This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 723525

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Jet fuel screening and preselection

international efforts to support SAF development and approval

Presenter: Bastian Rauch (DLR)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723525

Enable climate neutral aviation

Utilization

Production

Added value for on-going & future projects to valorize under utilized feedstock (residues, wastes, industrial by-products)

BECOOL (lignocellulosic biofuels)	eForFuel (TRL4 / 2022)	HyFlexFuel (TRL5 / 2021)	PhotoFuel (TRL5 / 2020)
SUN-to-LIQUID (TRL4 / 2019)	BioMates (TRL5 / 2021)	Heat-To-Fuel (2021)	TO-SYN-FUEL (TRL5 / 2021)
Bac-To-Fuel (TRL5 / 2021)	KEROGREEN (TRL4 / 2022)	FlexJET (TRL6 / 2022)	BioRen (TRL5 / 2022)

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Enable climate neutral aviation

Utilization

Production

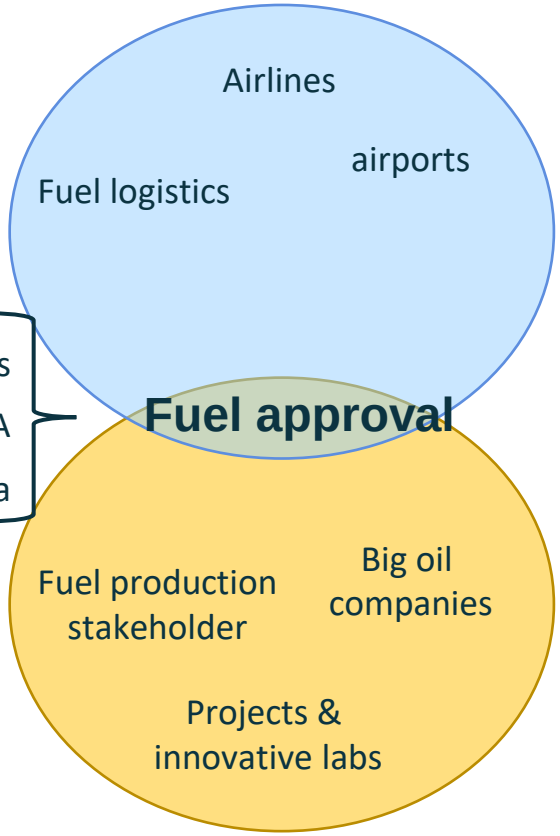
Knowledge gap I: approval

Aircraft & engine OEMs
ASTM, FAA, EASA
Academia

Projects & innovative labs

Big oil companies

Fuel production stakeholder



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Enable climate neutral aviation

Utilization

Production

Knowledge gap I: approval

Knowledge gap I – levels:

1. ~10%: No knowledge about aviation fuel requirements at all
2. ~ 40%: Approval means meeting specification properties
3. ~40%: ASTM D4054 is known, but not the costs and time
4. ~10%: Effort is known, limited knowledge about factors influencing Tier 3&4 properties

Projects & innovative labs

"Big oils"

Fuel production stakeholder

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Enable climate neutral aviation

Utilization

Production

Knowledge gap I a: approval

Knowledge gap I b: production

Knowledge gap I b - production:

- How are fuel specification constraints affecting produced volumes, prices, feedstock that can be used, … ?
- What are the challenges when developing a new fuel production pathway (chemical upscaling,…)?
- What are the most critical specification properties to get under control?
- …?

Our blind spot

Projects & innovative labs

Big oil companies

Fuel production stakeholder

Challenge III:
Very high complexity that hinders effective decision making

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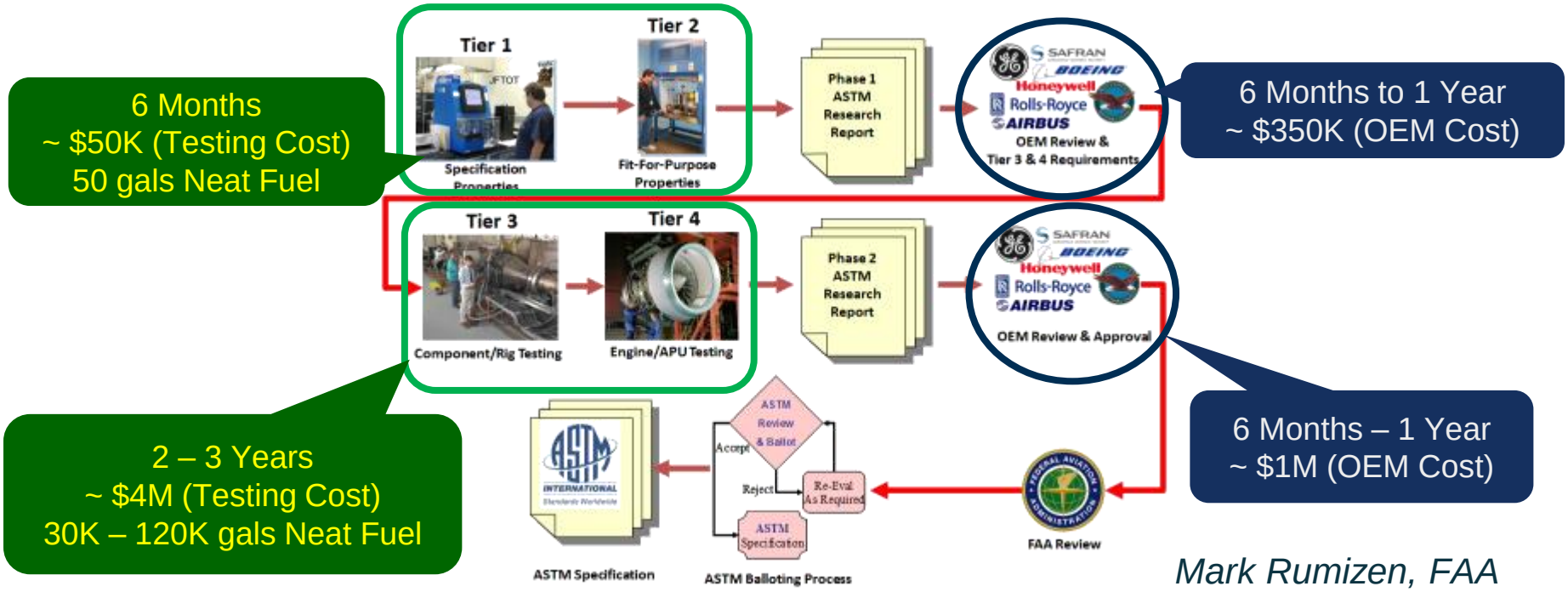
Ensure technical suitability: ASTM D4054 process



