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ALFA-BIRD OVERVIEW

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based on a collective work in the Alfa-Bird project

European Virtual Institute for Integrated Risk Management (EU-VRi) EEIG

Innovation Energy Environment

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Basic ideas and main objectives

<u>Al</u>ternative <u>F</u>uels <u>A</u>nd <u>Bi</u>ofuels for Ai<u>r</u>craft <u>D</u>evelopment

ALFA-BIRD aims at developing the use of alternative fuels in aeronautics.

In a context where the price of oil is increasing and with the impact of fossil fuels on climate change, sustainable growth of the civil aviation is conditioned by respect for the environment.

In this context, using biofuels and alternative fuels in aeronautics is a great challenge, since operational constraints (e.g. flight in very cold conditions) are very strict, and because current civil aircraft have long lifetimes (almost 50 years).

Basic ideas and main objectives

The main objective of ALFA-BIRD is to develop the use of alternative fuels in aeronautics with a long-term perspective, and therefore to help

- improving each country's energy independence,
- lessening global-warming effects,
- and softening the economic uncertainty of crude oil peaking.

ALFA-BIRD will investigate new approaches and new alternative fuels to power aircraft with the possibility of revisiting fuel specifications and reconsidering the whole aircraft system composed by the trio: fuel, engine and ambience.

➔ Strong links with and complementary to other EU and international initiatives (SWAFEA , CAAFI).

Basic ideas and main objectives

In operational terms, ALFA-BIRD addresses the following objectives:

- To identify and evaluate possible alternative fuels to petroleum kerosene, considering the whole aircraft system;
- To assess the adequacy of a selection of up to 5 alternative fuels with aircraft requirements, based on series of tests and experiments;
- To evaluate the environmental and economical performance of selected alternative fuels;
- To set the path towards industrial use of the "best" alternative fuels.

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Partners involved

1 European Virtual Institute for Integrated Risk Management, DE
2 Airbus France, FR
3 Airbus Central Entity, FR
4 Airbus UK, UK
5 Avio S.p.A, IT
6 Centre National de la Recherche Scientifique, FR
7 Technologica Group, BE
8 Dassault Aviation, FR
9 Deutsches Zentrum für Luft- und Raumfahrt e.V., DE
10 Institut National de l'Environnement Industriel et des Risques, FR
11 Institut National des Sciences Appliquées of Toulouse, FR
12 IFP-Institut Français du Pétrole, FR
13 Lesaffre Group, FR
14 MTU Aero Engines GmbH, DE
15 Office National d'Études et de Recherches Aérospatiales, FR
16 ROLLS-ROYCE, UK
17 SASOL Technology (Pty) Ltd., ZA
18 SHELL Aviation, UK
19 SNECMA, FR
20 University of Sheffield, UK
21 Universität Karlsruhe, DE
22 Graz University of Technology, AU
23 University of Toronto, CA

