AF3
Advanced Forest Fire Fighting

Final Report

Grant Agreement number: 607276

Type of funding scheme: Collaborative Project (CP) – Large Scale Integrating Project (IP)

Start date of project: 01/05/2014 **Duration: 39 months**

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REVISIONS LOG

REV	CHANGE REFERENCE	DATE	CHANGE DESCRIPTION	PREPARED
0.1	Draft #0	30/11/2017		Stefano Scafè
1	Final	24/01/2018		Stefano Scafè

ABBREVIATIONS AND ACRONYMS

ABBREVIATION / ACRONYM	DESCRIPTION
AB	Advisory board
AF3	Advanced Forest Fighting
AAFF	Advanced Aerial Fire Fighting
ASA	Advanced situation Awareness
CONOPS	Concept of Operation
C4I	Command, control, communication and Computer Information
CDR	Critical Design Review
DoW	Description of Work
FFL	Fire Fighting Lab
MM	Man Month
MODIS	Moderate Resolution Imaging Spectroradiometer
MSSDP	Multi sensor semantic data processor
NFFL	Northern Forest Fire Laboratory
SNSDEV	Sensors and Devices
WBS	Work Breakdown Structure
WP	Work Package
WPL	Work Package Leader

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1. EXECUTIVE SUMMARY

This report summarises the activities carried out during the whole duration of the AF3 project, giving as first a general overview of the project itself, as divided at the beginning into specific tasks managed by the different partners in charge of them; then, we will go more in detail into the third and final year of the project (M25-M36) and the three final months of extension for the project itself, until M39: what has already been presented in the 3rd Periodic Report mainly in term of Project Management, will be now highlighted in term of specific moments along the AF3 program lifecycle.

2. PROJECT ACTIVITIES

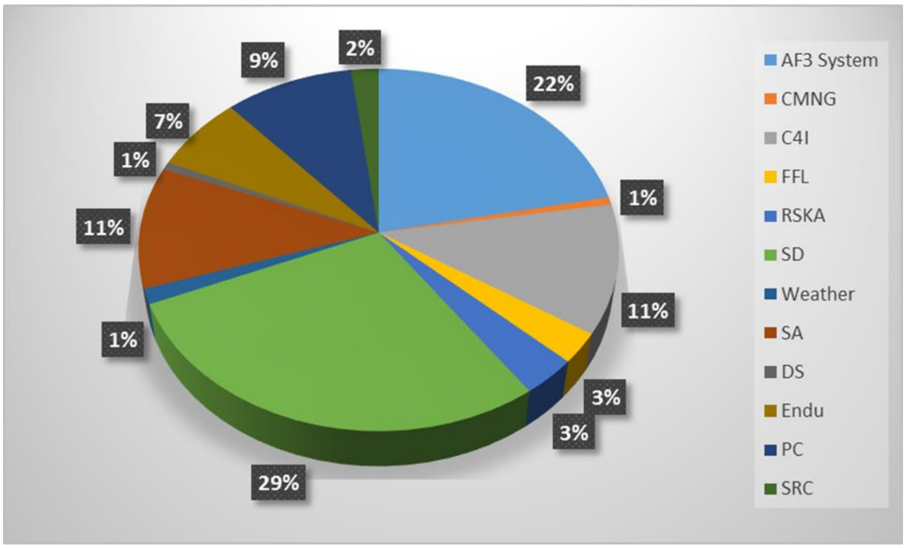
AF3 project has been subjected to some changes in the coordination (and the coordinating organization, now named LEONARDO, passed itself through many changes in this period) during the whole life of the program, so what is important is to highlight the progress for the different tasks individuated at the beginning, and partially re-modulated when needed: this could be done presenting, as a summary, the main results for each of the WPs the project was divided in. A brief but hopefully exhaustive overview in this sense will be done here below.

2.1 WP1 – PROGRAM MAMAGEMENT

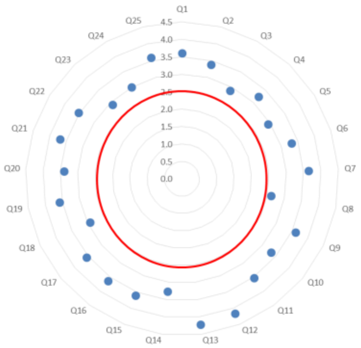
The program management activity has been carried out by LEONARDO-FINMECCANICA along the whole duration of the project. Three different coordinators have had the responsibility of AF3 project, more or less each one for each of the program years. For its specific nature, PM activity is a sort of *merging* of the different aspects of the project, so further in this chapter manly the other WPs will be presented, while WP1 activities will be described more in detail in the following parts of the document, with a specific focus on the third year of AF3, and on the period of extension.

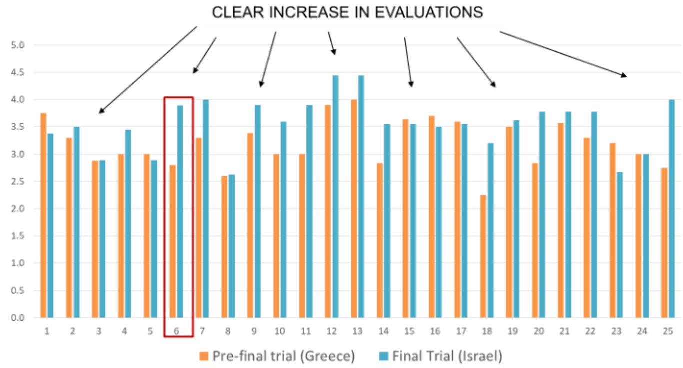
2.2 WP2 – CONOPS, REQUIREMENTS & SYSTEM DEFINITION

Activities within WP2 had the main aim of defining the AF3 system architecture on the basis of the end-user requirements as well as verifying the compliance of the same requirements by the system. The collection and analysis of users' requirements needed to evaluate suitability and effectiveness of the AF3 system have been performed in WP2.1. In particular, in WP2.1.1 the missions have been defined and in WP2.1.2 the requirements have been defined.

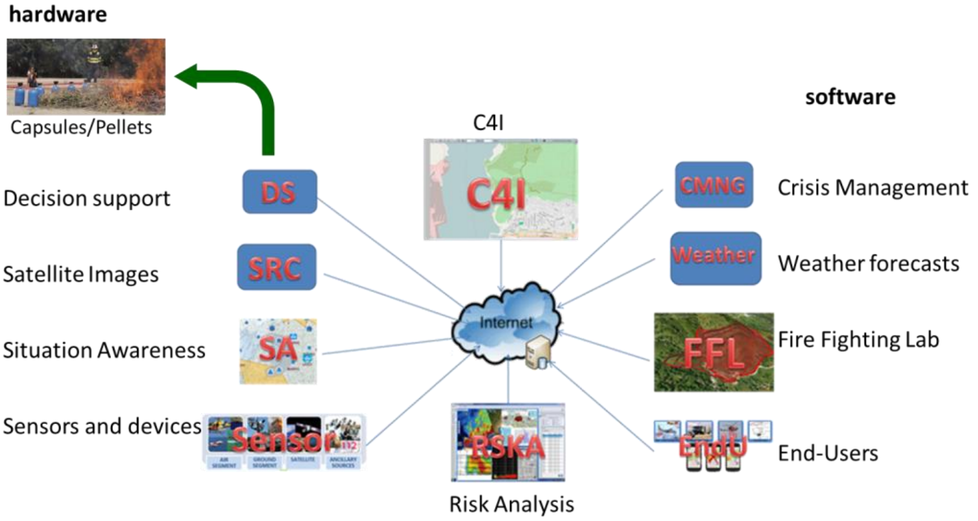


In order to have an End User oriented perspective, the work based on a strong collaboration with experts and users, in order to access their knowledge and identify currents gaps and future needed benefits to be generated by tailored innovative solutions for specific fire scenarios. A strong focus was put on the method used to collect and process such knowledge, distinguishing the contribution coming from secondary research and primary research (interviews, workshops, questionnaires) activities. These requirements have been periodically updated, through analysis of the deliverables issued by the consortium and, on the other side, targeted interviews with experts. Requirements have been divided into quantitative and qualitative requirements. Quantitative requirements have been checked through evaluation of quantitative performance and comparison with an acceptance value. Qualitative requirements have been checked through evaluation from experts. An overall evaluation has been also obtained through questionnaires which have been filled in by the advisory board and experts participating to the various trials. In WP2.3, the traceability matrix and the compliance table have been prepared for the requirements that apply to the AF3 system. An overall evaluation of the system performed through analysis of the questionnaires has been also performed.





In WP 2.2, the technology requested for matching the various fire scenarios has been identified and the AF3 system architecture has been defined. The architecture is based on the REST protocol. The various modules interact through a web service where information is exchanged through JSON messages. The ICD, containing the list of the various messages interchanged by the modules and the data structures, has been issued and updated during the project.



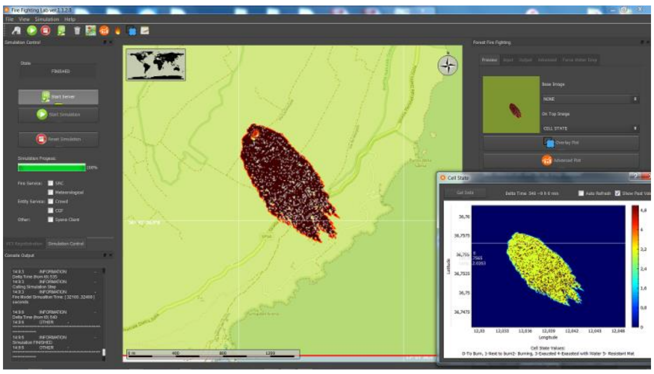
Overall, the activities have been performed according with the DOW, with no relevant deviations.

2.3 WP3 – MODELLING AND SIMULATION

WP3 was composed from three sub-packages, providing respectively:

- a software application which implements a comprehensive Forest Fire Propagation Model (WP3.1)
- a software application which implements Crowd behavior Models intended for crisis management. (WP3.2)
- a Simulation Host Computer (Fire Fighting Lab) which integrates the various Forest Fire Fighting models. (WP3.3)

FFL is an innovative forecast firefighting simulator that allows to calculate the evolution of the fire events (past and future). It is web based and can be extended with other modules designed as a web-service. Challenging of this WP3 was to collect and integrate the contribution of all the partners. The major effort was to create a simulation host to control fire evolution simulation and its external modules.



The FFL lab developed by Leonardo integrated into the simulation different models as:

The pellet effect, water effect, drop of the pellet, computer generated force models, weather forecast, crowd model and the map service.

The partners involved in the task were ELBIT, Polito, Aria, CBK, Demokrytos. For the WP33 the FFL implemented an interface to communicate with external subsystems as C4I, and Decision Support.

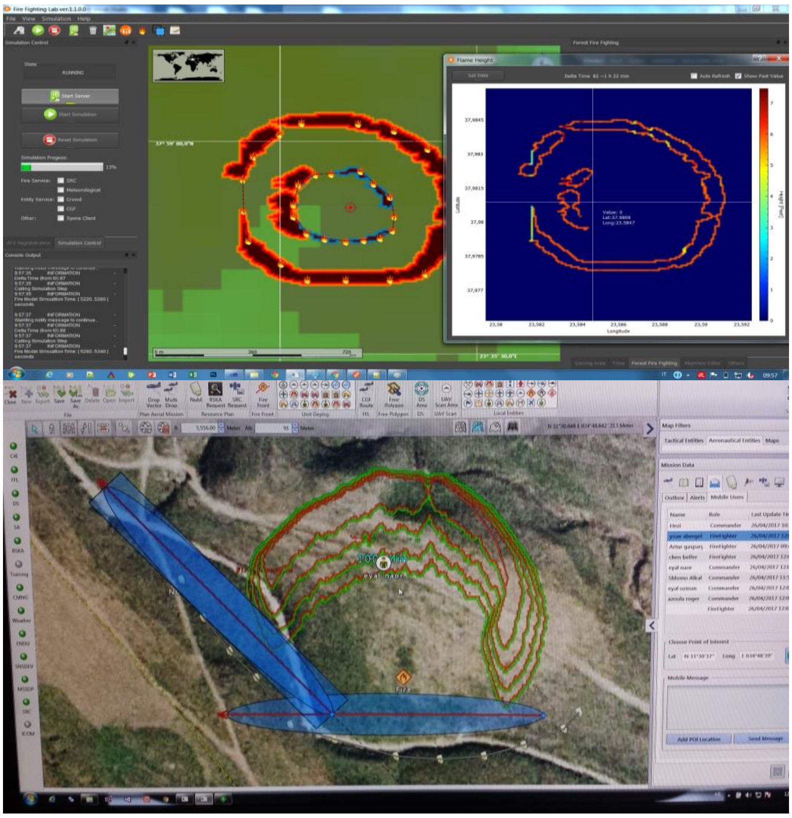
Simulation Host

Leonardo developed the simulation host application to integrate all those internal and external models used in the simulation. The services integrated by Leonardo are the following:

- Integration of the Meteorological model with the FFL.
- Integration of the Pellet/Water model with the FFL.
- Integration of the CGF model with the FFL.
- Integration of the Satellite Images service.
- Integration of the Decision Support Tool.