Mark Rumizen, FAA

- Why is it so costly? What are the risks?
- How can JETSCREEN help?

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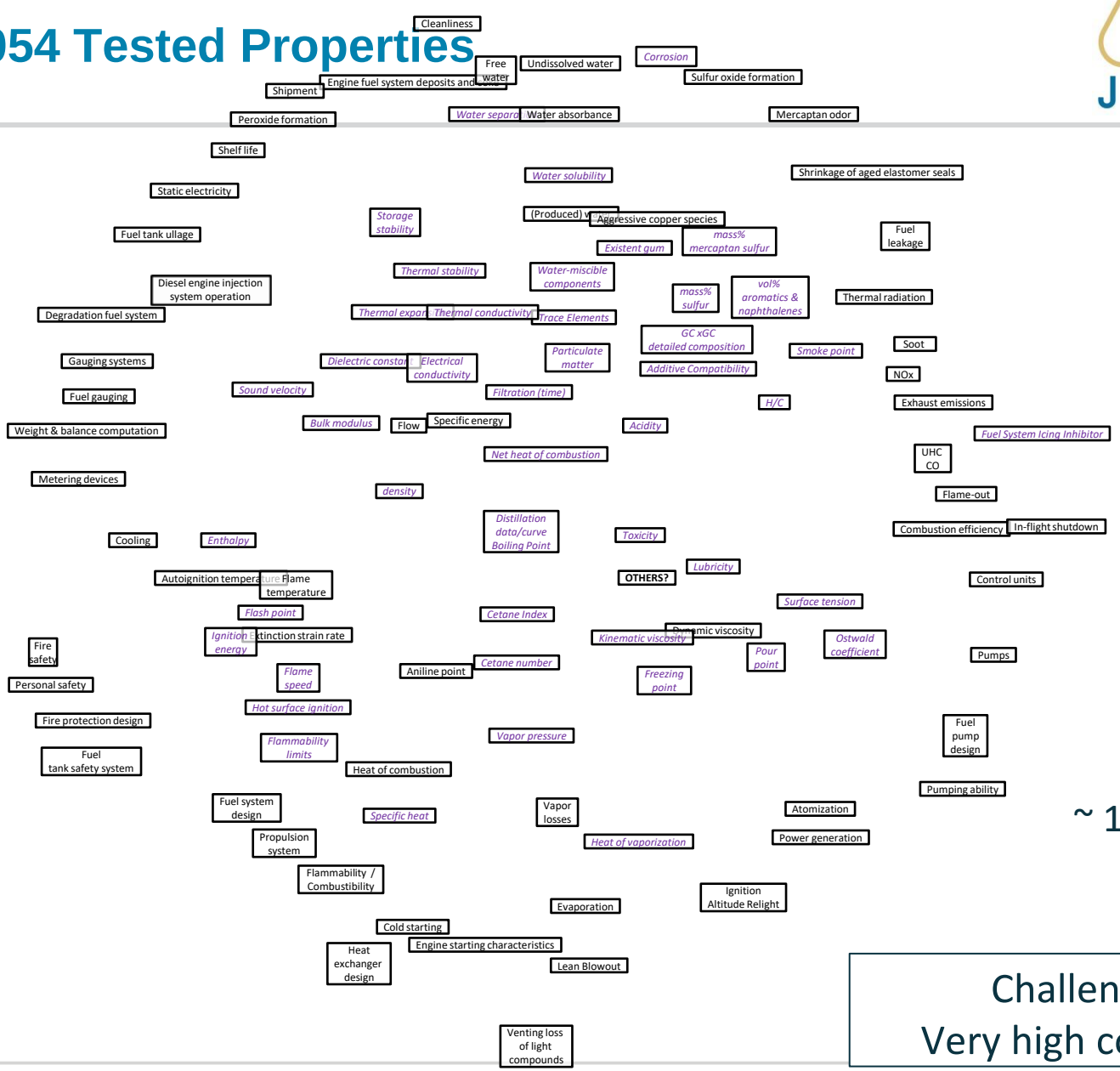
ASTM D4054 Tested Properties



