THEME 7: TRANSPORT
(including Aeronautics)

D1.3: Contractual Periodic Progress Report (M18) – Publishable Summary

Project ref. n°	SAFUEL - 314032
Start Date / Duration	01 Sept 2012 / 36 Months
Dissemination Level[1]	PU
Title	Contractual Periodic Progress Report (M18)
Nature[2]	R
Date – Contractual date of delivery	28/02/2014
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Keywords	SAFUEL, Contractual reporting, Periodic Report
Abstract	Report of SAFUEL project technical progress M1-M18 with publishable summary followed by detailing of work package progress.
Related Items	
Filing code	SAFUEL-WP1-ZODIAC-D1.3-periodic report-M18-Publishable Summary.docx

Date / Deliverable Leader visa	**Date / Coordinator visa**
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[1] PU: Public; PP: Restricted to other programme participants (including the EC services); RE: Restricted to a group specified by the Consortium (including the EC services); CO: Confidential, only for members of the Consortium (including the EC services).

[2] R – Report; O - Other

Project co-funded by the European Commission within the Seventh Framework Programme

1. Publishable Summary

1.1 Project context and objectives

Thanks to the effective contribution of the safe fuel system, air travel is today the safest form of transport worldwide. However, safety can never be taken for granted. Constant effort is therefore needed to maintain the highest safety level, taking into account the global air transport industry and its changing operational context (i.e. new technologies, the evolution of flight conditions and climate changes).

SAFUEL objectives:

Addressing air transport constraints and answering needs for a European-led research and technological development in FS safety, the overall objective of the SAFUEL project is to develop, test and validate the Safer Fuel System of the future.

Fully compliant with safety requirements, this Safer Fuel System will be able to deal with more extreme temperatures, stronger temperature gradients, higher humidity and more frequent exposure to lightning, due to:

- Future flight conditions

  Flight conditions are changing due to the opening of new routes at higher altitude or routes crossing the Arctic. Also, during landing and take-off, faster climbing and approaches are required to optimise the flight routes
- More exposure to hazardous weather conditions
- Emerging technologies

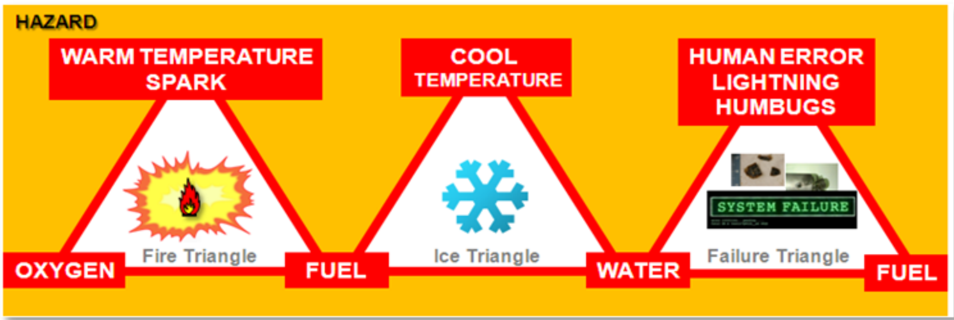

Figure 1: Hazard triangles challenged in SAFUEL

Figure 1 depicts the hazards (fire, ice and FS failure) that are addressed by the SAFUEL project while integrating the needs of future a/c platforms such as usage of alternative fuels, more composite aircraft or more electrical aircraft.

Consequently, SAFUEL has the following overarching technological objectives:

1. Improve water detection in fuel tank and gain knowledge on icing phenomena in the fuel system
2. Enhance flammability protection in the fuel tank and improve reliability, robustness and performance of inerting
3. Remove possible ignition sources from the fuel tank
4. Verify and validate full compatibility of the results to Composite Aircraft and More-Electric Aircraft requirements, considering the increased exposure to lightning and induced arcing in these new technologies
5. Verify the compliance of results with Alternative Fuel standards.

The work is organised in four 'RTD' WPs, all driven by SAFUEL overall objectives to develop the new generation of safer FS (robust and integrated) which can better protect an aircraft against hazards ('Ice', 'Fire' and 'Failure'). **WP2** develops the water management function, gaining S/T knowledge about ice in FS with associated recommendations for FS design and developing an optical water in fuel sensor (electrically passive). **WP3** develops the in-tank wire-free dual oxygen/temperature sensor (electrically passive) and the optimised FTIS architectures. **WP4** develops the metal-free gauging (electrically passive). **WP5** provides the High Level Requirements to WP2, WP3 and WP4 and will assess the results against Safety, emerging technologies and technological breakthrough (TRL maturity level and integration level) at system level. Assessment is performed by independent reviewers.

Two 'OTHER' WPs and one 'MGT' WP respectively take care of:

- Dissemination (**WP6** notably prepares the Public Forums scheduled at M21 and M36 and hosts and maintains the SAFUEL public website www.safuel-FP7.eu to widely disseminate results),
- Exploitation (**WP7** maintains the SAFUEL Knowledge Register recording ownership and access/use rights to SAFUEL Foreground, verifying the Foreground is protected to fully support the exploitation plan),
- Management and the coordination of the Consortium (**WP1**).