Simulated units

UPVLC and TRAGSA integrated their training systems (SIMTAC and ERVIN) in order to provide a virtual training environment for the AF3 end users. This virtual training environment were tested during the three drills performed in the project (Greece, Spain and Israel). During these drills were performed different training workshops before the demonstration day in order to allow to the end users to use the AF3 tools in a simulated environment. UPVLC used an extra PM due to the final integration complexity of both systems.



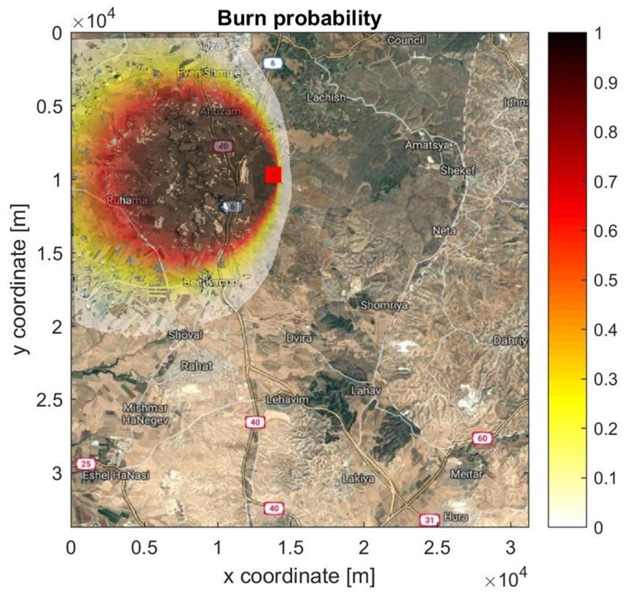
Integration with C4I

Leonardo and ELBIT integrated their systems by implementing all the messages defined in the ICD document e.g: Scenario initialization, Drop water, Simulation step, CGF step, Etc.

The WP3 reached its aims during the tests performed in Greece, Spain and the most important the final one did in Israel.

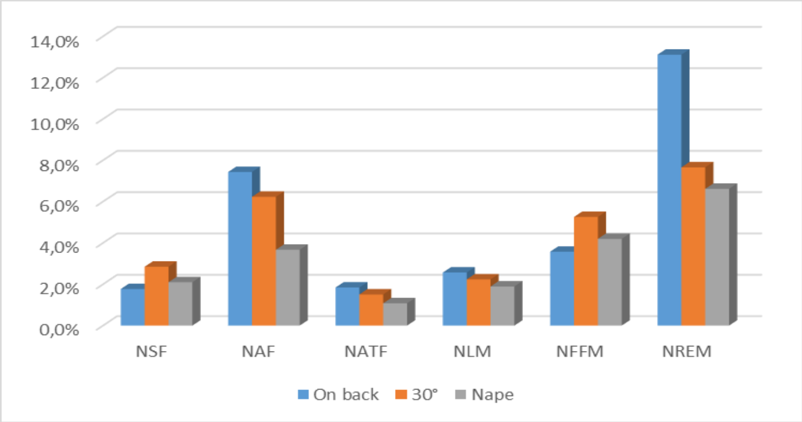
2.4 WP4 – RISK ANALYSIS

The activities performed within WP4 have been developed with two major goals: 1) develop a methodology and tool for the analysis of risks and damages to people, wildlife, vegetation and infrastructures associated with wildfires; 2) perform the analysis of possible risks associated with the use of pellets and capsules.
The fire risk and damage analysis has been developed within WP4.1, WP4.2 and WP4.4. Two integrated tools have been created, one for the risk analysis and one for the damage analysis. The risk analysis tool receives the input related with orography, vegetation distribution, people distribution, infrastructure distribution on the basis of the approaches developed in the first part of the project. The preventive risk analysis has been conceived considering a probabilistic approach related with possible locations of fire ignitions based on historical data. Both the preventive and real time risk analyses are performed considering probabilistic distributions of the weather conditions based on the forecasts for the period the analysis is applied to. On the basis of the various input distribution, the expected fire evolution is calculated and the risk is obtained. Once this result is obtained the damage analysis is performed. The two modules are integrated together via an exchange of JSON messages, as described in the ICD. The tool is also linked with input related with the position of operators in the field.



The risk analysis associated with capsules has been performed in the design phase through analysis of the materials adopted for both the extinguishing materials and the capsules. The technological aspects related with the operating conditions, such as the pressures, have been also considered in the analysis.

In the case of the pellets, the analysis has been performed considering two major aspects: 1) safety and risks associated with the airborne firefighting platforms; 2) Assess risk of persons due to the airborne dispersion of pellets. The potential health hazards of impact of pellets has been evaluated on basis of the Head Injury Criterion (HIC) and Neck Injury criterion (NIJ) through a large number of experiments with crash test dummies, under different conditions. On the basis of the results, it is expected that pellets are safe to ground personal and will not cause severe or irreversible injury, or penetrate the skin, during impact.



Concerning airborne platforms, specific tests have been performed on firefighting aircrafts and helicopters: Safety assessment provided and accepted by the HMOD for the operation of the CL-215 with AAFF system installed. The AAFF system has been installed on helicopter KA-32 with a test in Leon and on UH-60 Black hawk helicopter with tests performed in San Bernardino under daytime and nighttime operation. In the case of cargo platforms, the C-295 has been considered and the AAFF dispensing system has been designed and the safety requirements of the system have been defined.

Under 4 journal papers and 8 conference papers have been published.
All deliverables have been issued and the milestones have been reached. The only significant deviation has been related with the fact that in the case of the cargo the risk analysis has been limited to the definition of design requirements and the design of the dispersing system.

2.5 WP5 – INTEGRATED CRISIS MANAGEMENT

The technologies that have been developed in AF3 Project provide outstanding capabilities to the decision makers and the area managers dealing with large area forest fires, from the aspect of Crisis Management Center and C4I – integrating all the resources in the field under one program and developing new prevention and aerial firefighting means. AF3 provides extraordinary improvement to the efficiency of current fire-fighting operations and to the protection of human lives, the environment and property by developing innovative technologies and means to ensure a high level of integration between existing and new systems.

The scope of this paragraph is to describe the activities made during the program in WP5 and summarize the final results.

The WP 5 provides two levels of tools:

1. Documents that detail the different aspects of crisis management. These papers allowusers to understand the different concepts and restrains while managing a fire crisis

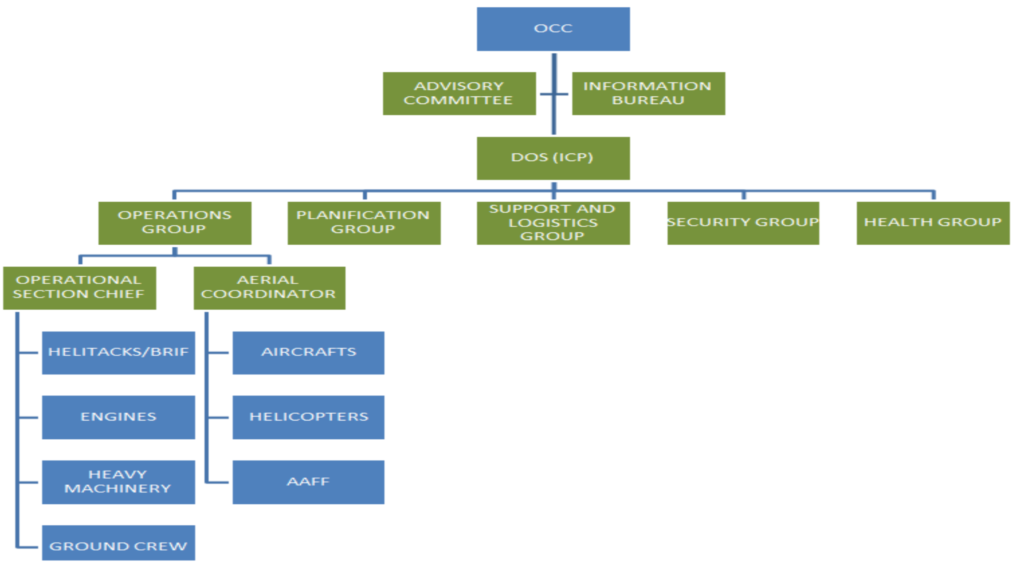
2. Software systems for the crisis management center.
   These systems combined, allow decision makers to understand the situation, and control and manage all forces and resources in the scene.

WP5 OBJECTIVES

1. **Establishing Concept of Operations (CONOPS) for crisis management**

<u>Pre-emergency</u>

- Fire prevention and Air and Ground crew Readiness



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Emergency

- Preventive intervention
- Fire Detection
- Monitoring and Crisis Management and Simulation
- Fire Fighting and Rescue operations

Post-emergency

- Debriefing and Feedback

2. **Integrate and test procedures and systems that will improve capacities in the following areas:**

    - International interoperability

Term (definition)	Emercarto (TRAGSA)		HMOD		UPV		INDIGO		Homeland Security Working Group		AF3 – C4I System (ELBIT)	
	Term (definition)	Symbol	Term (definition)	Symbol	Term (definition)	Symbol	Term (definition)	Symbol	Term (definition)	Symbol	Term (definition)	Symbol
Active Fire	Incendio Activo		Ενεργή πυρκαγιά		Incendio Incendio domestico Incendio industrial		Fire Incident		Fire Incident		Fire (current location)	
Engine	Autobomba		Μηχανή, κινητήρας		Camion de bomberos						Fire truck	
Tank truck / Lorry Tank	Cisterna		Βυτιοφόρο		Camion de bomberos							

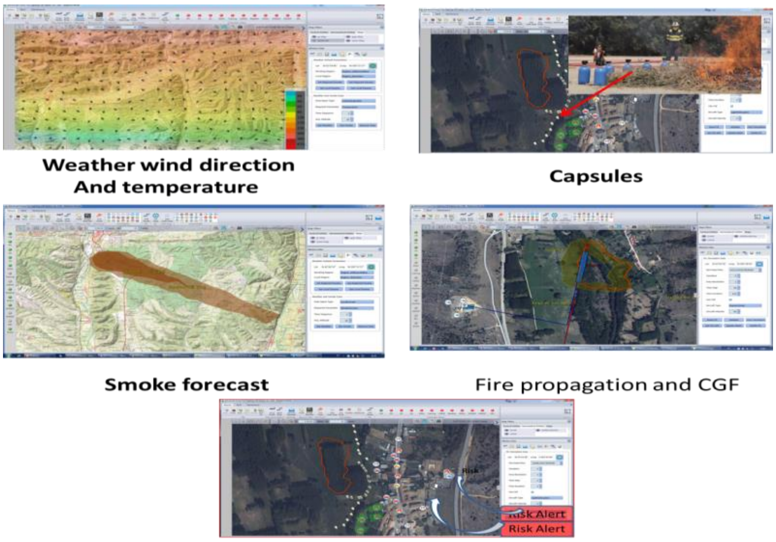
    - Safety management of responders, public and wildlife
    - Public information channels