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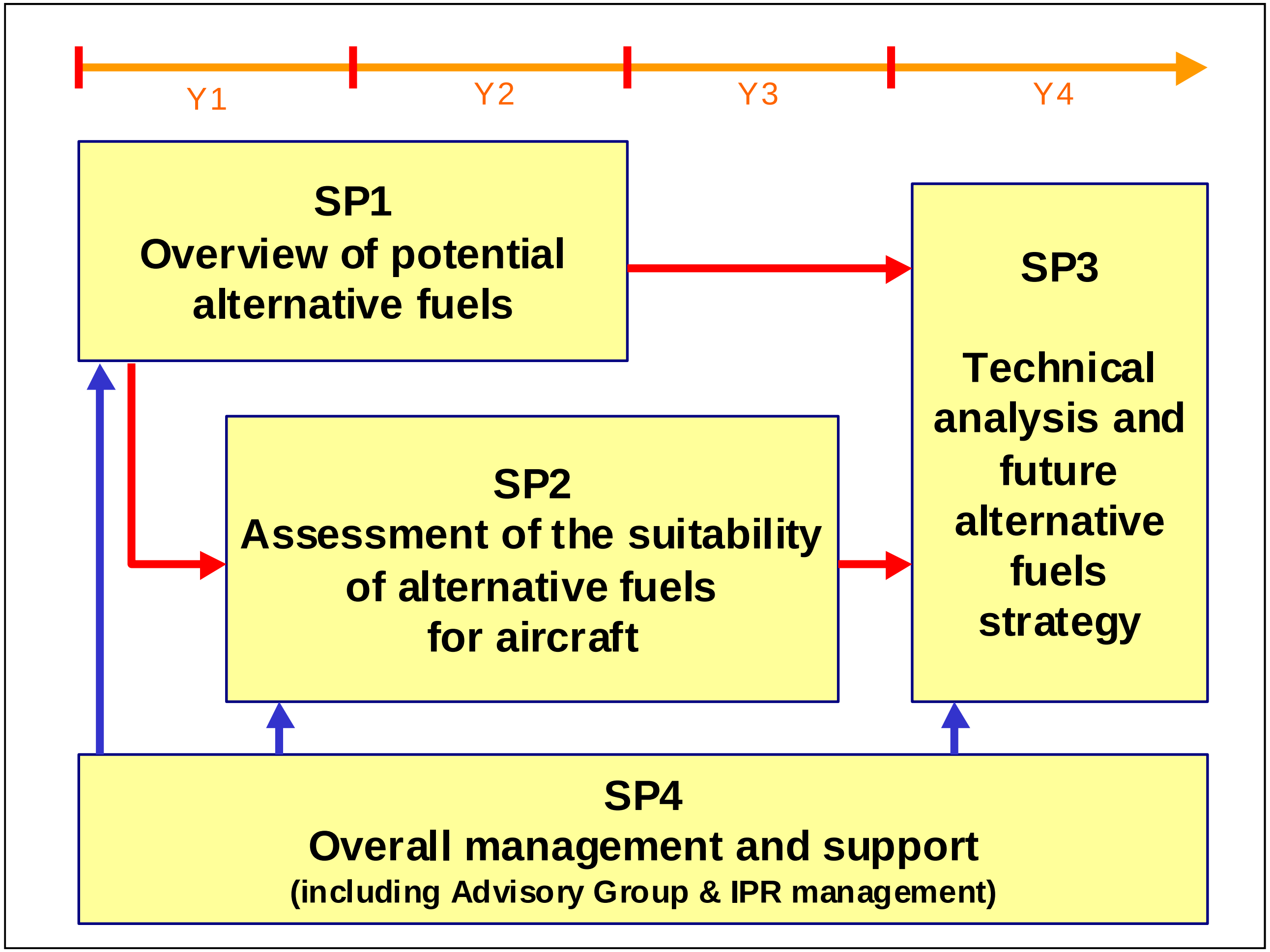
Project overview – 4 Study Packages (SPs)