~ 100 properties

Challenge III:
Very high complexity

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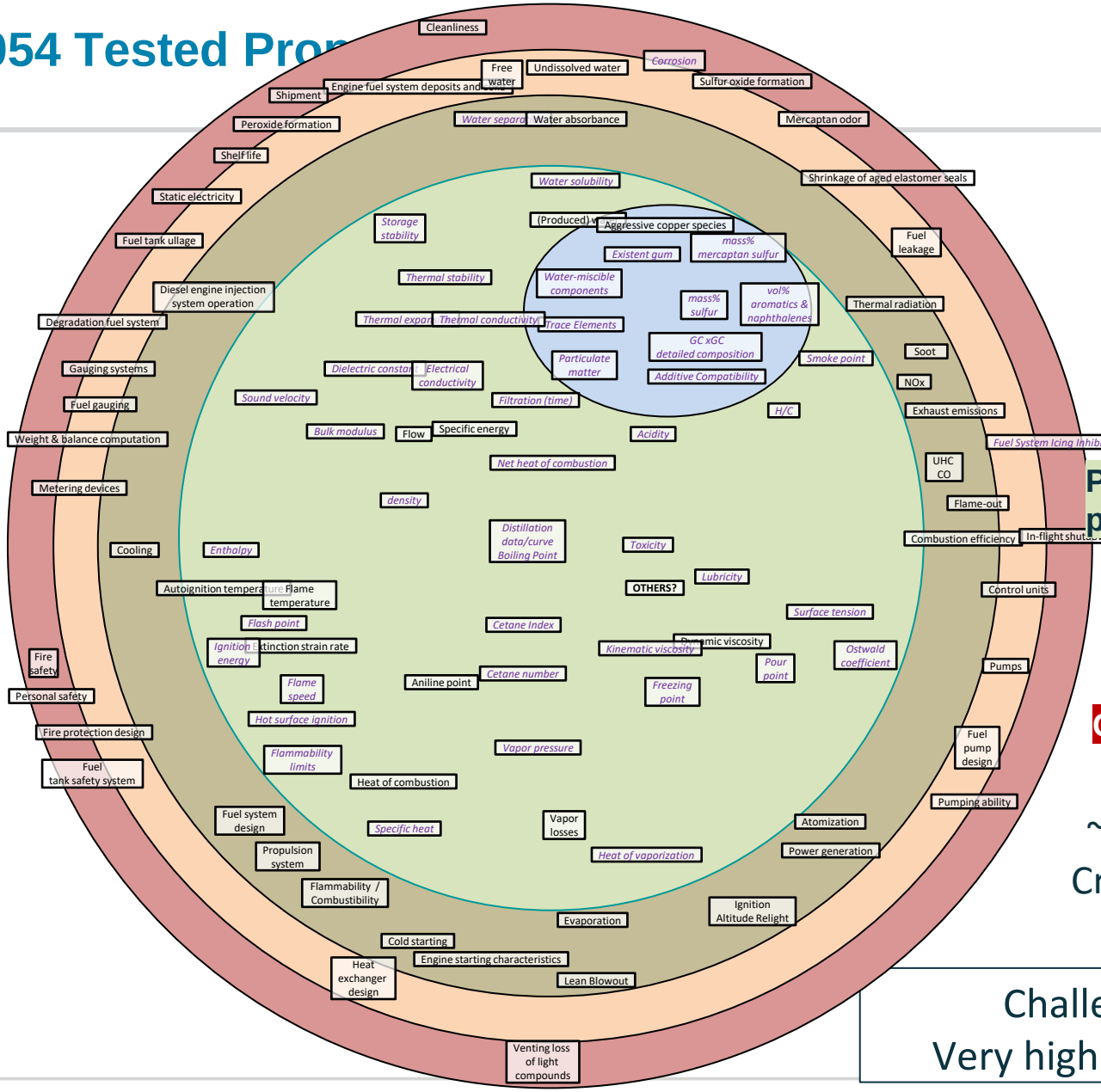
ASTM D4054 Tested Pro



Composition

Physical chemical properties

Engine

Airframe

Ground-handling

~ 100 properties
Cross-disciplinary

Challenge III:
Very high complexity

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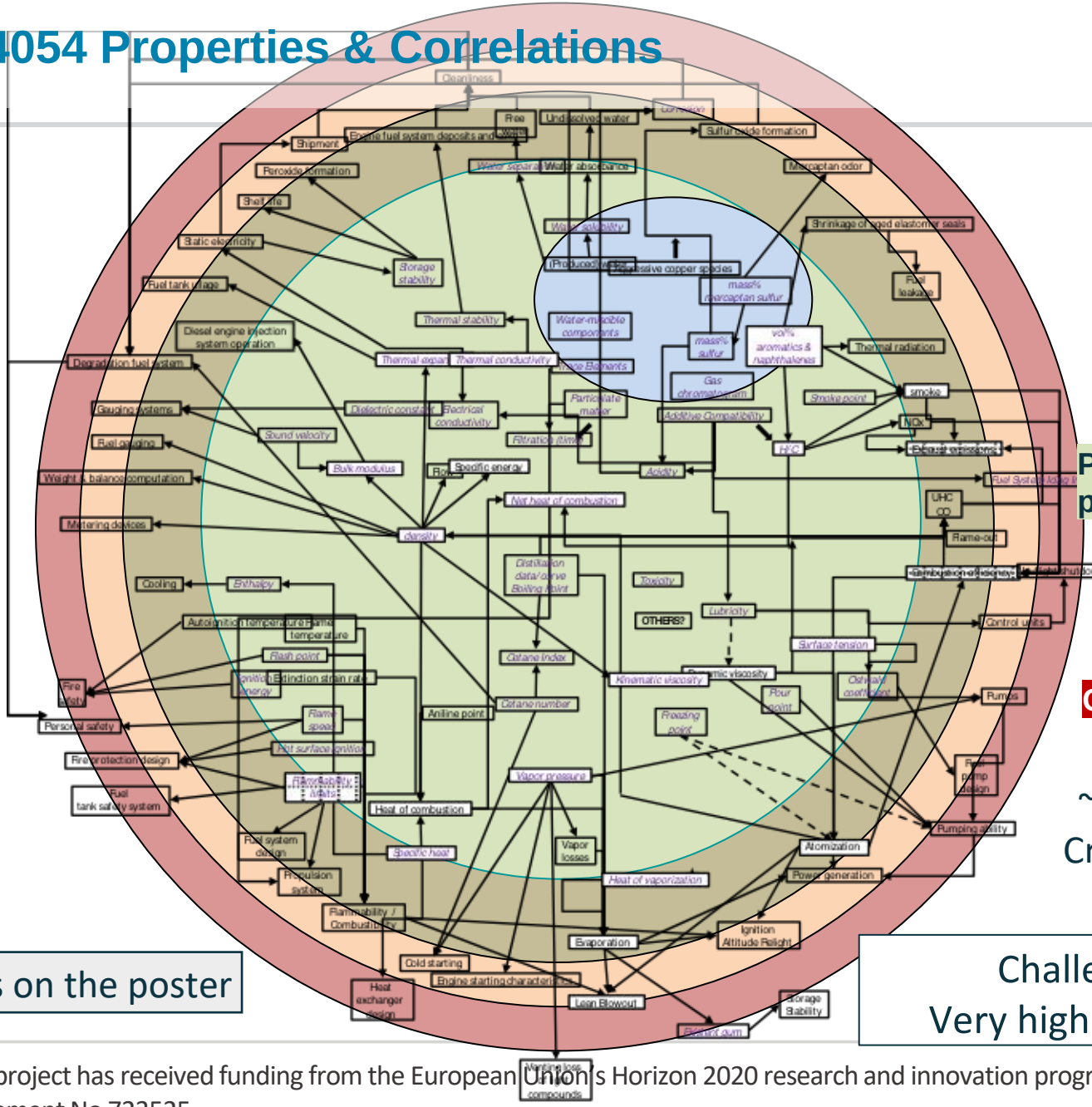
ASTM D4054 Properties & Correlations