3. **Provide the following tools for decision makers during crisis management:**

    - Situation Awareness
    - C4I
    - Decision Support

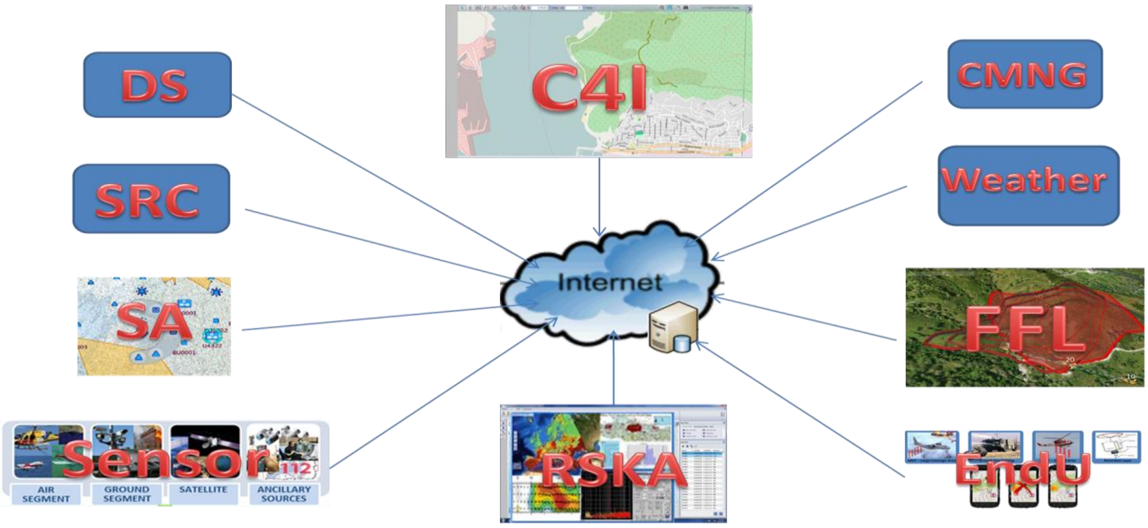
4. **Define training procedures and concepts**

5. Demonstrate the C4I systems capabilities in drills

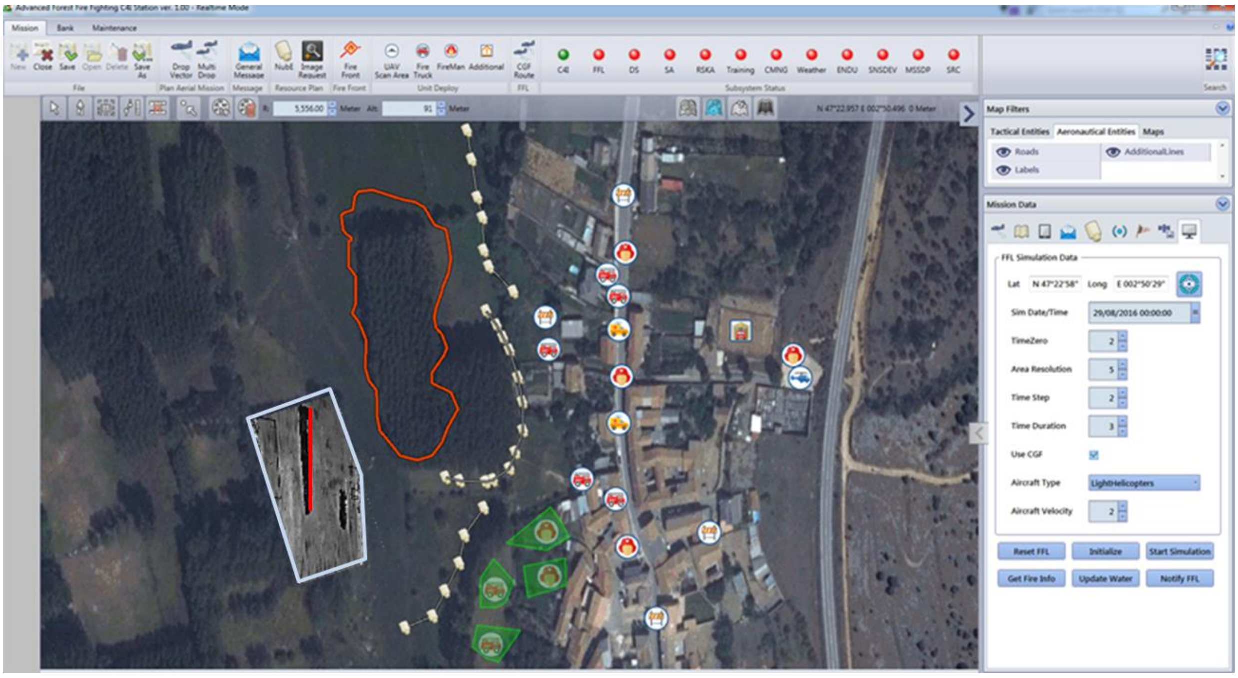


- <u>The C4I system capabilities</u>:
  - Help the Commander to communicate with and command all the operating forces
  - control their activity regarding: location, mission, status, configuration, reports
  - communicate with all the operating forces based on wireless communication.

- <u>The C4I concept of operation</u>:
-
  - Display the SA on a background map
  - Mission Planning Commands
  - FFL fire propagation simulation
  - Decision support
  - Send the command to the Actuators



Advanced Situational Awareness modules (ASA) and Decision Support systems (DS) have been also developed and tested under this WP



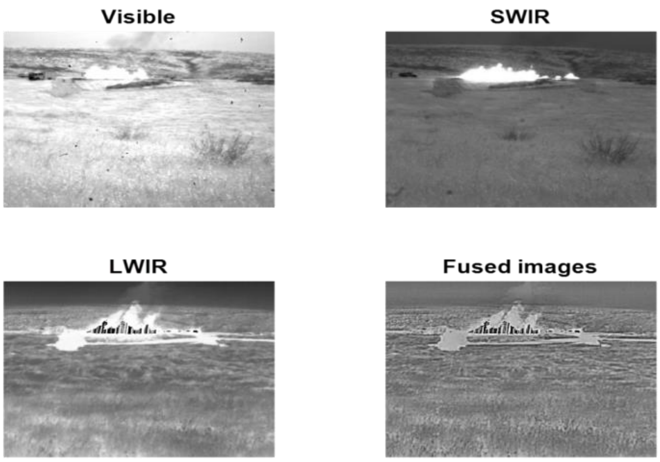
ASA developments were available during the three project drills

2.6 WP6 – MONITORING AND DETECTION

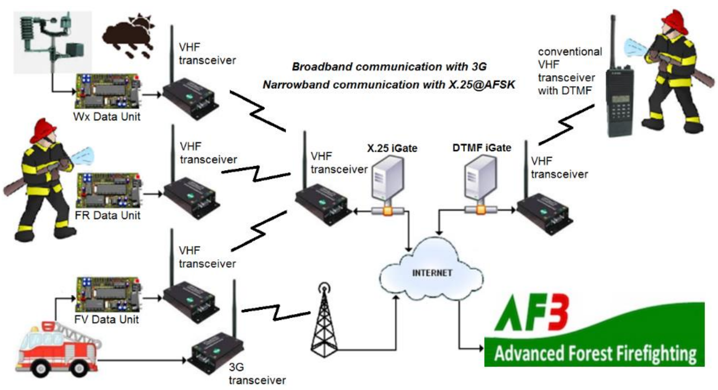
WP6 “Monitoring and Detection” worked throughout AF3 project towards the challenging objective of fire early detection and monitoring. The technical work in this work package included the development, Integration and deployment of different systems including satellites, UAVs, and both mobile and stationary ground systems for the early detection and monitoring of fire and for monitoring the propagation of smoke and toxic clouds.

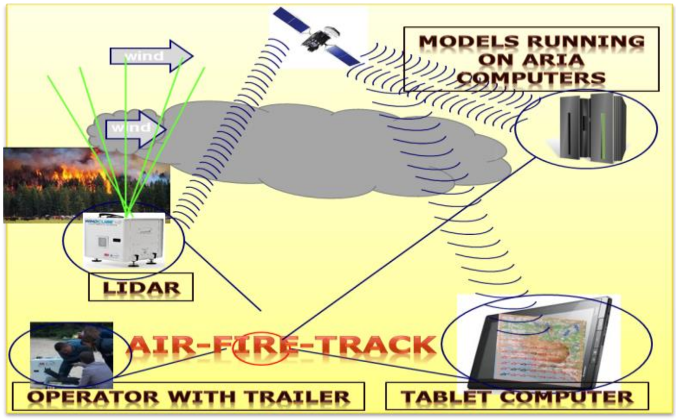
In the area of air and space observation WP6 provided results in terms of field testing of UAVs such as Skylark LEX with Dual Camera Pod (Day/Thermal) and PHGASOS UAV II (Hellenic Air Force operational Asset), the latter was successfully operated during the Greek trials transferring real time video streaming to the Command & Control Room supporting fire detection and patrolling. Construction of variety of maps was constructed through means of satellite observation offering helpful layers of information to the command and control such as vegetation and fire fuel maps among other types.

Multi Spectral Sensor

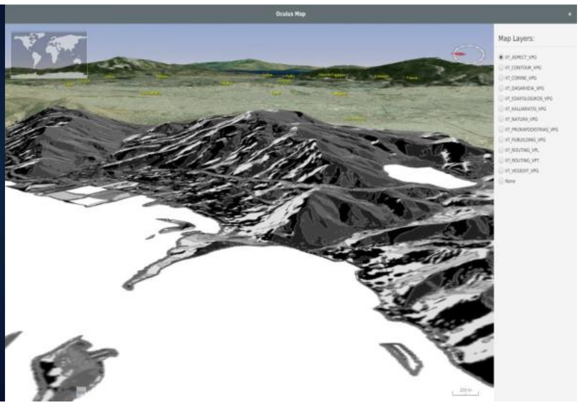


On the ground, a variety of innovative s/w and h/w modules were provided providing enhanced awareness on the field such as low power and robust sensor nodes for autonomous environmental sensing, specialized h/w mission telemetry components wearable by firefighting personnel (FR units) and equipped in fire engines (FB vehicle units), low capacity & bit-rate data communications (e.g. location, telemetry, short text messages) through the onboard 2-way VHF voice transceivers, real time health monitoring of fire crew members, Lidar measurement coupled to a physical model allowing to extrapolate the wind information, interpreting the Lidar observation and using DEM information and physical laws (air mass conservation, atmospheric stability effect) and other.





In the context of WP6, given the wide range of observation sources, an intelligent and efficient data fusion scheme was implemented, deployed and tested on the field, with data fusion and reasoning unit able to combine multi-source observation data with results from fire prediction and fusion algorithms integrating visualization tools both for command and control as well as for ground personnel and first responders.



To conclude, WP6 offered diversity and wide range of systems covering all monitoring and surveillance modalities. All solutions were integrated, deployed, tested, optimized and tested again throughout Greece, Spain and Israel field tests, while the Fusion and Visualization evaluated by End Users and appreciated the operational added-value and significant enhancements offered in terms of early detection and real time monitoring.

2.7 WP7 – ADVANCED FIRE FIGHTING AND PREVENTIVE INTERVENTION

The main objectives of WP7 were:

- Introduce, integrate and test the new AAFF methods & concepts, new system and materials providing complementary solutions and improvements to existing methods.
- Introduce, examine, integrate and test innovative preventive intervention methods and systems reducing the chance of large forest fires and provide protection and separation of critical infrastructures and wildland-urban interface using Nub-e Capsules (Pyro).

2.7.1 WP7 – Main Tasks

WP7.1 - Physics and Chemistry of Firefighting - Pellets & Capsules

Study and analyse the physics and chemistry of the firefighting process for each mission in order to develop advanced physics and chemistry models and scientific simulation tools to optimize the adaption of an innovative AAFF system and choose the appropriate active materials for each mission.

WP7.2 - Advanced Aerial Fire Fighting

- Integrate and test the AAFF systems on Cargo airplane - C295
- Compatibility analysis and adaptation of the AAFF System to:
- Firefighting airplane: CL-215/415
- Helicopter
- Day and night targeting
- Logistic and accessories – Pellet Manufacturing system
- Post mission debrief and analysis

WP7.3 - Ground Fire Fighting Vehicles

Define the requirements for improving the ground equipment of firefighting brigades and for integrating emerging technologies, such as fire fighting vehicles and UGVs with the AF3 architecture.

WP7.4 - Preventive Intervention Means (Capsules)

Design and develop Preventive layers/Capsule Subsystem that allows protecting wildland-urban-interfaces and wildland critical infrastructures without removing vegetation.