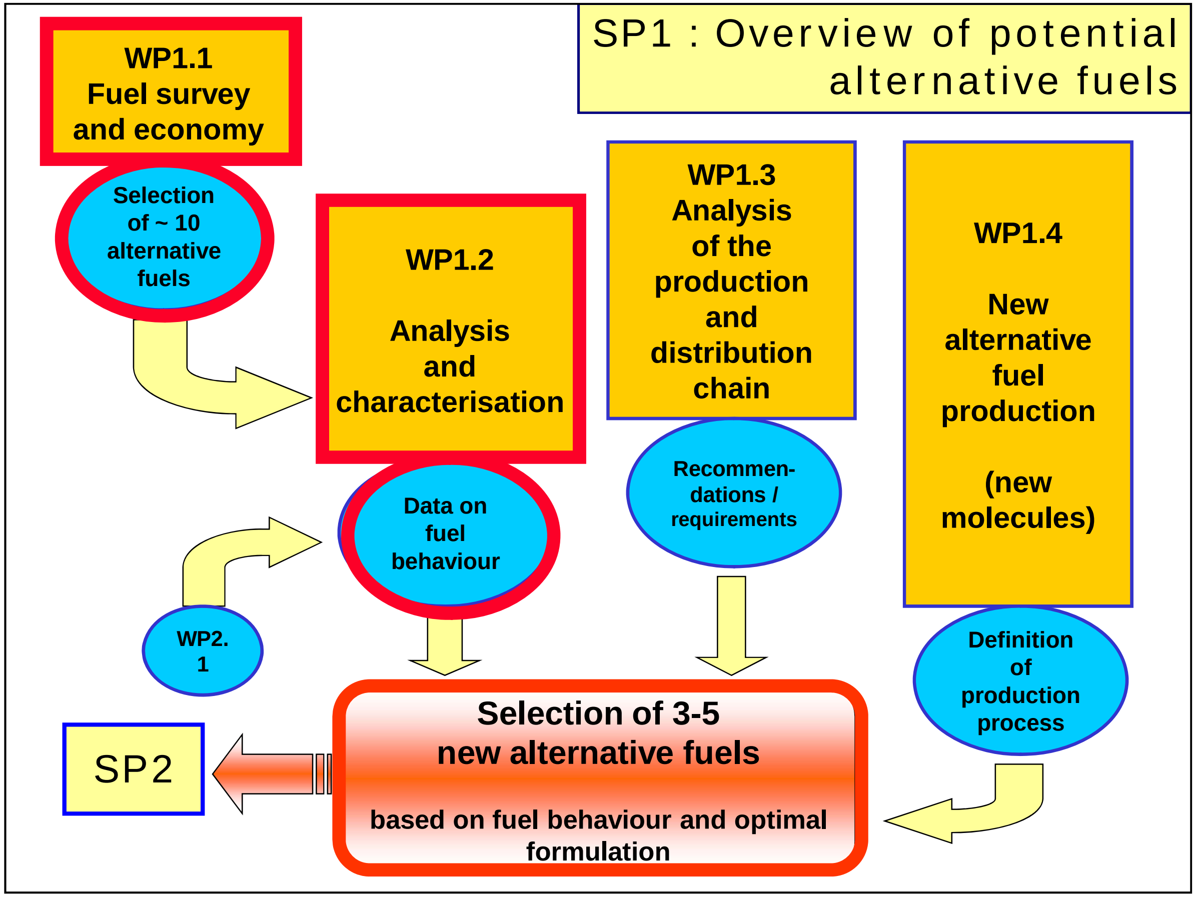
14 Work Packages

44 tasks

52 deliverables

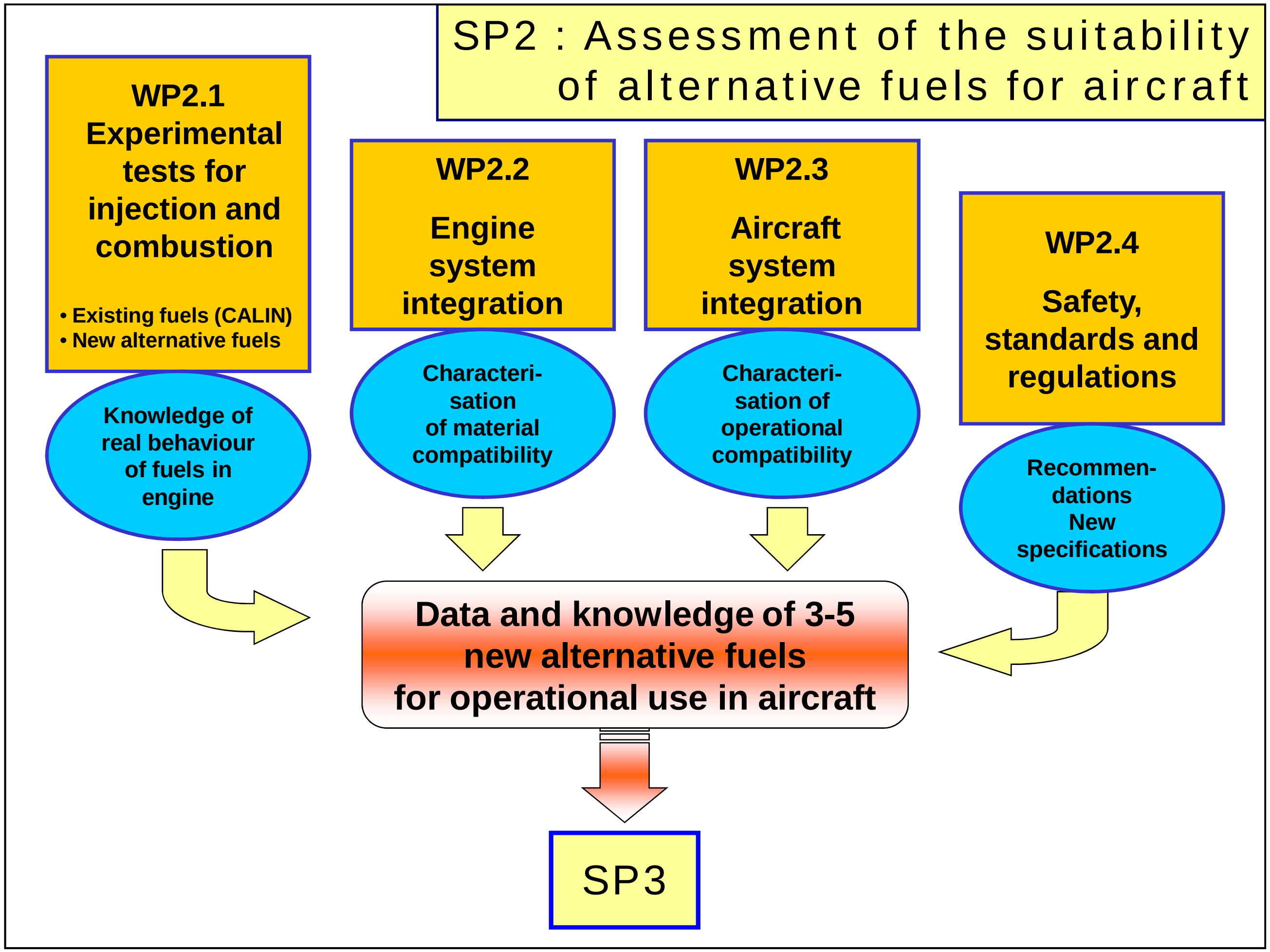
9 Milestones

SP1

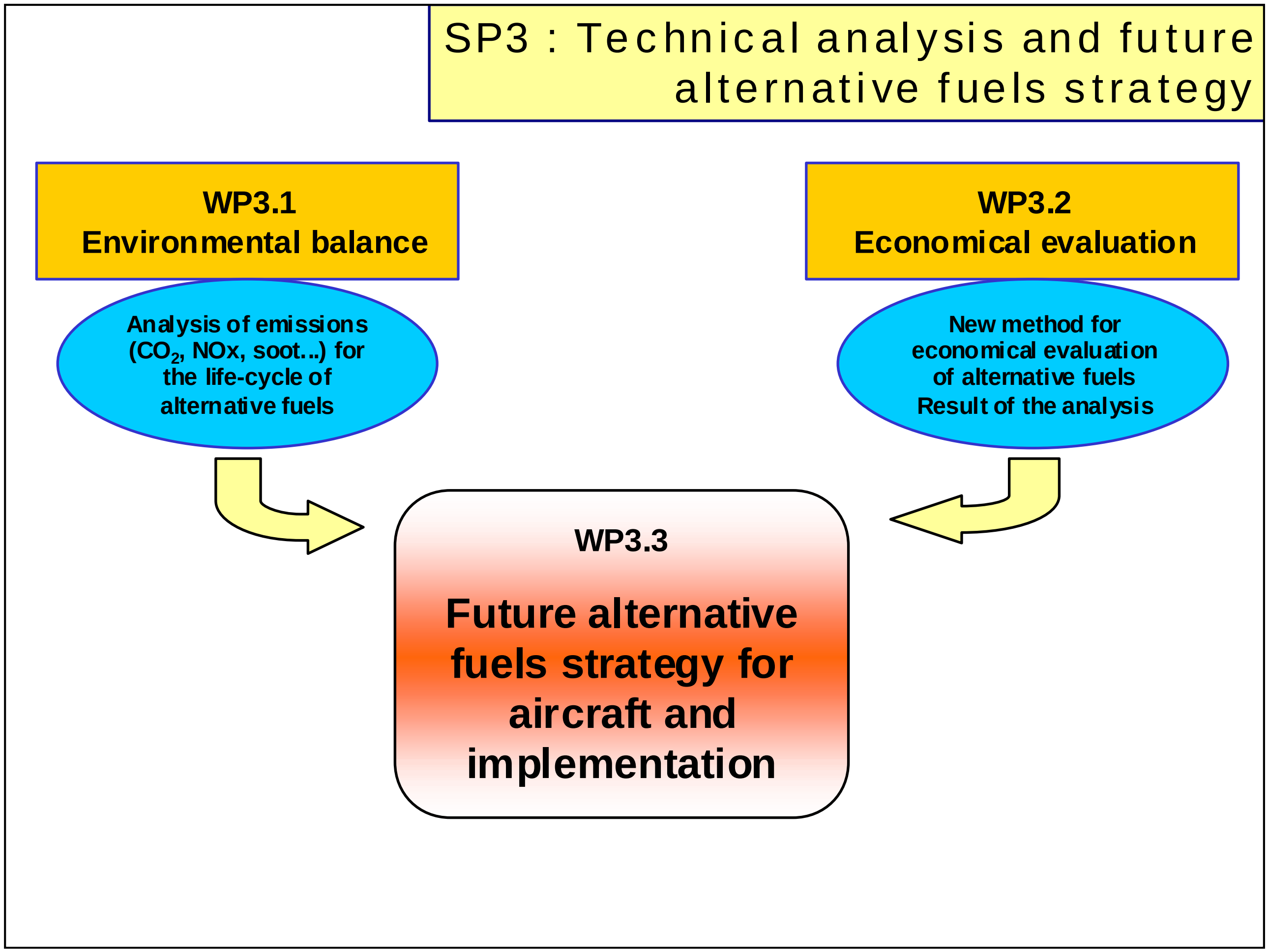


SP1 : Overview of potential alternative fuels
WP1.1
Fuel survey
and economy
Selection
of ~ 10
alternative
fuels
WP1.2
Analysis
and
characterisation
Data on
fuel
behaviour
WP1.3
Analysis
of the
production
and
distribution
chain
Recommen-
dations /
requirements
WP1.4
New
alternative
fuel
production
(new
molecules)
Definition
of
production
process
WP2.
1
Selection of 3-5
new alternative fuels
based on fuel behaviour and optimal
formulation
SP2