JETSCREEN



Composition

Physical chemical properties

Engine

Airframe

Ground-handling

~ 100 properties
Cross-disciplinary
~400 relations

More details on the poster

Challenge III:
Very high complexity

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Risks associated with fuel approval

I. Fuel Approval -

- Early stage producers underestimate fuel approval process (considering only D1655 Table 1)
- Risk of late stage pivot (high costs):
  - Fail in high volume combustion testing
  - Difficulty to get strongly non-linear phenomena like thermal stability or non-linear blending behavior, e.g. freezing point under control

II. Chemical Process Development.

- Target properties that cannot be addressed directly (e.g. chemical composition, high altitude relight, unspecified properties)
- Difficult upscaling of chemical processes → Vicious circle:

De-risk to get funding for upscaling

Best chances: Deliver all fuel when entering approval*

** during upscaling fuel properties might change significantly*

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JETSCREEN-NJFCP Impact

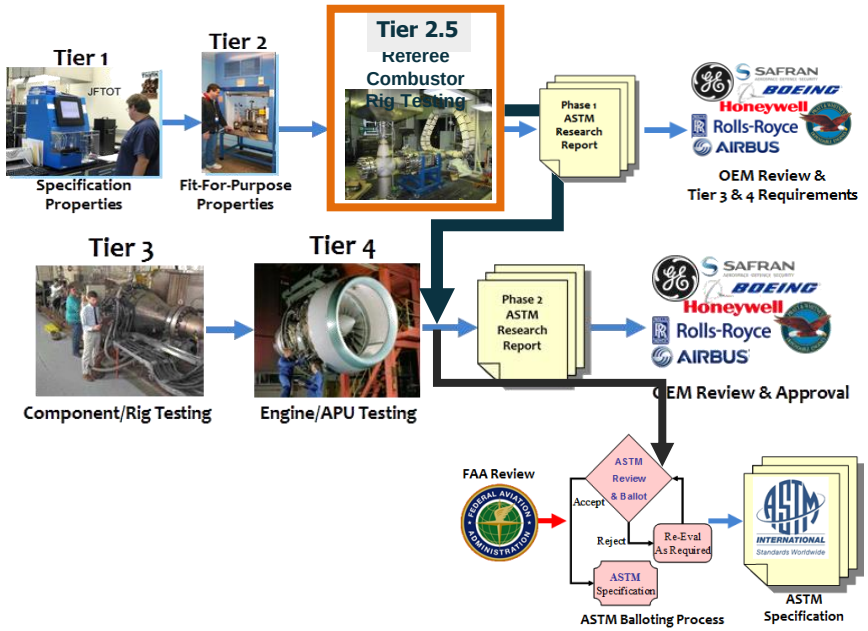
Two Prescreening and One Approval Tier

Prescreening to educate and de-risk

Educates about ASTM D4054 & provides indicative target values and direction

Systematic de-risking for preparing ASTM D4054 based on low cost measurements and accurate predications

ASTM D4054



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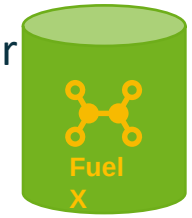
Fuel Prescreening Example

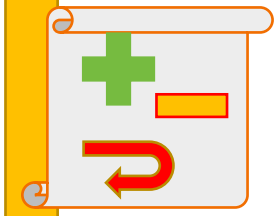
container-size PtL with minimized fuel upgrading

Fuel producer

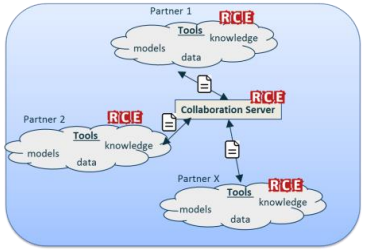


Is it possible to produce an aviation fuel with minimum fuel upgrading (—> out of ASTM D7566 Annex 1)?