2.7.2 WP7.1 - Physics and Chemistry of Firefighting - Pellets & Capsules

This task was performed by FHG-ICT

2.7.2.1 Characterization of fire retardants

2.7.2.1.1 Forest ground fire simulation

Determination of the extinguishing efficiency of fire retardants on a pine needle bed using a high speed IR-camera and temperature measurement by NIR-spectroscopy

$$Velocity\ factor = \frac{v_{fire\ front,without\ fire retardant}}{v_{fire\ front,with\ fire retardant}}$$

Figure 1 - Extinguishing efficiency ranking of various fire retardants

2.7.2.1.2 Physical properties

Cooling effect (Differential Scanning Calorimetry, DSC)

Evolved Gas Analysis (EGA)

Thermogravimetric Analysis (TGA)

Viscosity

2.7.2.1.3 Toxicity tests:

Luminescent bacteria tests with new fire retardants

2.7.2.1.4 Dispersing tests

Sedimentation behaviour of FR-CROS with different dispersing agents for the capsule system - Close cooperation with Pyro

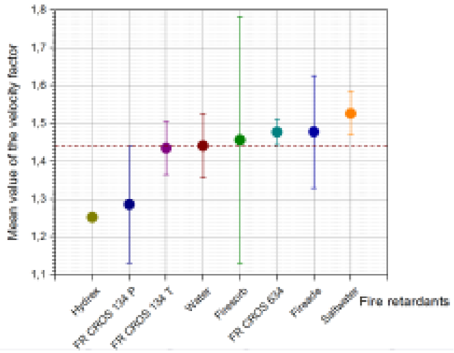


Figure 2 - Dispersing tests

2.7.2.2 Branch impact pellet opening tests

- Interaction with tree branches of water pellets dropped off airplanes
- Adaptation of an air gun setup for the acceleration of pellets on simulated free fall speed to investigate opening behaviour and water distribution

2.7.2.2.1 Test Setup

- Pneumatic gun to accelerate the pellets to 22-25 m/s
- Light gate to measure pellet velocity
- Impact chamber with 7 target branches and twigs (variable size and water content)

Figure 3 – Test Setup

2.7.2.2.2 Results

Mechanical interaction with the crown already occurs for branches Ø>1cm.
Previous experiments showed the pillow-shaped pellet geometry leads aerodynamically to stable flight in horizontal orientation.

➔ Maximization of cross section in drop direction which supports impact probability

2.7.2.3 Large scale fire tests

Objective: Opening behaviour of water pellets in a wood fire - Determination of time to open the pellet under realistic fire conditions

Experimental Setup

- Rack (2 x 2 x 2 m3) with 80 vertical wood bars

- Max. height of the fire 5 to 10 m
- Temperature control by fast emission spectrometry

4 cameras for time to spill/collapse determination

Figure 4 - Test Setup

2.7.2.3.1 Test Results

- 0.3 to <1 s till first spilling @ 2200K
  No influence of air inside the pellets
- Constant falling velocity 25 m s-1
  Flame height in forest fire is 20-30 m
  ➔ crown fire fighting possible

2.7.3 WP7.2 - Advanced Aerial Fire Fighting

2.7.3.1 Main Objectives

- To integrate the AAFF system with dispensing capability on the following 3 aerial platforms:
- Dedicated fire fighting airplane: CL-215 or CL-415
- Helicopter
- Cargo airplane: Airbus DS C295
- To integrate a targeting systems on each of the platforms
- To integrate logistic accessories and capabilities that will support the AAFF systems

2.7.3.2 WP7.2 Technical Results CL-215

AAFF System was demonstrated in Greece on CL-215 on 1st June 2016.

A Pellet Manufacturing Machine was transferred to Greece, Elefsina Air Base and pellets were manufactured on site.

The pellets were loaded manually through the overflow windows of the aircraft.

Excellent accuracy was demonstrated in the Greek trials.

CL-215 drops pellets on Fire

Pellets Manufacturing Machine

Pellets Distribution and Accuracy on Target

2.7.3.3 WP7.2 Technical Results on Helicopters

- AAFF Systems was integrated and tested on UH-60 Black Hawk in California US and on Kamov 32 in Spain
- Flight Envelop approved for up to 75 Knots flight speed, dropping 3 tons of pellets

HyDrop on UH-60 Black Hawk , 2 tons of pellets 500ft., 60 Knots

HyDrop on Kamov 32, 3 tons of Pellets, 500 ft. 60 Knots

2.7.3.4 Final AAFF tests demonstrating Extinguishing of Live Fire Day and Night

The final test was performed successfully in San Bernardino Californa, using special test installation that produced high flames fire at San Bernardino Regional Emergency Training Center. The test was conducted in day time and in night time, droping each time 2.2 tons of Bio-Degradable Pellets from Sling Loaded Fin Stabilized Tank carried by UH-60 Helicopter.

Test results showed excellent hit accuracy of about 2 meters day and night with coverage level of 4 litters per $1M^2$.

Figure 2 - San Bernardino Regional Emergency Training Center

Figure 6 – Pellet Distribution on Target in Day time

Figure 7 – AAFF Night Aerial Fire Fighting demonstrated in San Bernardino

2.7.3.5 AAFF on Cargo Airplane - C-295

The Aerial Firefighting market needs the AAFF solution to be deployed also on big cargo aircraft in order to treat Mega Fires, but without changing or affecting the aircraft itself.

Elbit have developed on its own IR&D funding a system to be used in Cargo Aircrafts. The system is based on pair of conveyors that are planned to be loaded to the cargo aircraft via the back cargo door. From this door, the conveyors designed to drop huge amount of pellets enabling large area coverage with water to suppress Mega Fires 24/7 enabling continuous operation day and night and in degraded visibility.

The dropping concept is similar to dropping pellets from the sling loaded Fin Stabilized Tank carried by Helicopter as described above, using the same computerized system to accurately calculate the ballistic trajectory and the drop time in order to hit the fire center during straight and level flight taking into account the height, speed, wind speed and current position of the aircraft knowing in advance angle of approach and fire coordinates (provided to the system by Area commander.

In AF3 the target aircraft was C-295. The integration activity including the design constraints on the conveyors to prevent any effect on the cargo floor of the aircraft and the airworthiness requirements were provided by AIRBUS DS engineers. However, this task was more critical than expected and the design was completed to a point that AIRBUS DS and to confirm airworthiness and Elbit to assemble the system and load it into the C-295.

Although this task was not finished due to end of program schedule, there is still intention of Elbit to complete the this task out of the AF3 program together with AIRBUS DS and different business setup.

2.7.3.6 AAFF Main Achievments

- Compatibility analysis and adaptation of the AAFF System to Firefighting airplane was performed successfully on CL-215.
- AAFF on Helicopters was performed and demonstrated on Kamov 32 and UH-60 Black Hawk.
- Day targeting was performed and demonstrated successfully on CL-215, Kamov 32, and UH-60 Black Hawk
- Night targeting was performed and demonstrated on UH-60 Black Hawk in the US
- Logistic and accessories – Pellet Manufacturing system – was completed and demonstrated in Greece and in Spain Trials

2.7.4 *WP73:* Ground Fire Fighting Vehicles

The main task was to define the requirements for improving the ground equipment of firefighting brigades and for integrating emerging technologies, such as fire fighting vehicles and UGVs with the AF3 architecture.
This Task was performed by Polito.

2.7.5 *WP74:* Preventive Intervention Means (Capsules)

2.7.5.1 Main Task

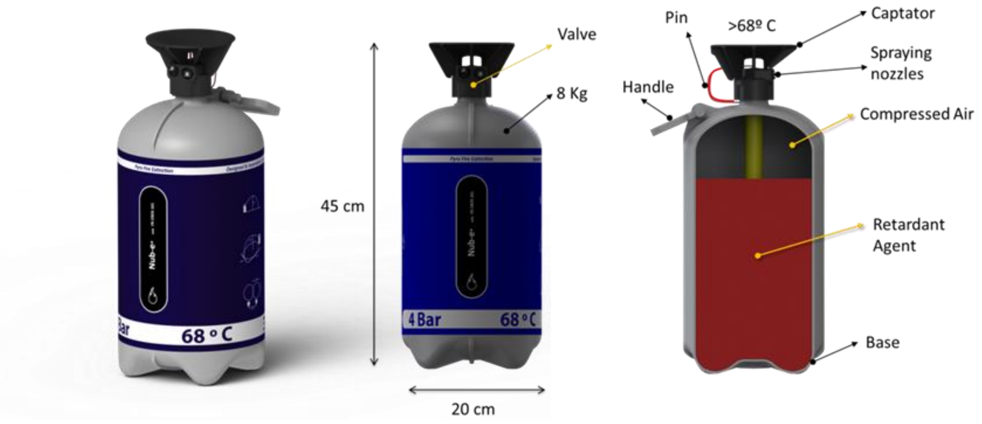
Introduce, examine, integrate and test innovative preventive intervention methods and systems that will reduce the chance of large forest fires and provide protection and separation of critical infrastructures and wildland-urban interface using Nub-e Capsules. Design and engineering of the Preventive Layer/Capsule subsystem

2.7.5.2 PYRO NUB-E Capsules

The preventive means developed by PYRO allow overcoming the actual chemical firebreak (a firebreak is understood as a discontinuity of the available amount of fuel in the fire front that leads to a decrease of flame length, and eventually to fire control and extinction) concept by introducing industrial scale economies in the forestry domain. By means of the use of a line of NUB-E Capsules. NUB-E Capsules are affordable compared to hydrants network, and reduces land occupation required by firebreaks, reducing execution costs and conflicts associated to strip bands or fuel breaks. Furthermore, it is a scalable system, capable to be adapted to changing user’s needs.

2.7.5.3 PYRO Capsules Development Process

- Based on End-Users requirements (D7.4.1), short series of functional capsules have been engineered, produced and tested in more than 20 locations with real fire.
- An experimental methodology (D7.1.1) has been developed in order to translate lab scale fire data to design specifications and benchmark.
- Several design, prototyping and testing iterations have been required to achieve an optimum result (D7.4.2, D.7.1.2)



- Capsules performance results, easiness' use and flexibility make possible to use them in combination with other existing fire fighting techniques, being a fire fighting tool available for Fire Brigades and other non-specialist security forces (police, civil protection).
- Capsules are purely mechanical activated, robust and inherently safe.
- Low maintenance required.
- Capsules are patent pending

Figure 8 – Nub-e Capsules in Actions preventing fire propagation

Figure 9 - Nub-e Capsules Barrier Effect

2.7.5.4 Nub-e Capsules Test Results

- Capsules test show that capsules lines have demonstrated their ability to stop and reduce fire intensity over fires up to 3.5 meters in different fuel models
- Activation is achieved in time. Fire retardant deployment stops fire front advance in the protected area.
- Capsules use is compatible with safe manual tool fire extinction by Fire Brigades or volunteers.
- Placement can be done at a high rate in order to establish fire defence perimeters, secure evacuations and allow Fire Brigades to reinforce their action in critical areas
- AF3 Capsule trials show an important improvement in the fire retardant efficiency against fire compared to existing references in several Fuel Models. Optimized fire retardant distribution and correct activation make possible to achieve the result. Results have been presented in several scientific forums (World Forestry Congress, Congreso Forestal Español, SINIF) for dissemination.
- Fire retardant products used are available and currently being used by Aerial and Ground Means from Fire Fighting Services in EU and USA. Products used in Nub-e are compliant with REACH and other regulations and certifications applicable. Capsules' use safety has been discussed, analysed and tested (**D4.3.2**)

2.7.5.5 Nub-e Capsules Main Achievments

- Nub-e Capsules have been completely developed and tested, achieving a TRL8 making them able to market introduction in the next months.

- Thanks to the outstanding collaboration with End-Users and their Fire Brigades, it has been possible to test extensively capsules in several conditions with an ambitious field testing campaign, providing a useful experience for the development of usability aspects of the product in real emergency conditions.
- Capsules allow non-specialist forces and volunteers (police, civil protection) to play a role in fire fighting. Pilot experiences with different local authorities in Spain are already planned, providing a driver to introduce innovations to improve the self-protection and Management Strategies at the Wildland-Urban Interface.

2.7.6 Summary

WP7 was completed successfully in accordance with its objectives.

The Companies that participated in this WP were – Elbit, FHG-ICT, Polito and Pyro.

Besides Lab tests in FHG, there were 3 formal field tests in Greece, Spain and Israel, and other field tests in United States that demonstrated the advantage of the AAFF technology and the preventive means of Nub-e Capsules.

