R&D Full-Scale Facility for Aircraft Engine Fire Safety

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Context

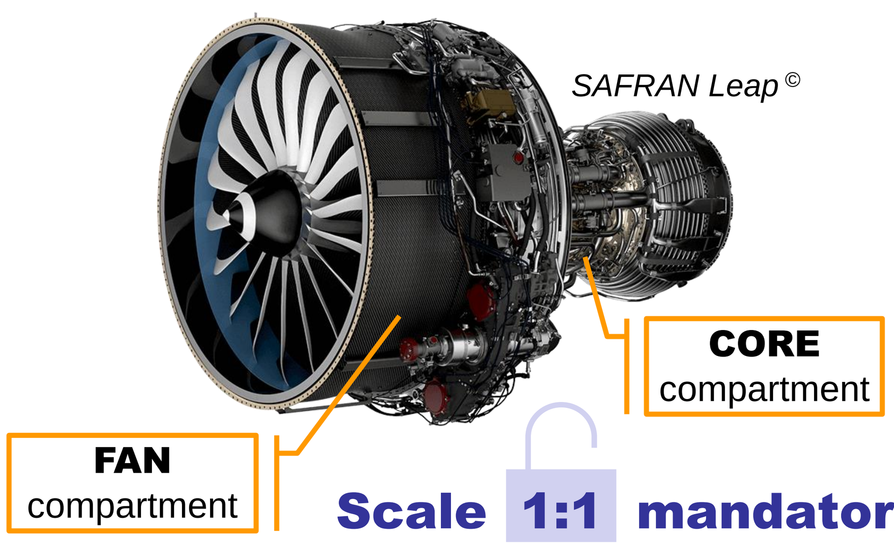
- Aircraft/engine fire safety
- Greener aviation: next generation composite materials for lighter structures
- Greener extinguishing agent: halon replacement
- European strategic and industrial independence:
  - *Alternative to FAA engine nacelle fire simulator*

Technical scope

- Engine compartments located in fire areas:
  - *FAN & CORE compartments*
- Assessment of thermal environment induced by:
  - *Jet fuel leak combustion (spray or pool fires)*
  - *Latent leak or burst of a high pressure hot air duct*
- New fire suppressant efficency evaluation