Fast Feedback

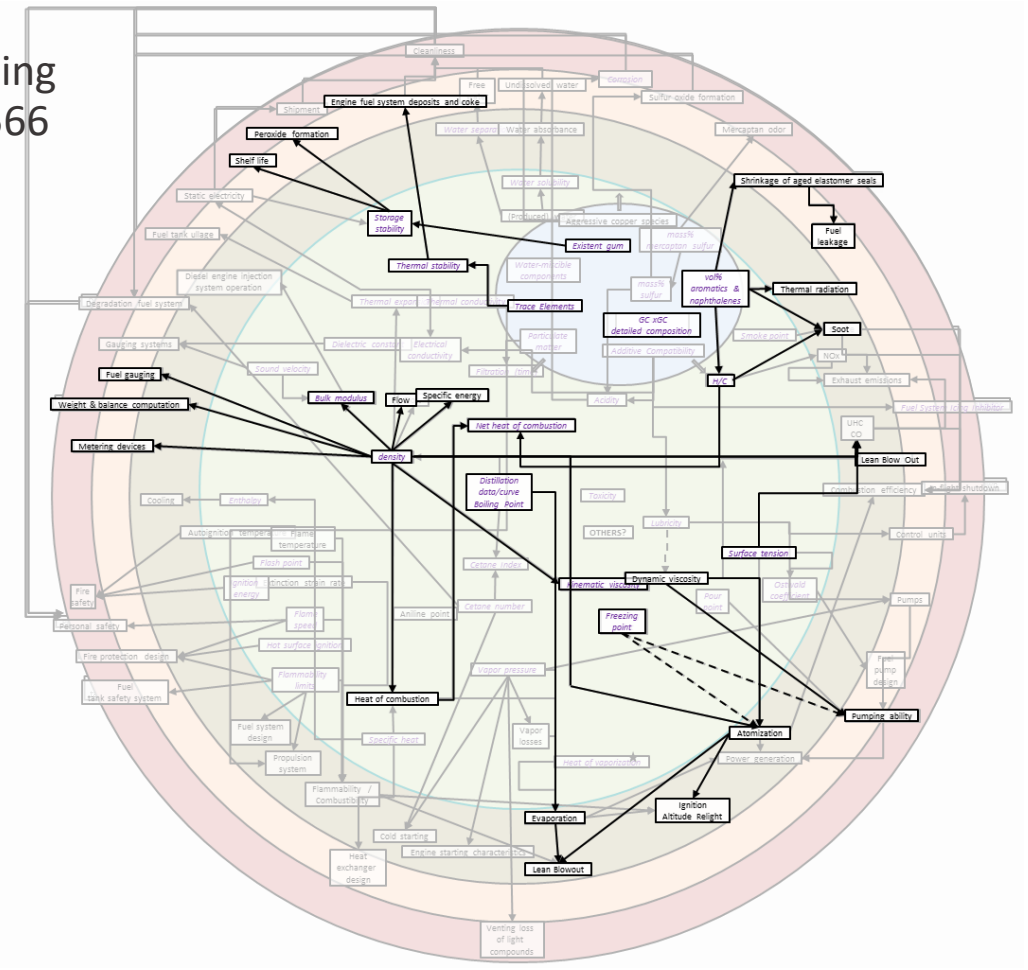


Fuel prescreening consortium



Primary screening property

Derived fuel performance property



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Tools integrated into Fuel Assessment and Optimization Platform

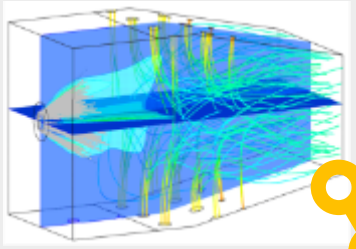
JETSCREEN

JETSCREEN WP 2,3,4,5,6,7

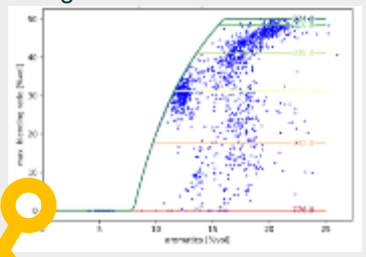
JETSCREEN WP 8

Emprical correlations
Physical-based models
CFD
Machine learning models

High fidelity simulations



Big data



Accessible fuel databases with significant amount of data

Remote component environment
Data exchange format

distributed multidisciplinary design

Real world experiences

Generic experiments
Technical systems
Expert knowledge

JETSCREEN WP 8

JETSCREEN WP 2,3,4,5,6,7

JETSCREEN collaborations:

US National Jet Fuel Combustion Program

ASCENT Alternative Jet Fuel Test Database

\+
Future collaborations

→ Enable holoistic fuel assessment and optimization

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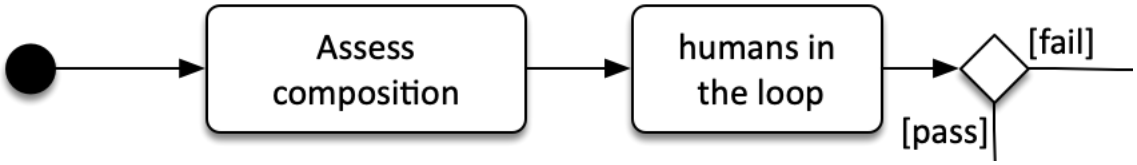
Fuel Prescreening Example

Step 1: Assess composition



Assess composition

Purpose:

- How close is the composition to Jet A-1?
- Are there any harmful components?

