochasticity of ignition	visualization of the different phases in the ignition process Ignition probability maps.
Numerical Level	Only semi-empirical ignition models, only simple evalaution of the ignition probability of a burner, no demonstration of the LES unsteady application to the ignition phase	Real unsteady multi-factor ignition models tested, multi-physics models developed, complex sub-models developed for LES that treat ignition

Conclusions and related projects

- **A breakthrough in ignition understanding and modelling**
  - Visualizations
  - Unsteady simulations
  - Numerical assessment

- **A milestone in research on engine operability**
  - Injections systems
  - Ignition methods
  - Importance of Large-Eddy Simulations
  - Bottleneck with primary atomisation

- **To go further: related FP7 projects**
  - KIAI: ignition and instabilities
  - FIRST: primary atomisation