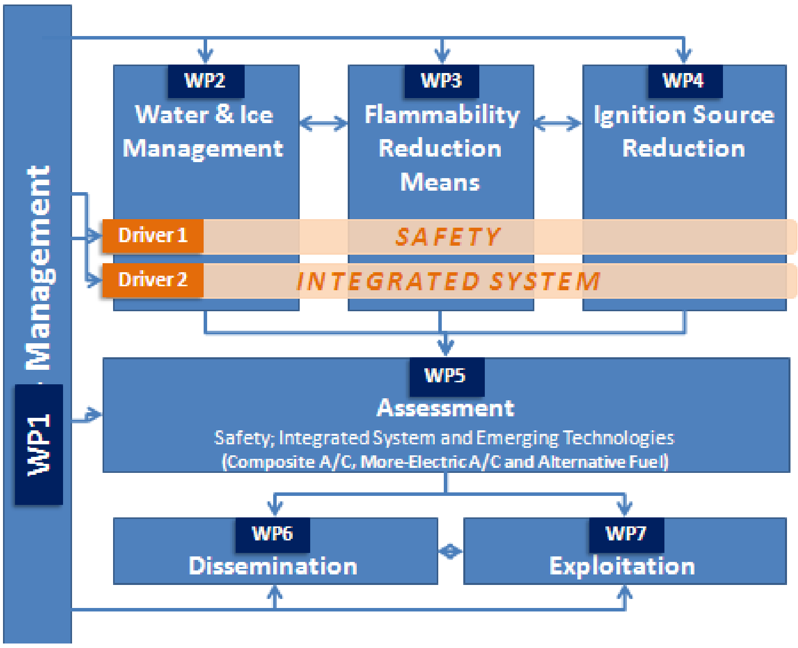

Figure 2: Work Breakdown Structure

1.2 Work performed and main results achieved

Period 1 work performed:

- For the development of the new technologies (optical water detector, in-tank oxygen sensor, closed loop FTIS architecture integrating oxygen sensor, and hydrodynamic acoustic, and optical gauging), an a/c baseline was defined and specifications for each development were issued first at a/c level, then at system and component level.
- To be able to assess the benefit of the new technologies, the criteria on technology maturity (TRL), safety and compliance to emerging technologies have been defined.
- Two workshops have been held by the Consortium, the first one on alternative fuels and the second one on contaminants in fuel tanks.
- Water detector in fuel tank development:

First, an extensive analysis of the accident reports has been performed and completed with a literature survey.

Based on the requirements, an optical dissolved water sensor is under development with the challenge of meeting the response time performance and flight environmental conditions. Aging tests in aviation fuel has have been conducted to assess the long term behaviour of the optical fibre. The relationship between water detection and temperature has been studied.

- Icing phenomena investigation:

  An experimental approach has been adopted in SAFUEL. This is done at a laboratory scale and at a larger scale (equipment). Therefore, the first activities were to design the relevant test benches that will enable partners to correctly model the environmental conditions during actual flights.

  Then, the first tests to study the influence of different parameters on ice accretion were performed.

- In-tank oxygen sensor development:

  During the first period of the project, adequate sensor/matrix materials fitting a/c fuel tank specific environment were developed. The first laboratory tests were performed.

- FTIS architecture optimization:

  First, a classical FTIS architecture was designed for the a/c baseline as a reference. Second, different strategies for FTIS architecture optimization were developed. Third, the first optimized architecture integrating an in-tank oxygen sensor was designed. The first estimation of the energy consumption and comparison with the reference architecture was performed.

- Gauging technologies:
  - Acoustic based gauging

    The first part of the activity consisted in modelling and the second part in developing the acoustic architecture and a small-scale test bench.
  - Optical based gauging

    Based on the requirements, a technology trade-off has been made leading to the choice of the most promising technology.
  - Hydrodynamic based gauging

    The tank model of the SAFUEL baseline was defined and calculations have been performed using both explicit and implicit methods.

Achieved results:

- Optical based water detector:

  The aging tests demonstrate a very good long term behaviour of the optical water sensor. The relation between water activity sensing and temperature has been elucidated. Operation of the sensor over much (but not all) of the target temperature range has been studied. The resolution obtained is better than 1ppm water in fuel. A good response time has been achieved.

- Icing phenomena investigation:

  An innovative test bench that will enable the observation of ice formation and ice release in non-accessible parts such as pipes was developed.

  First results on parameters impacts were obtained.

Figure 3: Icing phenomena – first results on parameters impacts

- In-tank oxygen sensor: the first sensor materials were developed. Their robustness and response within the aviation fuel environment will be further investigated.