Method:

- GCxGC analysis
- Trace component analysis

Results Influence		I: Negligible	II: Minor	III: Moderate	IV: Significant	V: Catastrophic
	5: Controlling	(G)	(Y)	(R)	(R)	(R)
	4: Significant	(G)	(Y)	(Y)	(R)	(R)
	3: Moderate	(G)	(Y)	(Y)	(Y)	(R)
	2: Minor	(G)	(G)	(G)	(Y)	(Y)
	1: Negligible	(G)	(G)	(G)	(G)	(Y)
		Decision Consequence				

E.g. aromatics content <8 or >25%

e.g. harmful components

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Fuel Prescreening Example

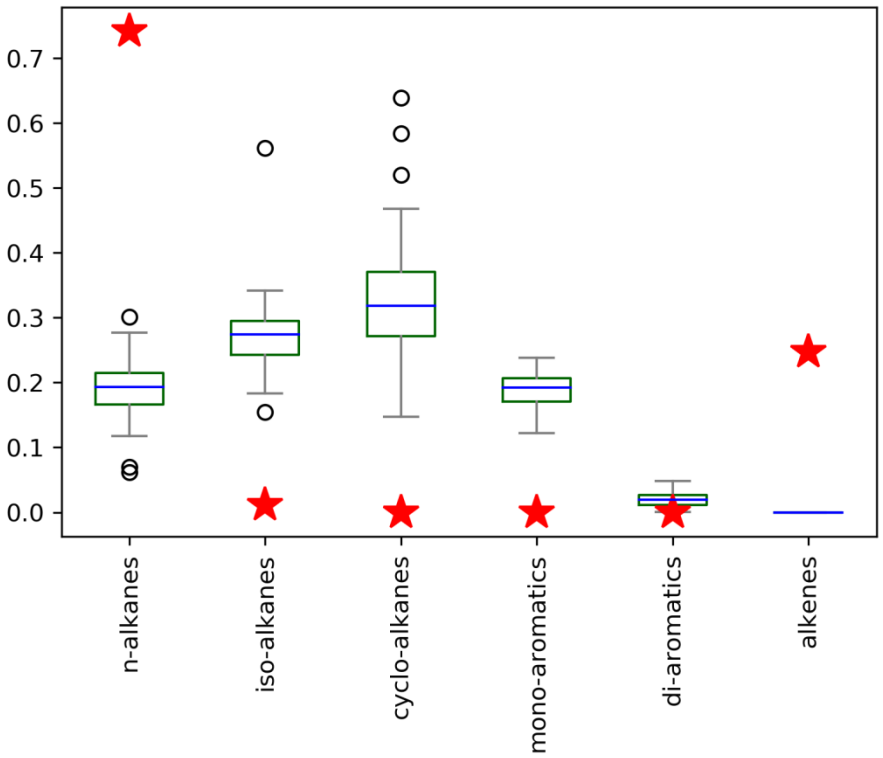
Step 1 Assess composition - result

Composition:

relative to field of experience: CRC fuels

- 57 fuels, world wide, (Jet A-1, Jet A, JP-5, JP-8)

★ Within field of experience
★ At the boundary of field of experience (outliers)
★ Completely out of experience



Trace Components:

CHEMISTRY		
Trace elements (Zn, Fe, V, Ca, Li, Pb, P, Na, Mn, Mg, K, Ni, Si)	report	<0,5 mg/kg
Trace element Cu	<20 µg/kg	10 µg/kg
Water content	max. 75 mg/kg	369 mg/kg
Acidity, total mg KOH/g	max. 0,10 mg KOH/g	0,163 mg KOH/g
Chloride content	report	< 2mg/kg
GROUND HANDLING PROPERTIES AND SAFETY		
Potential gum point	max. 7 mg/0,1L	186mg/0,1L
Existent gum point	max. 7 mg/0,1L	185mg/0,1L

Fuel stability critically influenced by trace components

Aromatics content 0%

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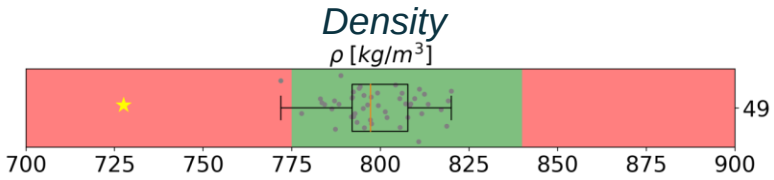
Fuel Prescreening Example