pycofire

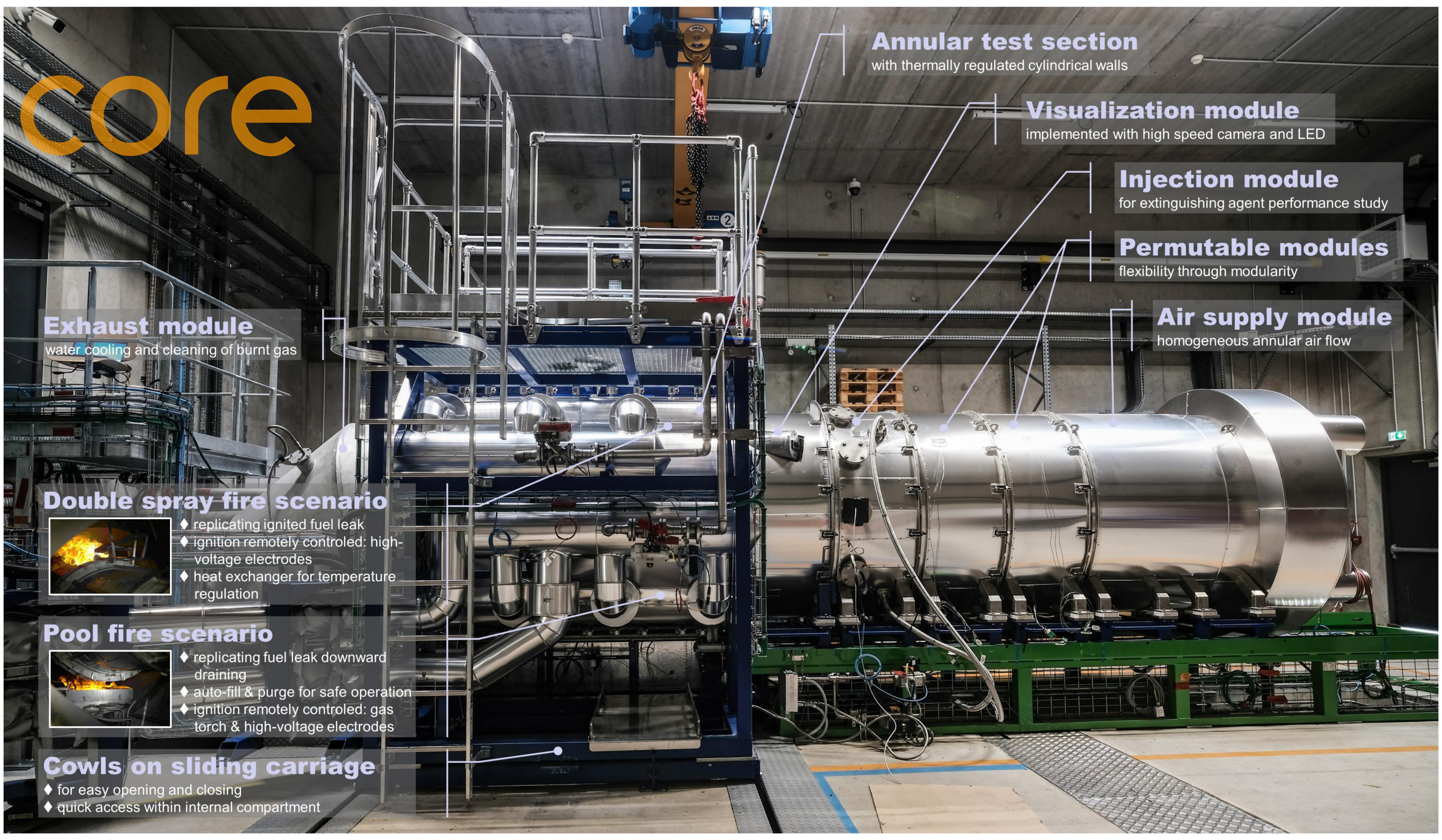
Pyrénées Composite Fire Research



Scale 1:1 mandatory

Objectives

- Integration and combination of physical and optical measurements to build detailed reference database for model development and validation on large scale configurations:
  - *representative test environments (air/fuel/agent injection and boundary conditions)*
  - *fire onset and growth within confined compartments*
  - *heat transfer on components across wide range venting conditions*
  - *thermal regulation of the test section and fluid supply for test conditions to be accurately repeatable*
- Fire resistance improvement of metallic and composite materials
- Extension of experimental research resources to new environmental and societal issues