2.8 WP8 – INTEGRATION, VALIDATION & TRIALS

According to DOW the activities within WP8 Integration, Validation and Trials were scheduled to be performed during the second and third year of the AF3 Project. This WP is split into three ones:

- WP8.1 (Airbus DS responsibility),
- WP8.2 (Elbit responsibility) and
- WP8.3 (Leonardo responsibility)

WP8.1 related to the Partial Tests and Integration Trials started in year two of the Project and was focused in the verification of the integrated system readiness for the overall firefighting tests to be done in WP8.2 during the third year of the Project.
These tasks have been fulfilled because:

- Each subsystem has been developed and tested individually. To that each partner has:
  - Supported the integration of its technologies.
  - Performed validation tests.
  - Provided the tests reports to ELBIT prior to overall system integration and customization to the field trials.
- Advanced Aerial Fire Fighting System (AAFF) Integration Tests:
  - The pellets have been manufactured, and tested
  - Available a computerized delivery system comprising of ruggedized Laptop.
  - Integration and test in a helicopter fulfilled

  - The sling loaded tank has been designed, developed and initially tested on Bell 412 in Israel.
  - Prepare the paperwork necessary to allow the drop of pellets in a foreign country.
  - Tests of the AAFF system in Kamov 32 in Spain in November 2016 previously to Spanish Trials.
  - Day and night tests in a UH-60 Black Hawk helicopter in California in February 2017

CL-215 Ground Acceptance Test

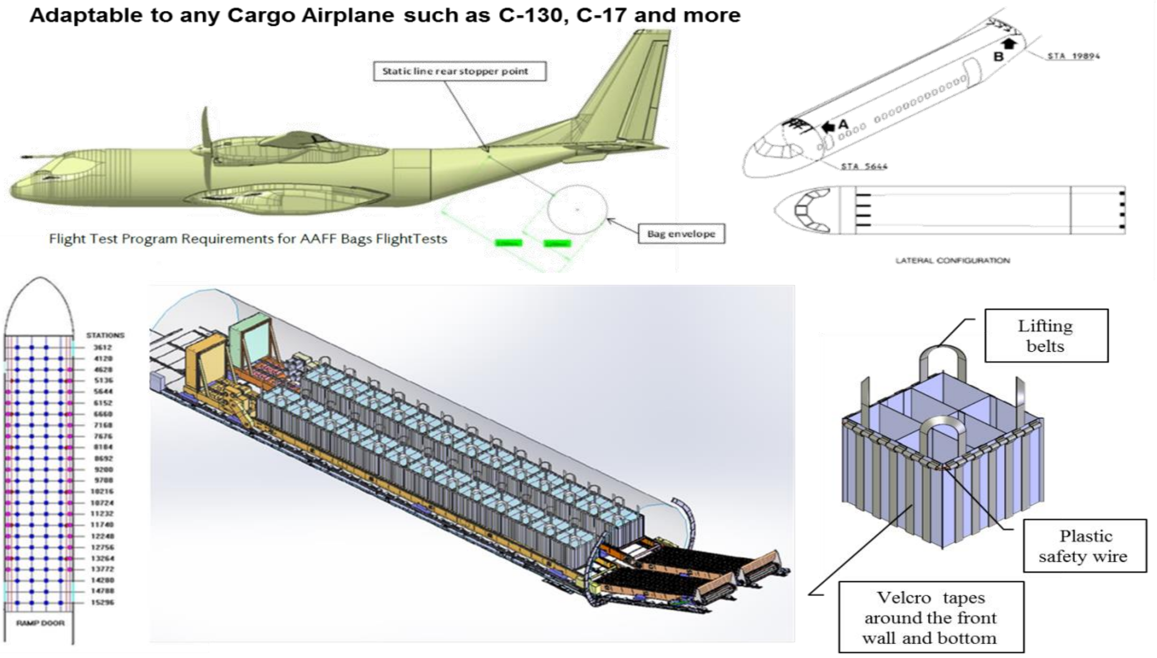
- Integration in the CL215 aircraft fulfilled:
  - Available documents to obtain the Permit to Flight
  - Ground tests performed
  - Safety Review approval available
  - Flight tests performed before Trial in Greece in May 2016

CL-215 dropping pellets during training

- Integration and test in the C295 aircraft partially fulfilled:

- The activities during the the project have been the technical support to Elbit in the design of the AAFF dispensing system (conveyor) in order to have a system that meets with the technical and safety characteristics required to any system to be installed within the C295.
- In the meanwhile, the schedule for the integration and first flight has been provided, showing that between the design validation and the first flight would be necessary not less than 6-7 months.
- At the end of the Project the AAFF dispensing system (conveyor) has not been ready in time.



- The integration of the subsystems has been tested during the Trials in Greece, Spain and Israel showing:
  - Good coordination between the Command and control (C4I); Risk Analysis and Fire Fighting Lab (FFL)
  - Good communication between these three subsystems with satellites, aircrafts, UAS, ground vehicles, mobile devices and personal devices, supporting the decisions maker.
  - Successful integration and test of the AAFF system in two of the three flight platforms established in DOW

The objectives of WP8.2 related to the Overall Fire Fighting Tests have been fulfilled. Three Trials were performed during the third year of the Project:

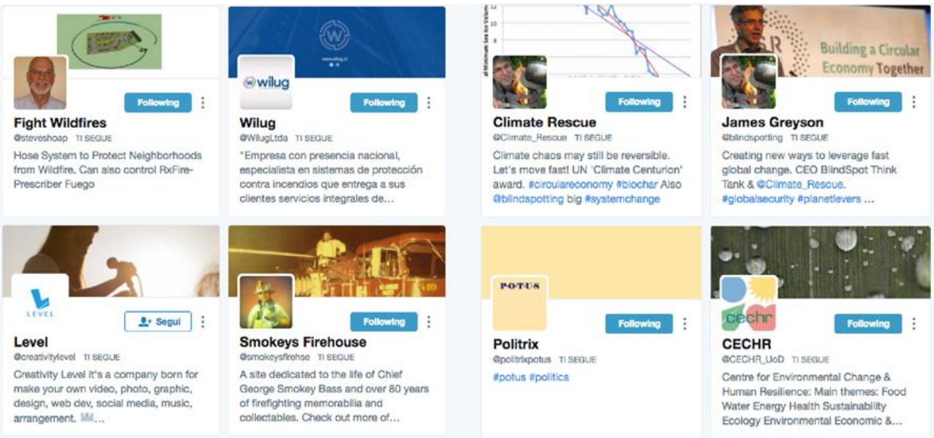
- Greece (May/June 2016)
- Spain (November 2016)
- Israel (April 2017)

These Trials have shown the good integration between the new technologies and have validated the Human-Machine Interaction.
Finally the AF3 system has received a positive outlook from the end-user feedback providing a positive impact to the fire-fighting process in terms of Decision Support and Situation Awareness. For end-users the system appears to be effective, flexible, easy to learn and use.

2.9 WP9 – DISSEMINATION AND EXPLOITATION

The activities developed in the present WP were related to dissemination, standardization and exploitation.
Dissemination activities have been oriented to two main end-users: technical operators (firefighters, engineers, etc.) and general public. The technical dissemination has been performed through the project website, where the publicly available material has been uploaded or linked. Milestone activities are the AF3 summer school and the AF3 workshop on forest fire modeling, where a quite large participation has been obtained. An International workshop on forest fire modeling has been organized on June 22, 2017 at the ISA (Rome). The program included presentations from experts outside the project as well as from members of the AF3 consortium. The international workshop was attended by about 110 participants, mainly engineers and firefighting operators.

In addition, the members of the project consortium have attended 33 national and international conferences and published 33 papers, 10 on scientific journals and 23 in conference proceedings. This type of dissemination is completed by numerous posts on Twitter and a webinar showing the main features of the AF3 system software.



Concerning the dissemination to the general public, this has been mainly conducted through social media, such as Instagram and Facebook. The various partners have also issued 22 press releases on national and international newspapers, together with interviews on national televisions and radios, in order to reach a large variety of public.

Medios aéreos y terrestres muestran en Fontanos de Torío el proyecto europeo AF3 contra incendios

Radio Televisión de Castilla y León

The standardization activities have been conducted on: interoperability rules, flying rules to be applied in order to operate with the proposed systems, airplane loading and extinguishing materials. The first part of the work has been focused on the identification of the relevant standardization organizations and the different existing standard rules and guidelines. An overview of specific European standardization requirements concerning firefighting has been also provided. Last part of the activity, which has had direct impact on various modules of the AF3 system has consisted in the analysis of opportunities for standardization with particular attention to the standards for terminology, object identification and classification (i.e. European Glossary guidelines), standard for interoperability rules (i.e. DISASTER, INDIGO approach), potential use of INSPIRE directive and practical approach to the standard flying rules with reference to the RPAS.

The exploitation activities have been based on a market analysis and the business plan for the most promising products developed within the AF3 project. The worldwide market associated with forest firefighting is promising, having shown a growth rate of 5- 10% per year since 2009, and reached just below 100 billion Euro in 2015. A targeted market analysis also considering the applicability of the proposed technologies has been conducted. The ultimate goal was to define “solutions” that could be replicated in many other situations for planning future investments. Exploitation planning has been conducted, including the potential commercialization of AF3 solutions and possible creation of a spin-off SME and patent applications. A preliminary business plan has been developed showing the status of the technologies which are closer to the market.
Overall, the activities have been performed according with the DOW, with no relevant deviations.

2.10 WP10 – ENVIRONMENTAL AND ETHICAL ISSUES

Workpackage 10 is split into two workpackages:

WP10.1 Ethical issues
WP10.2 Environmental issues & evacuation

EFPC (UK) Ltd. was the workpackage leader of both.

WP10.1 Ethical issues

This Workpackage was setup during Grant Agreement negotiations. Our Project Officer decided to hold the Ethical Issues for AF3 in a separate Workpackage rather then have it broken into tasks across all of the AF3 workpackages.
This Workpackage monitored all ethical aspects that may be applicable to the AF3 Project. The Ethical Manager had the right to halt the research if it was required.

This Work package monitored the Ethical issues arising by the AF3 research to ensure that AF3 maintains the highest ethical standards.

The Monitoring included:

Task 10.1.1 –Ethical Management
This Task covered the Ethical Management of AF3 across all the Workpackages and included:
a) Monitoring all AF3 Ethical Issues and ensuring that the ethical standards and guidelines of FP7 were rigorously applied, regardless of the country in which the research is carried out.
b) Part of the Project Management Office and attending relevant meetings.
c) Liaising with the Advisory board on Ethical Issues as appropriate.
d) Being the AF3 contact for Ethical Issues if any Researcher, User, Participant, Ethical Body or EC has any questions or requires any information.
e) Holding meetings with the Technical Manager and Workpackage and Task leaders as required.
f) Review of each deliverable prior to release to ensure Ethical Compliance.
Monitoring that the research is being conducted in accordance to EU ethical standards and included:
• asking questions of the research team, inspecting all consent documents and records and being guided through any physical experiments associated with the project;
• advising on and approving the research methods, including unexpected changes or opportunities that may come up during the research;

• taking appropriate ad-hoc decisions with regard to minimising unforeseen harm that may have occurred during the research.

Monitoring of the safety of the project activities with regard to the researchers.
This monitoring included:
• Health and safety issues of the researchers that test research carried out in the other WPs;
• The risk of physical or emotional harm to the researcher, and steps to be taken to mitigate it;
• Arrangements for reporting and dealing with any adverse reactions to the project.

Task 10.1.2 – Informed Consent and Ethical Approvals
This Task ensured that:
a) Informed Consent Forms were produced
b) The application to the competent local/national ethical boards/bodies/administrations for authorization/notification/opinion includes detailed information on the procedures that was used for the recruitment of participants.
Copies of examples of the Informed Consent Forms and Information Sheets was included which will be in language and terms understandable to the participants. Procedures will be put into place on how to actually get the informed consent forms filled in.
c) Copies of ethical approvals/notifications/opinions by the competent legal local/national Ethics Boards/Bodies/administrations were submitted to the EC/REA before the commencement of the relevant research.

T10.1.3 and T10.1.4 were merged with T10.1.1 following the first review.

Task 10.1.5 - Minimizing Misuse of research results.
This Task monitored the AF3 Project results and took action to ensure the potential for the misuse of the Project Results is minimized. These included possible misuse of agents or equipment that could be directly misused for criminal, terrorist or unethical military purposes.

WP10.2 Environmental issues & evacuation

AF3 wanted to show that aerially-applied fire retardant via pellets reduces wildfire intensity and rate of spread, decreasing risks to firemen, enabling them to construct fireline safely.
This Workpackage monitored the Environmental and health aspects of using these pellets and capsules to tackle wildfire and the usage risk will be assessed and compared to the advantages.
This Workpackage also addressed the complicated issue of Evacuation – in particular if it becomes mandatory.

Task 10.2.1 - Environmental Impact issues
This Task monitored the Environmental impact issues of the use of the pellets.
This task worked closely with WP4 to ensure that the pellet shells are biodegradable.
The task will conclude with an Advantages Vs. Risk Assessment.
AF3 was only involved in the use of Capsules/Pellets that contain only liquid retardant agents that are biodegradable, nonexplosive or toxic.