Additional results

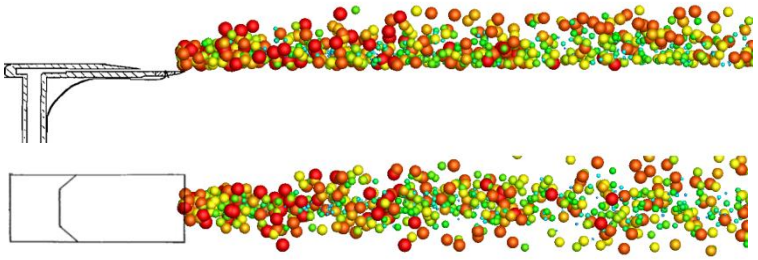
Tier 1: Physical properties



Predicted using ML methods with uncertainty quantification

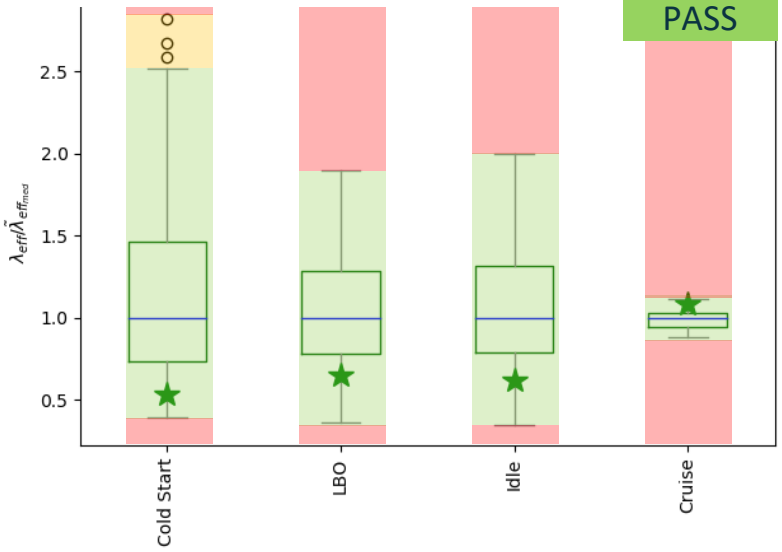
Tier 3: Technical-grade atomizer

PASS

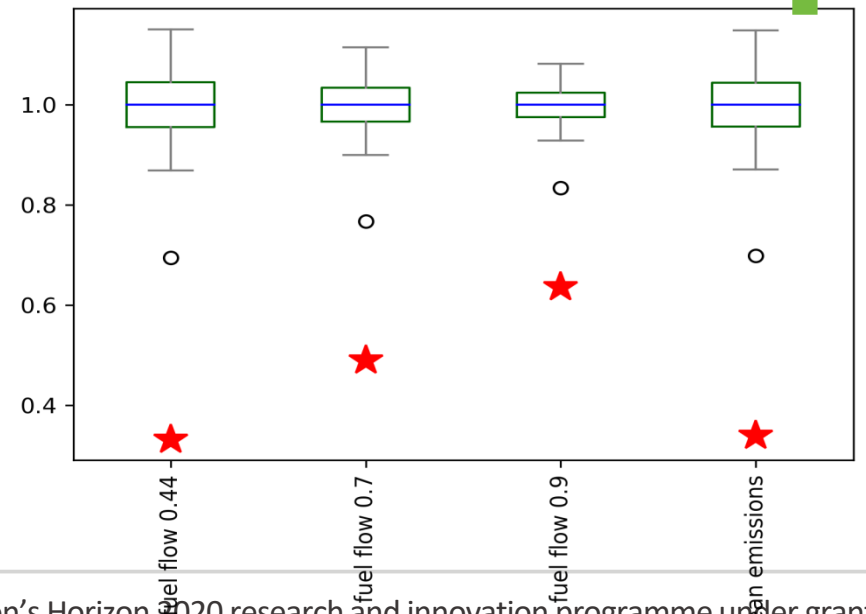


Unspecified property: Droplet evaporation

PASS



Tier 4: Soot emission reduction potential



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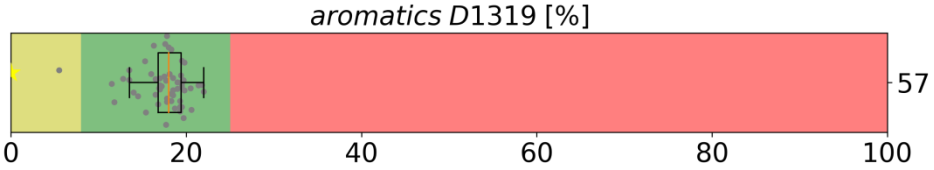
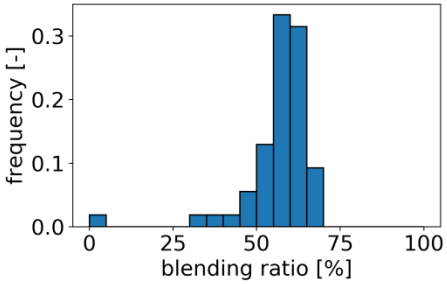
Fuel Prescreening Example

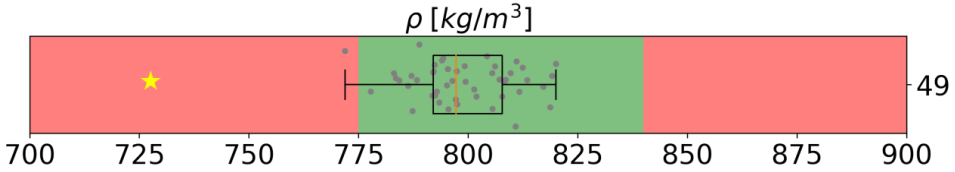
Limiting factors —> blending

- Estimate (economic) potential of alternative fuel candidate
  - Identify limiting factors (properties outside of ASTM D7566 limits)
  - Perform blending ratio calculation for these properties