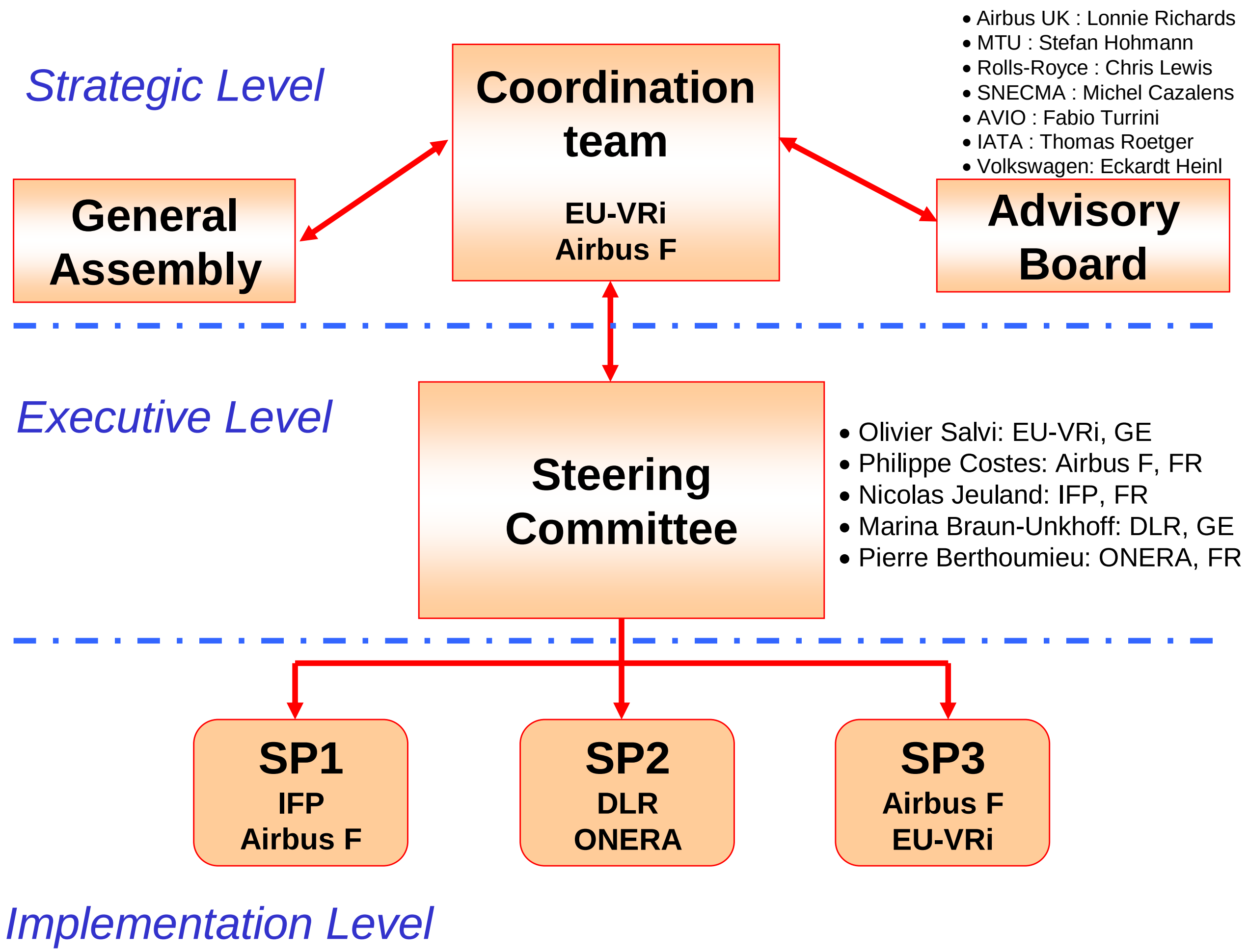
SP2


SP2 : Assessment of the suitability of alternative fuels for aircraft
WP2.1 Experimental tests for injection and combustion
• Existing fuels (CALIN)
• New alternative fuels
Knowledge of real behaviour of fuels in engine
WP2.2 Engine system integration
Characteri-sation of material compatibility
WP2.3 Aircraft system integration
Characteri-sation of operational compatibility
WP2.4 Safety, standards and regulations
Recommen-dations New specifications
Data and knowledge of 3-5 new alternative fuels for operational use in aircraft
SP3

SP3


SP3 : Technical analysis and future alternative fuels strategy
WP3.1
Environmental balance
Analysis of emissions (CO_2, NOx, soot...) for the life-cycle of alternative fuels
WP3.2
Economical evaluation
New method for economical evaluation of alternative fuels
Result of the analysis
WP3.3
Future alternative fuels strategy for aircraft and implementation

Organization



Features

Total Budget: **9 750 000 € (9.75 million Euros)**
EC Grant: **6 820 000 € (6.82 million Euros)**

Start: **1st July 2008**
End: **30 June 2012**

Coordinator:
EU-VRi (European Institute for Integrated Risk Management)

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Objectives of this presentation

- **Explain choice of fuels that will be tested in 2nd phase of project:**
  - Injection and combustion
  - Engine systems integration
  - Aircraft systems integration
  - Safety, standards, regulations

- **Selection of fuels is based on results of analysis of the initial fuel matrix according to main elements of ASTM D7566 (Jet A-1 and 100% SPK).**

1st phase of ALFA-BIRD: Evaluation of 12 blends

- **Based on standard characterization (ASTM D7566, for finished Jet A-1 and 100% SPK).**
- **This fuel matrix consisted of a range of blends of synthetic fuels with novel organic components and bio-derived components, currently outside Jet fuel specification compositional boundaries.**
- **Fuel matrix built around three axes:**
  - Paraffinic compounds ➔ FRL 7-9
  - Naphthenic compounds ➔ FRL 3
  - Oxygenated compounds ➔ FRL 1

FRL = Fuel readiness level, a measure of the fuel's progress towards full commercialisation

FSJF
FT-SPK
FT-SPK + 50% Naphthenic cut
FT-SPK + 20% Hexanol
FT-SPK + 10% Furane
FT-SPK + 20% Furane
FT-SPK + 30% Furane
FT-SPK + 10% FAE
FT-SPK + 20% FAE
FT-SPK + 30% FAE
FT-SPK + 50% HVO
FT-SPK + 75% HVO

Shell is acknowledged for conducting this first phase of analysis.

The reference fuel ➔ FRL 7-9

- **The reference fuel is identical for all tests and all partners.**

- **Jet A-1 / Jet A is the conventional fuel for aeronautics but**
  - Large variability according to the crude oil and the process ➔ for example, large variability in the level of aromatics and sulphur.

- **FSJF from Sasol is used as the reference fuel:**
  - To place the study in a long-term view
  - To have coherence with and be complementary to other EU and international initiatives (SWAFEA , CAAFI).
  - To have less variability on the reference.

- **FSJF consists of 50 % FT-SPK and 50 % of severely hydrogenated coal tar kerosene.**
  - Well-defined composition ➔ an identified refinery with a controlled process.
  - A synthetic fuel contains inherently less chemical families with a narrower distribution of components within each family.

The paraffinic compounds → FRL 7-9

- **FT-SPK is used as a blending base:**
  - Availability of this product
  - Complementary with respect to other initiatives (SWAFEA, CAAFI).