Task 10.2.2 – Evacuation
In a state of emergency, people are highly excitable and have to be controlled carefully, in particular if the fire leads to a forced evacuation.
Mandatory evacuation orders necessitate confronting a series of policy questions which this task will look at:

- What happens if some persons refuse to evacuate? Given the fact that those who fail to leave their homes endanger primarily themselves, not other people?
- What level of coercive authority ought to be applied to those who fail to comply?
- Should penalties be sought in such cases?
- What duties of rescue, if any, do public officials bear for those who resist orders of evacuation?
- How are vulnerable people managed? Such as the disabled and the elderly?

This task produced a deliverable that was fully completed on time and submitted.

2.11 SUMMARY OF THE WORK PACKAGES

Here above an overview of the activity along the 3-year period, in term of different tasks it was divided in, has been presented. This overview is a bit heterogeneous, because of the intrinsic differences among the partners responsible for each WP, some of them were institutions, some research institutes, some other SMEs, and large companies were in charge of many tasks of the activity.
In the following, instead, a picture will be done –already presented, with a different detail, in the 3rd Periodic Report- more focused on the final year of AF3 project: this time the activity will be shown not in term of WPs, but of steps and specific results achieved during its final year.

3. AF3 FINAL YEAR RESULTS

3.1 HIGH LEVEL OVERVIEW

The most important steps toward the conclusion of AF3 project after the second annual review held in June 2016 (M25), have been mainly devoted to a further integration of the system, respect what was already done in the first two years, and to a demonstration on the field of the capabilities and performance of the system itself.

The first important result in this direction was the organization of a session of field trials in Greece (June 2016), whose aim and preparation had been already described in detail in the 2nd year Progress Report; a more detailed description of these trials will be given in the next chapter of this document.

Just after the *Greek Trials*, at the end of the summer a specific event strictly related to AF3 project has been held, the so-called *Summer School.*

A second trial session, with a higher integration of the system modules respect to the previous one, was organized in Spain (*Spanish Trials*) in November 2016.

At the beginning of the new year some management job has been done in order to implement the *Project Amendment* which included many slight changes and deviations already decided and agreed in the first two years, and not officially approved yet; with this same Amendment, AF3 project has been extended for a further duration of three (3) months, so its final duration was 39 months.

One of the consequences of the Amendment was the shift of the final trials session (*Israel Trials*) from the initially foreseen M34 (February 2017) to two months later, so April 2017 (M36). These trials will be described more deeply in the following part of this document as well. After these drills, in June, the *last Project Meeting* took place in Rome, just before the summer, as a formal conclusion of the project's activities and in preparation of the Final Review of September.

In the following part of the document the two different main branches of the activity, that actually in a temporary scale have been strictly interconnected, will be presented separately: the System Implementation and integration in the next chapter, and the more specific Project Activities in the following one.

3.2 SYSTEM IMPLEMENTATION AND INTEGRATION

Just from the previous year, the consortium has made a big effort in order to present preliminary integrated versions of modules/subsystems functioning properly for the pre-trial in Athens, in advance respect to what agreed with the DoW. The further parts of the plan for the integration were by force strictly connected with the dates of the trials in Greece - June 2016, Spain - November 2016, and the completion of the whole integration before the final test initially foreseen in Israel in February 2017, then moved to April 2017.

3.2.1 Greek Trials

The Pre-final real firefighting trial carried out in Greece, was the first large scale field test of AF3 project, included real, prescribed fire and HMOD firefighting airplane CL-215 & CL-415/helicopters to assess use of the AF3 advanced firefighting capabilities on real fire. During this test, UAV and other airborne platforms demonstrated fire detection and monitoring capabilities. The efficiency of the operation was compared to existing and conventional methods of fire extinguishing.

The consortium agreed in October, during a plenary technical meeting, to perform the pre-trials in early June in Greece, anticipating of 3 months the deadline . The organization of the pre-trials was under NCRSD and HMOD responsibility.

The relatively advanced deadline of the first tests in Greece, with respect to the delivery of some modules/subsystems as foreseen by the DoW, has stressed the integration plan of the different sub-assemblies and accelerated the process of software and integration. The integration plan has been organized in order to schedule the steps from each separate module integration to the integration among different modules/subsystems during the month of April 2016, in order to execute the overall software integration by the second week of May 2016 via remote connection.

Objective of the exercises was the first pilot integration of systems, sub-systems, devices and applications developed in the AF3 framework. In particular:

- The first pre-final firefighting trial flown by HMOD firefighting airplanes CL-215 implementing the novel AAFF (Advanced Aerial Fire Fighting) system to accurately and safely disperse extinguishing materials from high altitude in any condition.
- Demonstrate the effectiveness of the pellets in terms of accurate and safe deliver extinguishing materials.
- Demonstrate detection and monitoring capabilities, integration and deployment of diverse systems including satellites, airplanes, UAVs, and both mobile and stationary ground systems for the early detection of fire and for monitoring the propagation of smoke and toxic clouds.
- Preliminary testing and debugging of the integrated deployable Crisis Management System based on C4I, Situational Awareness, FFL, Sensors & Devices, DS, Risk Analysis and other subsystems in order to improve its level of integration.
- Pre-final trial of capsules' preventive layer.
- To assess use of the AF3 proposed advanced firefighting capabilities in the current firefighting Enterprise Model of Hellenic Civil Protection Authorities and recommendations for adoption and possible standardization required.
- Improve the level of integration and collaboration of AF3 technologies and identify issues for improvement/correction.
- Demonstrate the effectiveness of the Fire Fighting Lab to predict fire front propagation (simulation of the fire).
- Demonstrate the effectiveness of the Real Time Risk Analysis tool to predict risk evolution during a fire event.

The exercises in Athens have represented the first concrete, on field, test concerning the behavior of the integrated project architecture.

The chosen baseline scenario has been a mega-wildfire near populated area in the wildland-urban interface of the HMOD Naval Base and a second low-scale wildfire which breaks out in Ionian Sea one day after the ignition of the fire in Athens. This is hence a close to double and parallel disaster. The extent of the disaster and the conditions create the need for simultaneous wildland fire suppression, aerial firefighting and structure collapse rescue operations, while as the situation evolves, populated areas and infrastructures of the Naval Base need to be evacuated.
As foretold, the scenario concludes with a close to parallel fire ignition in Ionian Sea. The incident is detected by tourists and confirmed by PEGASUS UAV during its patrolling over the area, normally carried-out when the area is considered of very-high risk level. The fire size is of low-scale compared with the event of Athens and fire suppression is done only though ground means.
Whole scenario has been analyzed in two (2) days and sequential episodes.

The AF3 concept depicted in figure 4 of the Dow, and here below, has been tested accordingly with the actual project architecture status.

Monitoring sources: all the foreseen monitoring sources were present in Greece. The link among the monitoring sources and the AF3 Core expert engine , with particular attention to interface to the Commander, was partially assured due to the preliminary version of each components. However all the monitoring sources worked correctly in standalone configuration. This fact was monitored by the presence of dedicated self-owned man machine interface.

AF3 Core Expert Engine: It is formally constituted by three macro elements, the real time risk analysis, the Fire Fighting Laboratory and the integrated crisis management station. The real time risk analysis was tested in standalone configuration due to a slight delay due to the reallocation of this activity to a new responsible (POLITO instead FHG-EMI). Evidences of partial connection with the C4I have been found. During the Greek trials the FFL run on a portable workstation integrated with the overall system and it was monitored through the following HMI. The simulation started at the reception of the specific request by the Commander, via C4I.The crisis management station collects some tasks among several subsystem, C4I, Situation Awareness and Crowd Behavior. Due to the crucial role of this element, that is the real core of the management of the firefighting mission, there were some capabilities only partially implemented and, consequently, only partially tested.

AF3 Active countermeasures: The retardant agent layer have been tested in different fuel models, including grass, shrub needles and logging. In all of them, Nub-e has been able to extinguish the fire or, at least, to reduce significantly the fire intensity in which fire fighters' operations are possible in order to perform a direct attack. The effectiveness of NUB-E system has been demonstrated in both the autonomous working mode and the manual one. AAFF System was demonstrated in Greece on CL215. Several flights were performed including ground training to the pilots, INS calibration, 100 Kg. drops (X2), 2 tons Drop pretrial drop and final 2 tons drop on real fire. Excellent accuracy was demonstrated in the Greek trials. Ground fire firefighting were involved on the different scenarios proposed.

All the foreseen missions have been played and successfully attempted.

All the AF3 subsystems were present in Athens at least in an engineering configuration, part of them working as in the expected final trials.
With reference to the DoW, the following elements, completed by the end of the second year of the project were successfully tested during the pre-trials in Greece:

- Forest Fire propagation scenario model (WP3.1)
- Crisis management (WP3.2)
- Airborne, space, ground and ancillary observations components (WP6.1-P6.2)

A draft version of the Fire Fighting Laboratory (WP3.3), foreseen for M32, was also tested.
A preliminary section of training (WP5.3), expected by M30 was also presented.
A Pellet Manufacturing Machine was transferred from Israel to Greece, Elefsina Air Base and pellets were manufactured on site. The pellets were loaded manually through the overflow windows of the aircraft. A ground test for measurement of drop time of two tons of pellets from the,aircraft tanks was made (90% of the two tons, dropped in 2 seconds).

The exercises have highlighted some logistic aspects that have been gradually solved in Spain and Israel, related to the Internet connection and to the bandwidth used for the communications among subsystems and to the Command and Control room.

The partners managed to show good integration and well managed trials although the pre-trial integration efforts shortened considerably.

The Greek Trial was the first Airplanes CL-215 implementing the novel AAFF (Advanced Aerial Fire Fighting) system to accurately and safely disperse extinguishing materials (pellets) from high altitude in any condition. The demonstration has shown the effectiveness of the pellets in terms of accurate and safe delivery of extinguishing materials. The large scale test also included demonstration of detection and monitoring capabilities, integration and deployment of diverse systems including satellites, UAVs, and both mobile and stationary ground systems for the early detection of fire and for monitoring the propagation of smoke and toxic clouds. Preliminary testing and debugging of the integrated deployable Crisis Management System based on C4I, Situational Awareness, FFL, Sensors & Devices, DS, Risk Analysis and other subsystems in order to improve its level of integration took place as well as the pre-final trial of capsules' preventive layer.

The success of the exercise was founded in an exceptional area: the Naval Base Skaramagkas, SW of Athens. The area is mostly covered by forest with large terrain variations which affect its micro-climate. In its approximately 1.500 acres (607 ha) are sited: a 1.200 acres (485 ha) forest, crucial storage facilities, costal navy facilities, Hellenic Navy Petty Officers Academy facilities, which accommodate approximately 500 students. To demonstrate the ability of handling multiple events from the command and control a parallel side exercise took place in the Air Force resort close to Vonitsa village, 350 km NW of Athens and 7 km away the Aktion Air Base.

The Greek Trial was an important and very successful milestone for AF3 project which set the continuation of real firefighting tests on good foundations. The success of the trial is also highlighted by the extensive participation, with 194 registered participants and a great End User representation and active participation with 90 participants from End User organisations from Greece, Spain and Italy, 70 operational and tactical players and 13 external participants from the Advisory Board.

3.2.2 Spanish Trials

During the third week of November 2016, a second AF3 drill took place in the Spanish province of Leon. The AF3 prototypes had been previously tested in a trial in Greece (june 2016), which allowed to attain conclusions about their functionality, as well as check the ongoing of developments, at their level of maturity and integration at that moment. In this occasion, all the utilities were expected to be tested as completed utilities, and to demonstrate a high level of integration as subsystems and modules of the AF3 as a whole system.
In this sense, special care was put into carrying out a drill in an scenario of high reality in what concerns the involvement of the real Agencies holding the competencies for fire-fighting emergencies in the area, and the need for the compatibility between new AF3 technologies and methods and already existing Emergency Response regional and National Protocol.

The main objectives of the second trial session held in Spain in November 2016 have been the following:

- Contribute to validate new AF3 technological concepts and the human-machine interface (HMI).
- Evaluate the overall functioning of the new system and the improvements with respect to the current capacities
- A flight test in a segregated air space in Spain to demonstrate the accuracy and efficiency of Advanced Aerial Fire Fighting using AAFF system integrated in Kamov Ka-32.
- A test with real fire (prescribed burn) to assess the efficacy of capsules' preventive layers (PYRO).
- Additional testing and debugging of the **integrated deployable Crisis Management System** based on Situational Awareness, FFL, DS, Risk Analysis, and C4I in order to further improve its level of integration.
- Assess the use of AF3 proposed advanced firefighting capabilities in the current JCyL firefighting model, as well as the State and other Spanish Civil Protection Authorities, and recommendations for adoption and possible standardization required.
- Improve the level of integration and collaboration of AF3 technologies and identify issues for improvement/correction throughout the development of a real time fire.