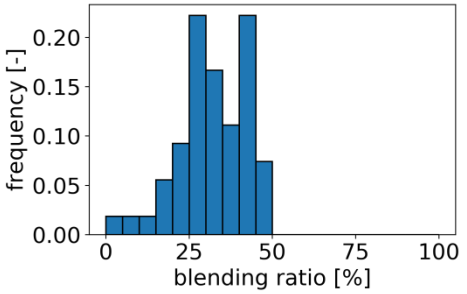


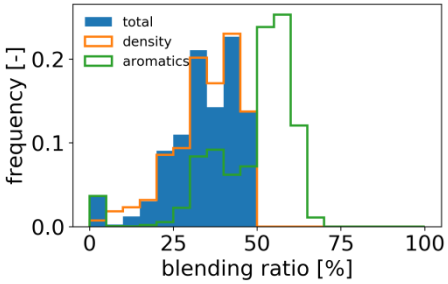
max ratio: 67.1%





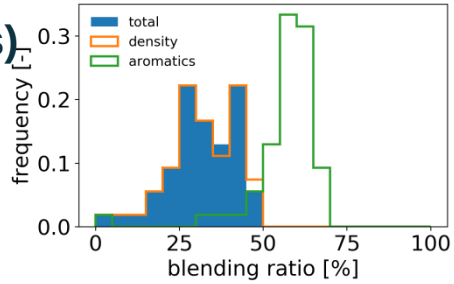
max ratio: 48.7%





Local market (>2700 fuels)
max ratio: 48.8%

CRC (57 fuels)
max ratio: 48.2%



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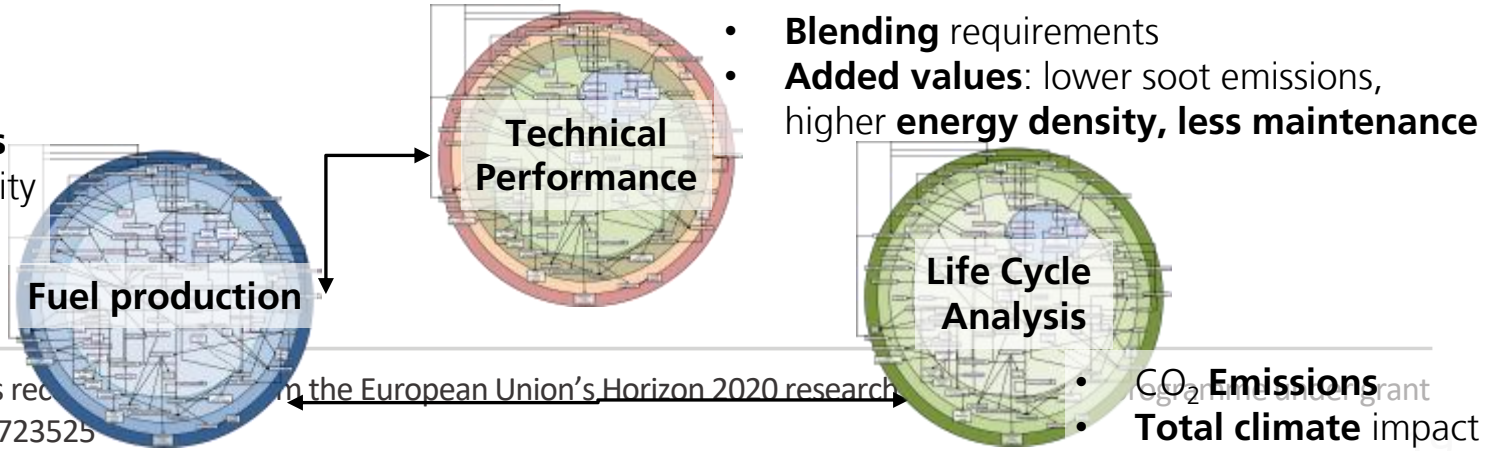
Summary

- Complex fuel effects on aircraft require a rigorous fuel approval process (ASTM D4054), that is costly and risky for innovative fuel producers
- Collaborative prescreening method developed and applied to:
  - Minimize risks of later stage pivots
  - Develop clear understanding of required efforts for approval
  - Identify added-values and indicate market potential

→ Significant de-risking that can be used to attract future financing

- Future: holistic fuel assessment and optimization



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JETSCREEN

JETSCREEN

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DLR

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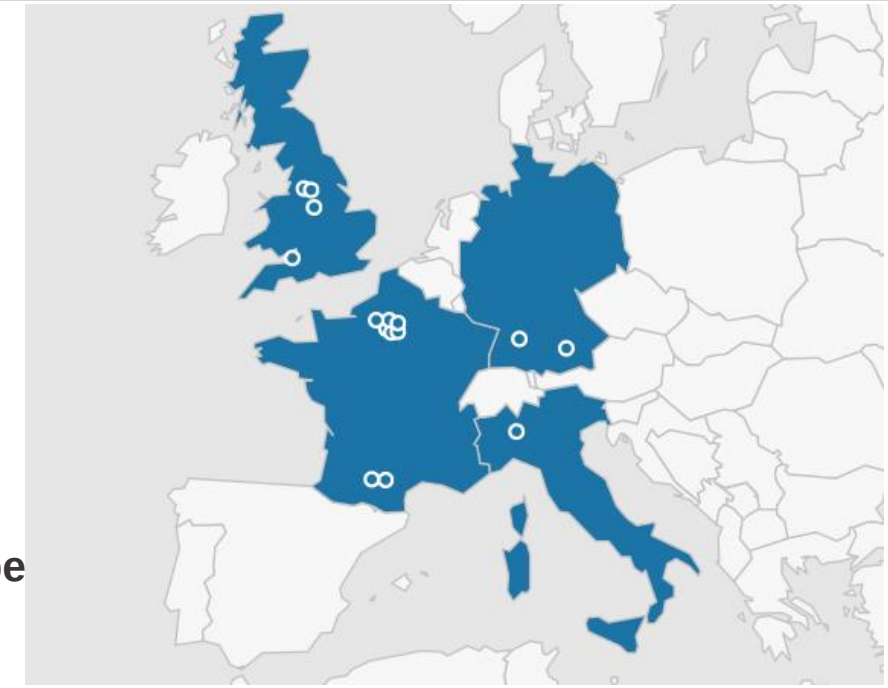

A project gathering **14 partners** from **4 Europe countries:**

DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center

AIRBUS

ZODIAC AEROSPACE

SAFRAN

The University Of Sheffield.

ARTTIC INTERNATIONAL MANAGEMENT SERVICES

CERFACS

MTU Aero Engines

Manchester Metropolitan University

POLITECNICO MILANO 1863

Rolls-Royce

ifp Energies nouvelles

ONERA THE FRENCH AEROSPACE LAB

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