- **FT-SPK is also tested neat to have the possibility of clearly identifying the fuel impact.**

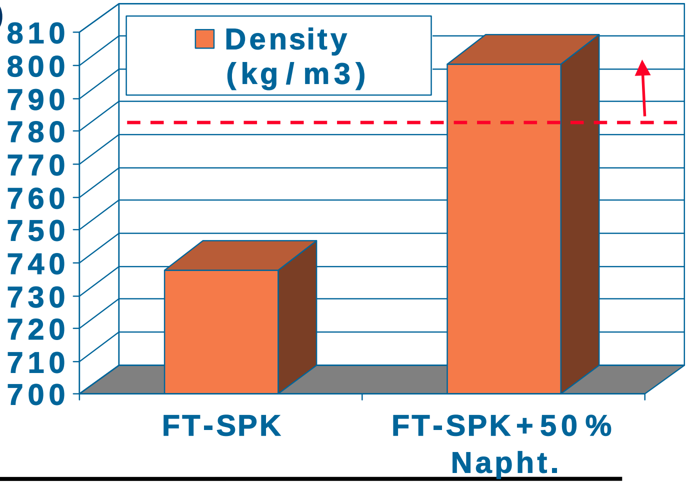
- **FT-SPK is within SPK specification limits (ASTM D7566). The FT-SPK used is a GtL from Shell.**

The naphthenic compounds → FRL 3

- **Produced from direct liquefaction of coal (nowadays) or of biomass in the future (sustainable).**

- **Some characteristics suitable for jet fuel use**
  - Good cold flow properties
  - Good energy content in volume
  - Some elements are still to be checked like the behaviour in combustion, the pollutant emissions, and the material compatibility.

- **Effect of adding naphthenic cut to FT-SPK → bring the FT-SPK blend into the Jet A-1 specification limits (ASTM D7566) in terms of**
  - Minimum aromatics contain (8% in volume by IP 156)
  - Density (775 kg/m3 as a minimum by IP 365).



- **Important to explore the potential of this product in more detailed tests.**

The oxygenated compounds → FRL 1

- **Not "drop-in" fuels**
- **Nothing in the chemical structure affects key fuel properties:**
  - Energy density
  - Volatility
  - Corrosion ability
  - Material compatibility
  - Combustion properties
  - ...
- **Not possible to use in significant proportions – need to avoid, for example, an important decrease of the energy content**
- **However,**
  - Possibility of reducing particulate emissions
  - Alternative in a long-term view
  - Important to evaluate their potential

The oxygenated compounds used in the 1st step

- **Alcohols**
  - Production by fermentation ➔ Products obtained ethanol and butanol
  - To fit with specified jet fuel properties (such as energy density, flash point or water solubility)
    - ➔ *need to use other alcohol (meaning higher carbon number) instead of ethanol because some of these drawbacks can be overcome*
    - ➔ *some properties are more or less proportional to the carbon chain length*
  - Need to find production pathways for alcohols such as hexanol
- **FAE (Fatty Acids Esters)**
  - Used as blending components for diesel fuel ➔ high availability, well-known process, large production investments
  - Esters have properties that depend on the starting material: esters can have different numbers of carbon atoms and varying degrees of unsaturation ➔ selection for jet fuels use
- **Furans**
  - Produced from carbohydrate found in lignocellulosic biomass, in sugar beet and in sugar beet pulp. Production method is still in the early stages of development.
  - In spite of a high density, the cold flow properties as well as the boiling and the flash point of this kind of molecule are in the range of a Jet fuel.
  - Oxygen content implies a low energy density in mass that can be compensated with a high density, and consequently, a correct energy density in volume.

- **Choice of Alfa-Bird : FT-SPK + 20% hexanol**

Conclusion: The fuel matrix for SP2 tests

- This selection is based on the standard characterization done on the initial fuel matrix (12 blends).

- The four fuels proposed for the tests (ignition, combustion, evaporation…) in the 2nd part of the project are:
  - FSJF → FRL 7-9
  - FT-SPK → FRL 7-9
  - FT-SPK + naphthenic cut (50%) → FRL 3
  - FT-SPK + hexanol (20%) → FRL 1

- Remark: If there is an opportunity during the run of the project to test some new fuels, this will be done with standard characterization.

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THANK YOU FOR YOUR ATTENTION

- http://www.alfa-bird.eu-vri.eu/

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