Two separated location were needed for this purpose, one for the Command Center (in the city of Leon, at the premises of the Centre for the Defense against Fire, CDF, of Regional Government of Junta de Castilla y León), where AF3 Control Room was allocated, and a second one for the emergency (an area of about 1.500 hectares on the vicinities of the village ‘Fontanos de Torío’, 20 km away from the control room). Important arranges had to be completed in both locations so as to ensure that all communication needs were covered, as well as to create the most realistic scenario at each moment of the drill (fires, availability of fire fighting resources from their usual bases and posts, setting-up of alternative channels to avoid interfering with real emergency communications, etc).

Some days before the drill, setting ups and integration on-site tests were performed, together with a training session, aimed at providing the attendees and participants with the knowledge and skills to face the drill.

The Drill consisted of a fire in a forest area close to a village and affecting the urban interface, which would be complicated by the extreme weather conditions and the existence of a landfill in combustion for days, which, under these conditions, would get out of control. During the exercise, the fire would reach the dimension and hazardousness required for the declaration of a Level 2 emergency (i.e. Fires which suppression is expected to require the intervention of national reinforcement resources in addition to the ones under the competencies of the regional Government, or when situations affecting the national interest might turn out).

Seven key sites on field were identified within the operations area in 'Fontanos de Torío', for supporting the exercise demonstrations, throughout the nine episodes (Table 1) that would sequentially arise as the situation progresses.

Episode	**Description**
Episode 1	Start of a fire and detection ➢ *Use of detection technologies: social networks, citizen app* ➢ *Use of UAV Skylark (Elbit)*
Episode 2	Forest ranger report, mobilisation and data analysis ➢ *Use of FFL for a starting assessment and comparison with current actual fire perimeter* ➢ *Use of damage analysis (preventive)* ➢ *Use of Skylark for a first assessment* ➢ *Streaming images by UPV system*
Episode 3	First Attack ➢ *Use of DS tools for the definition of an Attack Plan* ➢ *Use of SA tools for assessment of the incident (video streaming)* ➢ *Use of the weather station of the wireless sensors network for real time data provision* ➢ *Use of detection and monitoring technologies: UOW sensors*
Episode 4	Activation of the Emergency Management System for Forest Fires (Level 0) ➢ *Use of DS General Data (Emercarto, EmerMap) for decision support.* ➢ *Use of C4I for resource allocation and building of a simulation scenario.* ➢ *Use of End User tools (Firegoo) for displaying of intervention places and message reception.* ➢ *Use of ASA for awareness on the means location and fire perimeter.*

Episode 5	Firefighting simulation (Level 1) ➢ *Use of LIDAR for weather and smoke plume forecasts* ➢ *Use of detection and monitoring technologies: UOW sensors*
Episode 6	Impact on pine forest and infrastructure / WUI (Level 1) ➢ *Use of FFL for the evaluation of fire behaviour that approaches the wildland-urban* ➢ *Use of Crowd behaviour simulation for assessment of the evacuation actions.* ➢ *Use DS tools to support decision of evacuation and to make decisions on the use of preventive capsules.* ➢ *Use of Nub-e system to defend the area of wildland-urban interface.*
Episode 7	Episode 7: Impact on firefighting personnel (Level 1) ➢ *Testing of the spatial reference tools DS.* ➢ *Use of Firestress application to monitor the intensity of effort of the firefighters.* ➢ *Use of SA tools to provide accurate real-time images of the incident to the IC and the CCM.* ➢ *Use of e-Health tools ICOM to make decisions with the injured members.*
Episode 8	Advanced Aerial Fire Fighting techniques (Level 2) ➢ *Use of DS tools to make decisions about the advanced air strikes (AAFF).* ➢ *Use of the AAFF system to deal with the fire.* ➢ *Use of Skylark for assessing the performance of air means.*
Episode 9	Control demobilization and end of Trial (16:30 – 17:30)

Table 1. Description of AF3 Spanish trial Episodes

Aerial means in order to assess AF3 capacities, as well as other Remotely Piloted Air Systems (RPAS) and platforms that are aimed to detect and monitor fire, including transmission of information and instructions between the people involved in the emergency. The test results will be compared with conventional firefighting methods.

The fire reached the dimension and hazardousness required for the declaration of a **Level 2** emergency (i.e. Fires which suppression is expected to require the intervention of national reinforcement resources in addition to the ones under the competencies of the regional Government, or when situations affecting the national interest might turn out).

The trial took place over a single day, using the day before for a training workshop in order to show with a sufficient level of detail the purpose, functioning and integration in AF3 of each of the subsystems and its role regarding the management of the emergency. During the day after the trial, observers shared and exchanges their impressions and opinions about the performance of the trial.

From the detection to the final removal of fire fighting resources the Emergency protocols would be followed while using the AF3 system for more effective and efficient operations, including the use of the AF3 Advanced countermeasures (i.e. Advanced Aerial Fire Fighting, AAFF, and NUBe system).

The AF3 Trial included the following capabilities to be assessed:

- Detection and Monitoring Resources: Airborne, Satellite, Ground Observation and Ancillary Data, Data fusion.
- Visualisation Integrated Crisis Management Resources: Simulation tools: FFL, Risk Analysis tools, Situation Awareness, Command, Control and Communication, International Interoperability, Expert Systems and Decision Support Tools, Safety management of responders, public and wildlife, Public information channels
- Firefighting Resources: Advanced Aerial Fire Fighting, Ground Fire Fighting Means, Preventive Intervention Means (capsules' preventive layers)


As a result, the Trial allowed demonstrating most of the modules and subsystems developed under the AF3 project. The synchronization with the field was attained successfully and it was possible a continuous awareness of what happened in the intervention area. However some difficulties appeared in following the exercise from the command and control room in León (20 km away of the intervention área) due to the use of the several interfaces of the different subsystems and the duration of the exercise, which demanded quite a lot of attention on every detail by the audience, in order not to lose the track, which demonstrated the need for using an only single main interface for the Control Room Commander.

In the field area, two Firefighting light helicopters, one cargo and one coordination helicopters, three engines, two ground crews, one communications vehicle (Furgosat), one Incident Command Post Truck, 2 RPAS, one ambulance, and several 4x4 vehicules, supported the exercise in the nearby of Fontanos de Torío. Lidar sensor and wireless network of sensors were also set up for modelling of smoke plume and fire spread and for detection purposes. Mobile apps were used for detection, situation awareness, decision support and risk analysis for firefighters, as well as for health monitoring. The village of Fontanos de Torío was protected with the NUBe System, building a barrier along the village perimeter, and Hydrop System (AAFF) was tested.
In the Control Room, three rooms in the Center for the Defense against Fire (CDF- Junta de Castilla y León), were dedicated to host the control room, endowed with all the AF3 systems and three screens; a common room for the follow up of the drill, endowed with three video projectors, and a multipurpose room, for exhibition and training exercise on virtual environment.

3.2.3 Israel Trials

Three trials have been carried out in Greece, Spain and overall final trial in Israel, the trails subject was to demonstration and test the new AF3 system improvement compare to the technologies and systems currently available to fire fighters and emergency agencies.

3.2.3.1 Trial Objective

In the trials, the new AF3 system innovative technologies, and means has been presented and tested to reach the following objectives:

- Implementation of the novel AAFF (Advanced Aerial Fire Fighting) system to accurately and safely disperse extinguishing materials from high altitude by aircrafts and helicopters in any condition: day and night
- Fast build-up of preventive defensive lines of capsules to prevent the spreading of fire from forest to populated areas
- Early detection and monitoring, using satellites images, aero planes, UAVs, and both mobile and stationary ground systems for the early detection of fire
- Simulation tools to predict fire propagation, weather forecast, risk and damage analysis, decision support tool and Situation awareness map
- Protection of human and wildlife lives

- Using the real system for training
- Ground Firefighting innovative concepts and systems have been examined
- Monitored sensors operated from various platforms
- Validated the AF3 new technological concepts
- Validated the HMI (Human Machine Interfaces)
- Evaluated the overall performance of the new system and improvements with respect to current capabilities.
- Validated the Integrated Crisis Management Center (C4I) in both simulated scenarios and practices during the final trial in Israel.

An additional objective for the final trial session was the integration of the system in the C-295 Cargo aircraft, as foreseen in the DoW and more specifically in the WP 8.2. This was at the end not possible because in particular the AAFF Pellet Dispensing System required to be installed within the aircraft is actually a very complex system that had to fulfill:

1. The requirements imposed to the own system in order to be capable to deliver the amount of pellets (about 6 Tons) in the time (2-3 seconds) required to be effective in a real fire
2. The requirements to be installed within the C295:
    a. Requirements from the point of view of mechanical, operational and system integration.
    b. Flight Safety: the dispensing system shall be designed to demonstrate that the impact of the load jammed on the ramp do not affect the flight safety. The AAFF Dispensing system shall be designed to demonstrate that:
        i. The worst aircraft Center of Gravity (CG) through a single conveyor delivery (3 ton of water) is less or equal than the most aft CG position of the aircraft in cargo jettison emergency conditions
        ii. The event of both conveyors (6 ton of water) simultaneously stopped (either due to jamming or loss of power/control) during a delivery is Extremely Improbable (i.e. probability $<10^{-9}$ per Flight Hour)

So, the AAFF Pellet Dispensing System has not been integrated within the C295 because the safety assessment required to demonstrate the point (b.ii.) has not been available within the required time to allow the validation of the system, manufacturing and integration within the C295. During the whole duration of the 3rd year of the project it became evident that the schedule for this integration was too tight and not compatible with the final tests to be done, even with the 3 months of extension of the AF3 program.

A lot of preparatory actions toward this direction have been anyway taken, so in principle this task would be possibly completed in the next future. All the detail is better treated and explained in the WP8 description, and additional information will be given during the final review when presenting those specific parts of the activity.

The final firefighting trials carried out in Israel, in the area of Lachish, with the participation of the

Israeli MOPS via the Firefighting and Rescue authority, the Israeli Police Aviation, the Israeli Air Force, Forestry authorities, MDA – Magen David Adom (Israeli organization compatible with Red Cross), and University of Haifa, which have direct responsibility in such emergencies and which will provide first response resources.
The trials took place over a single day, using the day before for training, and the third day for summary and lessons learned. The trial day focused with a sufficient level of detail, on functioning and integration of each AF3 subsystems and its role, regarding the management and control of the emergency event. The last day has been saved for discussion and trial summarizations with the participants of the partners, observers and end users.

Location:
The trial has been carried out in LACHISH Area

- Forest fire intervention area: located in the LACHISH Area, in the proximity of BEN DEKALIM
- Command Center: located in the *Holiday Inn hotel in Ashkelon*

Forest fire intervention area

Consisting of the area where the operational and tactical actions for the emergency control will be carried out. It will host tactical and operational units:
Three teams of firefighters, rescue team, command post team, first-aid post, aerial observation, two extinguishing planes.
The LACHISH Area has been selected as the most suitable place to perform the trial, according to the following criteria:

- Communications:
  - Voice communication conducted using regular FM/AM VHF devices.

    - Data communication through Cellular Communication - LTE.
- UAVs operations
    - Landing and take-off of Skylark (ELBIT).
- Accessibility for off-road vehicles and firefighting resources - Allows mobility throughout the exercise.
- Area for prescribed fire will be available and prepared before the trial.
- Urban Area for enabling performing crowd simulations behavior.

3.2.3.2 SCENARIO EXERCISE IN EPISODES

The exercise was consisted of the AF3 system demonstration in managing a simulated large wildfire through a drill that will take place in the Lachish area, Israel. This will allow demonstrating the various applications and subsystems included in AF3, as well as their integrated use and the assessment of their level of integration.
The episodes will cover a full scenario, that starts from a citizen 102 call to the emergency fire center and then pass through all fire-levels, while using all AF3 partners firefighting means. The drill will be controlled and operated from the control room by the Operation Room Commander
The overall drill took a full day, starting from 9 AM and ending at 6 PM.
The context of the trial is a forest fire which quickly becomes a Big fire (larger than 500 ha), close to a forest area with high ecological value and near the BEN DEKALIM, small town near the GAD reserve park.
The scale of the disaster and the very adverse conditions for the fire spreading, raise the need to cut off communication infrastructures and evacuation of the town BEN DEKALIM.