FIRE SCENARIOS

DOUBLE SPRAY FIRE @12H

- $\dot{m}_{spray} = [0\ ;20\ g/s]$
- $T_{fuel} = [+20\ °C\ ;\ +70\ °C]$

POOL FIRE @6H

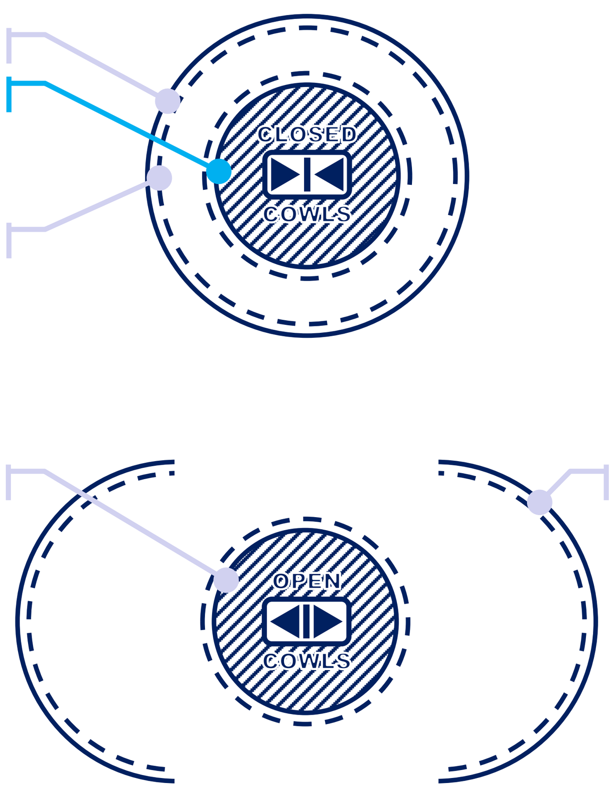
- $T_{fuel} = [+20\ °C\ ;\ +70\ °C]$
- *Length :* $L_{fuel} = 521\ mm$
- *Width :* $l_{fuel} = 274 \pm 50\ mm$

Annular test section

- External diameter: $1.4\ m$
- Internal diameter: $0.8\ m$
- Axial length: $1.8\ m$
- $3 \times 600mm$ internal zones
- Removable rib frames on cowls
- Instrumentated flanges between carters
- Free annular air outlet

Electrical power control
Carters 1&2 thermal management

- Electrical heating elements
- $T_{cowls} = [+50\ °C\ ;\ +370\ °C]$
- Zonal heating per quadrant (N,W,S,E)
- $P_{heating} = 8 \times 3.55\ kW$
- Independent temperature setpoint for carters #1& #2
- Adiabatic carter #3 (downstream position)



Modular design

- 360° uniform flow distribution within the plenum chamber to supply steady venting conditions to the test section
- Permutable function modules (rotation and/or interchangeable position) for a wide range of test configurations
- Sealed passages for probes (T, P, C, V)
- (De-)mountable equipment boxes to replicate engine's internal footprint

Circulation cryothermostat
Cowls thermal management unit

- Double-skinned heat exchanger
- $T_{cowls} = [-30\ °C\ ;\ +130\ °C]$
- $P_{cooling} > 160\ kW$
- $P_{heating} > 110\ kW$
- High mass flow rate of *Therminol D12* © liquid heat transfer fluid: uniform & constant cowls temperature during test

2 AIR SUPPLY LINES

VENTILATION REGIMES

- $\dot{m}_{high\&warm} = 1.4\ kg/s$ | $T_{high\&warm} = 38\ °C$
- $\dot{m}_{low\&hot} = 0.45\ kg/s$ | $T_{low\&hot} = 121\ °C$
- $\dot{m}_{cold} = 1.0\ kg/s$ | $T_{cold} = -30\ °C$