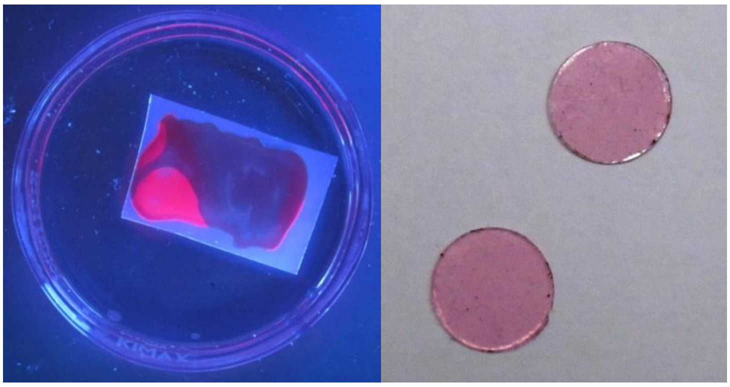

Figure 4: Optical oxygen sensing – Left: a film of sensing material under UV light, glowing red in deoxygenated zones, and not emitting in the zones exposed to oxygen. Right: disks of sensing material under ambient light

- FTIS architecture: first optimized architecture showing potential reduction of energy consumption up to 20% was developed.
- New gauging technologies:
    - Hydrodynamic: first simulation results of the tank filling at different configurations were obtained. They demonstrate the stability of the numerical methods. Further numerical simulations will be performed to determine the hydrostatic sensing experimental measurements.

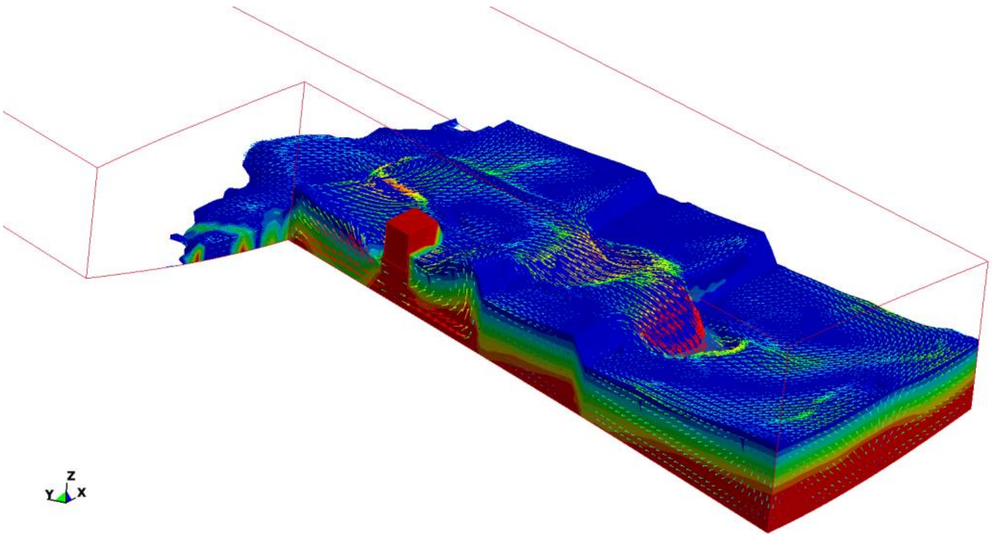

Figure 5: Simulation results

- Acoustic: small scale test bench is manufactured, tests validation will start at the beginning of the second period.

- Optical: The most promising technology and its performances were determined.

Dissemination actions have been undertaken during the period to increase awareness of the project, notably the creation of the public website www.safuel-FP7.eu and the presentation of the project by the Coordinator at SAE 2013.

Partner-level dissemination of results has also begun, with the submission of publications by ASTON and CRAN-U on work in WP2.

1.3 Expected final results and their potential impact and use

All key results are compatible with Composite A/C, More-Electric A/C and Alternative Fuels:

- Metal-free water detector in fuel tank
- Metal-free fuel gauging technologies
- Electro-optical in-tank oxygen sensor
- Optimised fuel tank inerting system (energy consumption reduction, maintenance cost reduction)
- Phenomena of ice accretion and ice release in fuel circulation understood
- Design rules for FS robustness against ice formation and release

The results of SAFUEL development regarding ice accretion and ice release in fuel circulation system will be shared with the regulation authorities (EASA) as well as the fuel systems actors (SAE fuel systems working group). These results will support authorities in establishing certification rules and regulations for safer flights in extreme icing conditions.

The significant gain in terms of energy consumption and maintenance costs for inerting system will enhance the competitiveness of both FS providers and a/c manufacturers. Moreover, the exploitation of the results regarding innovative gauging systems and in-tank oxygen sensor will have significant impacts for the SAFUEL SME partners.

The SAFUEL Consortium will organise two public forums in Period 2. The first one will be held M21 at IST where a large student attendance is expected. Furthermore, through wide dissemination of the knowledge gained on ice formation and the presence of water in the fuel system, SAFUEL will strengthen the excellence of European education for scientists and engineers. A public deliverable (D6.5) compiling education material for academics is also planned at the end of the project.