MEASUREMENTS

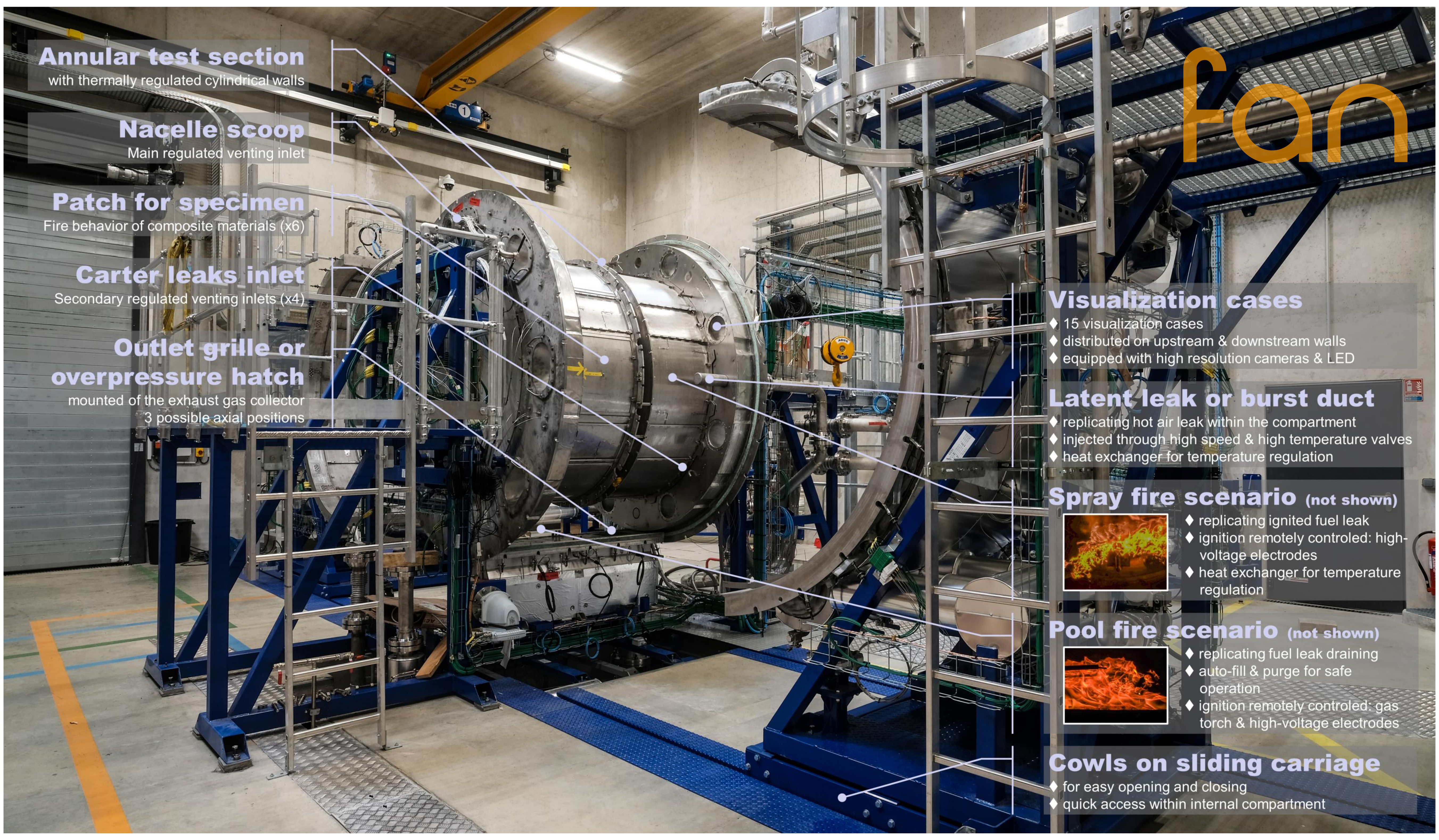
TEMPERATURE
- 288 thermocouples

PRESSURE
- 4 pressure sensors

AIR VELOCITY
- 4 hot film air flow sensors

GAS SPECIES CONCENTRATION
- 24 gas sampling tubes

OPTICAL TECHNIQUES
- high speed imaging
- laser velocimetry
- infrared thermography
- digital image correlation



TEST SCENARIOS

SPRAY FIRE @3-6-9-12H

- $\dot{m}_{spray} = [0\ ;20\ g/s]$
- $T_{fuel} = [+20\ °C\ ;\ +70\ °C]$

POOL FIRE @6H

- $T_{fuel} = [+20\ °C\ ;\ +70\ °C]$
- *Length :* $L_{fuel} = 521\ mm$
- *Width :* $l_{fuel} = 274 \pm 50\ mm$

LATENT LEAK & BURST DUCT

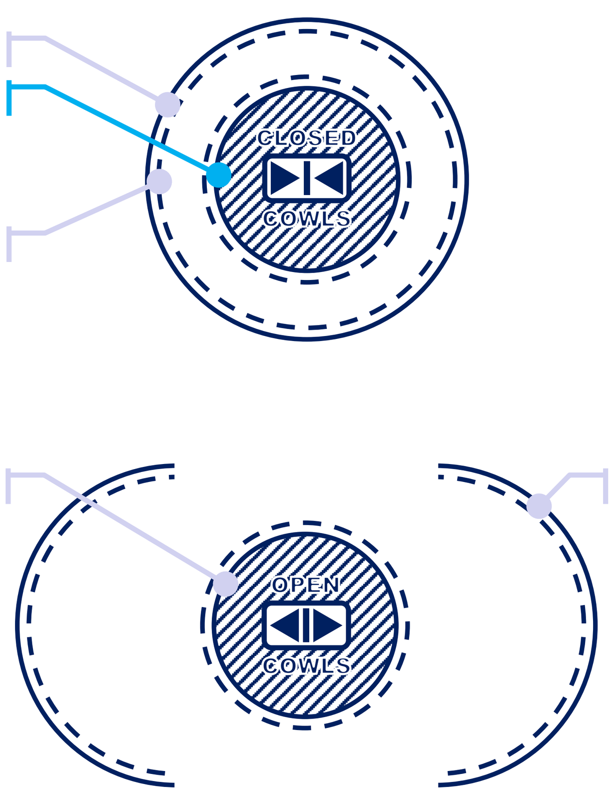
- Sudden hot air leak from a broken pipe

Annular test section

- External diameter: $2.4\ m$
- Internal diameter: $1.8\ m$
- Axial length: $1.3\ m$
- $2 \times$ internal zones (2-piece carter)
- Removable rib frames on cowls
- Instrumentated flange between carters
- Thermally insulated patched carter #1

Circulation cryothermostat
Carters #2 thermal management unit

- Double-skinned heat exchanger
- $T_{cowls} = [+50\ °C\ ;\ +160\ °C]$
- $P_{cooling} > 160\ kW$
- $P_{heating} > 110\ kW$
- High mass flow rate of *Therminol SP* © liquid heat transfer fluid: uniform & constant carter temperature during test



Modular design

- Rotating carter #1 for positioning material specimens in the fire ignition area
- 15 optical access windows for detailed visualization within the compartment
- Distributed piping connections to represent any engin architecture
- Sealed passages for probes (T, P, C, V)
- (De-)mountable equipment boxes to replicate engine's internal footprint

Circulation cryothermostat
Cowls thermal management unit

- Double-skinned heat exchanger
- $T_{cowls} = [-30\ °C\ ;\ +130\ °C]$
- $P_{cooling} > 160\ kW$
- $P_{heating} > 110\ kW$
- High mass flow rate of *Therminol D12* © liquid heat transfer fluid: uniform & constant cowls temperature during test

3 AIR SUPPLY LINES

- $\dot{m}^{max}_{scoop} = 0.4\ kg/s$ | $T_{scoop} = [-30\ ;\ 100\ °C]$
- $\dot{m}^{max}_{carter\ leaks} = 0.1\ kg/s$ | $T_{carter\ leaks} = [20\ ;\ 100\ °C]$
- $\dot{m}^{max}_{burst\ duct\ latent\ leak} = 1.0\ kg/s$ | $T^{max}_{burst\ duct\ latent\ leak} = +477\ °C$

MEASUREMENTS

TEMPERATURE
- 288 thermocouples

PRESSURE
- 12 pressure sensors

HEAT RELEASE RATE
- O_2 gas analyzer in outlet section

GAS SPECIES CONCENTRATION
- 24 gas sampling tubes

OPTICAL TECHNIQUES
- high speed imaging
- laser velocimetry
- infrared thermography
- digital image correlation

RÉPUBLIQUE FRANÇAISE Liberté Égalité Fraternité — ONERA THE FRENCH AEROSPACE LAB — AIRBUS — arianeGroup — SAFRAN — L'EUROPE S'ENGAGE L'OCCITANIE AGIT — UNION EUROPÉENNE — La Région Occitanie Pyrénées - Méditerranée

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