3.2.3.3 Episodes in Ashkelon

3.2.3.3.1 Episode 0. Daily risk analysis

Episode description

The risk map is sent every day until 16:00 (the day before), by the Israel Meteorological Service to the firefighting center, the risk map gathers and displays to the operational commander regarding the fire ignition risk, based on the analysis of following parameters: the weather components, wind speed and direction, continuity of the extreme weather conditions, the relative humidity and vegetation fuel type.

The daily risk levels are defined based on the daily Risk map by the operation commander. There are three risk levels: Regular day, High-risk day, and Extreme-risk day. The high/ extreme-risk days force the operation commander to inform the authorities to activate regulation suitable for the extreme day, such as; freeze all personnel vacations, Reinforcement of personnel, Field patrol, airborne observations patrol, Manning observation, and distribute capsules in high-risk area.
In these episodes we will use the SRC Risk map and ARIA weather data, to display to the control room commander, in order to simulate the daily operation.
The control room commander will order the operational commander to distribute NUB-E for preventive operations.

3.2.3.3.2 *Episode 1. Start of a Fire and Detection*

- Use of detection technologies: social networks, citizen app
- Use of one firefighting crew to verify and attack, regarding a small fire event.

1. Pre-Detection

A group of friends plan to celebrate a birthday party with barbeque and drinks in the public park. They had a very happy party and a few hours later they decided to return back home. They left the public park without extinguishing the barbeque fire. The fire started to become bigger and smoke plumes started to be seen from a distance.
Various citizens started alerting from different locations about smoke coming from the public park near BEN DEKALIM.
Episode 1 Activity:
The message was received by the fire alert operator and forwarded to the fire operational center, immediately two firefighting teams were sent to the fire incident location. On the way they were informed from the operation center, that the fire should be treated as huge fire event.

The following Operations are being use in this episode:

- Send the first ground forces to the incident (evaluate and inform the operation commander about the incident level)
- The operation commander Inform the Assistance ground forces to be ready (aerial firefighting forestry authorities volunteers, first-aid authorities, police operation commander)
- Identify the incident location on the map
- Activate the command and control room AF3.

3.2.3.3.3 *Episode 2: Huge Fire Level*

- Use of Skylark live-view, for a first assessment
- Establishing incident field commander
- Get fuel map and Risk map of the area (SRC)
- Get the area weather (temperature and wind data)
- Use of damage analysis (preventive)
- Streaming images by UPV system
- Use of End User tools (Firegoo) for displaying intervention places and message reception.

Episode Description

The fire level has been declared as a huge fire level. In this case, the C4I commander should be informed and control the fire event.

Report from the Field by the Local Incident Commander (IC)

The fire spreads from east to west. Unable to estimate the extent of the fire at this point.
The fire front-end quickly spreads at about 1000 meters per hour.
Three communities nearby are in immediate danger.
The incident field commander arrived and confirmed the fire situation awareness by reporting to the operations room.
The exact location of the forest ranger and the engine, is known at every moment by means of ASA systems, which provides images and positioning of the resources allocated to the incident.
A first perimeter of the fire is updated by the forest ranger, using the laser range finder (UPV). The perimeter is received by the C4I through the ASA.

The incident commander asks for Reinforcements of two more firefighting groups
Meanwhile he starts establishing an incident field commander and establishing a gathering area for all other ground forces.

The C4I commander starts to collect information displayed by the C4I and makes use of simulation tools to predict the fire's progress, in accordance with the analysis of fire fuel type, FFL and meteorological conditions.

2. Plan of attack and start of the firefighting tasks

The commander at this time wishes to attack with three groups of fire-fighters. One team will stop the fire on the right side, and the two other teams will be directed to provide protection of communities. Each team protects one community. The method of attack is through the engines and deploying water cannons toward the fire front.

3. Receiving pictures from Skylark in C4I

C4I-CMOC receives the first images from Skylark, and starts making an assessment of the situation, together with the reports from the forest ranger and the information from ASA and DS.

3.2.3.3.4 *Episode 3: First Attack*

Episode Description

Systems in use:

- Use of DS tools for the definition of an Attack Plan
- Use of SA tools for assessment of the incident (video streaming)
- Use of FFL for a starting assessment and comparison with current actual fire perimeter
- Use of the weather station of the wireless sensors network for real time data provision
- Use the LIDAR for the incident area weather
- Use of detection and monitoring technologies: UOW sensors
- Use of NUBE capsules
- Use of micro-UAV
- Use of Helicopter multispectral camera.

1. Plan of Attack

The engines that arrived together with the forest ranger, show via video-streaming, the actions carried out in-the-field via the installed cameras on the vehicle (UPV).

The firefighting team will be deployed in three places in front of the fire and two other teams placed at the community, one kilometer away from the fire frontend.

The teams will be deploying hoses and water lines toward the flames.

The C4I commander continues designating missions and allocating the resources present in the intervention area to the various operational locations. All this is displayed on the tablet carried by the Incident Commander through FireGoo application.

The C4I commander checks the information from ASA, fire perimeter, firefighter position, etc., and asks to run the FFL simulation tools

The C4I commander asks to switch between the Skylark UAV to the micro UAV live video.

The Skylark landed and the Micro UAV takes off.

The live view video received from the UAV was unclear due to big smoke plume cover the area, which prevents the clear view of fire frontend.

The commander asks to use the multispectral camera, to scan the incident area, via a command sent to the aerial force using the C4I send-message.

3.2.3.3.5 *Episode 4: Activation of the Aerial Fire Forces*

Episode Description

Systems in use:

- Use of DS for decision support.
- Use of C4I for controlling the scene.

- Use of End User tools (Firegoo) for displaying of intervention places and message reception.
- Use of ASA for awareness on the means location and fire perimeter.
- FFL simulation and pellets spread simulation
- Use of airplane dropping water
- Use of firefighting plan.

Winds are increasing the intensity of the flames and causing the fire-spread-rate to become extreme.

The C4I commander moves the LIDAR system to a new position, close to the fire area and gets the weather data around the fire area.
The C4I commander uses the decision support tool (DS) and decides to block the road for safety reasons while using firefighting planes.
The C4I commander orders to scan the fire area using the helicopter equipped with the multi-spectral camera, to receive a clear video that shows the strength of the fire and the fire frontend line, via the smoke and flames.
The C4I ordered to use the aerial firefighting aircraft to extinguish the fire with water to stop fire from approach the community area.

In addition, each community close to the incident was protected by a firefighting team which was connected to the existing water infrastructure, to protect the front line of houses facing the fire. The other team leads and protect the evacuation of the residents with buses.
The Police start to evacuate nearby communities that are near the fire front.

3.2.3.3.6 Episode 5: Emergency Rescue

- Use of Firegoo and send Risk Alert to C4I

The panic button was pushed by the firefighting personnel during the fire attacking, using the mobile app. The alerts popped up on the C4I display.
The field operation commander informs the control room commander about the emergency situation regarding one of the firefighters that fell off the cliff and into the river. The commander asks for a special rescue team to handle the situation.
The C4I commander immediately orders to send a special rescue team along with an ambulance to the event location to handle the problem and report back to the control room.
The C4I obtains information through system's Situational Awareness. Also using applications SA, Technical Director Extinction (all commanders and firefighters) can have real-time display of suppression resources.

3.2.3.3.7 Episode 6: Treatment of the injured firefighting personnel

- Use of Firestress application to monitor the intensity of the firefighters effort.
- Use of SA tools to provide accurate real-time images of the incident.

- Use of e-Health tools ICOM to make decisions about the injured members.
- Use of Pulsimeter to collect information from the injured personnel

The special rescue team pulled the injured firefighter from the river and the first aid personnel started to provide the treatments, using the health tools which help the medical group collect the injurer's health data.

3.2.3.3.8 *Episode 7: Community Evacuation*

- Use of FFL for the evaluation of fire behavior that is approaching the areas
- Use of Crowd behavior simulation for assessment of the evacuation actions.
- Use DS tools to support evacuation decision and to make decisions on the use of preventive capsules.
- Use of Nub-e system to defend the wilderness-urban area interface.
- Use of LIDAR for weather and smoke plume forecasts
- ASA system.

Fire approaches the vicinity of the village of BEN DEKALIM, the control room commander starts to analyze the situation using the C4I, ASA, Weather, CMNG and DS tools.
The commander found out the fire and smoke plume are approaching the BEN DEKALIM village. He decided to handle the situation with a parallel activity.

- Run the FFL fire simulation to predict the fire propagation within 2 hours
- Use the Weather subsystem to predict the smoke plume direction
- Order to block the road leading to the fire line
- Get the DS recommendation regarding the positioning the NUBE capsules
- Order to place capsules along the edge of the village
- Run the crowd behavior simulation of the BEN DEKALIM village
- Send ground forces to evacuate the population according the crowd behavior simulation.

3.2.3.3.9 *Episode 8: Advanced Aerial Fire Fighting techniques*

- Use of DS tools to make decisions about the advanced air strikes (AAFF).
- Use of the AAFF system to deal with the fire.
- Use of Skylark for assessing the performance of air means.

The fire continues to spread toward the houses, and the firefighting aircraft could not attack the fire since the fire was very close to the houses, the field operational commander asked for emergency AAFF aircraft attack to save the building from the fire, the C4I commander uses the DS tool for verifying the suitability of carrying out this type of attack in the given area (poor access of ground units, withdrawal of staff from the area, and controlled-risk for people), spatial references in the area (polygon and singular points) are introduced, which are obtained by the C4I, requesting

information decision support subsystem DS.
First the C4I commander orders to evacuate the first housing edge where the pellets are going to be dropped.
Blocks the roads leading to the dropping area, and sends a general alert for the entire staff for them to take into account that pellet drops will take place within a few minutes in the specific coordinates.

Order the AAFF air force group to start dropping pellets using the C4I pellets dropping tools, which mark the exact location and direction.

3.2.3.3.10 Episode 9: Control Demobilization and End of Drill

Around 16:00 p.m. the fire is under control as reported by the IC, which means that the perimeter is fully confined within the control lines with no probabilities of overcoming them. The burned area is checked to prevent eventual rekindling.
For surveillance purposes, the C4I commander orders to request the Skylark UAV operator to use the UAV to quickly identify potential hot spots.
From the UAV video, a fire rekindling in the area is clearly seen.
The C4I commander orders to send a firefighting team to attack the fire.
In a few minutes, the operational commander reported that the fire is under control again.

3.2.3.4 Summary of Israeli trials

The trial revealed a good level of integration of the sub-systems that composed the AF3 System as a very useful tool to handle Mega-fire event

The last Israel drill day was dedicated to the “Drill Discussion and Conclusions”, each participant (stakeholders, partners and end users) was asked to express their opinion on the trial activity and the exercises which was carried out two day earlier, all participants expressed their satisfaction with the successful drill and that all objectives has been successfully achieved.

3.2.4 CONCLUSIONS (from the 3 trial sessions)

Three trials have been carried out in Greece, Spain and overall final trial in Israel, the trials subject was the demonstration and test of the new AF3 system improvement compared to the technologies and systems currently available to fire fighters and emergency agencies.

In the trials, the new AF3 system innovative technologies and means have been presented and tested to reach the following objectives:

- Implementation of the novel AAFF (Advanced Aerial Fire Fighting) system to accurately and safely disperse extinguishing materials from high altitude by aircrafts and helicopters in any condition: day and night

- Fast build-up of preventive defensive lines of capsules to prevent the spreading of fire from forest to populated areas
- Early detection and monitoring, using satellites images, aero planes, UAVs, and both mobile and stationary ground systems for the early detection of fire
- Simulation tools to predict fire propagation, weather forecast, risk and damage analysis, decision support tool and Situation awareness map
- Protection of human and wildlife lives

All the trial progress revealed an every time higher level of integration among the sub-systems that composed the AF3 System as a very useful tool to handle Mega-fire event.

3.3 OTHER SPECIFIC PROJECT ACTIVITIES

3.3.1 Partners workshare and Project Amendment

From the management point of view, the big issue already met and solved during the first part of the second year has been the reduction of the involvement of Fraunhofer Ernst Mach Institute. Fortunately, as described in the risk and contingency plan of the DoW, the consortium was well balanced and partners with similar competences have been found in order to seamlessly substitute Fraunhofer Institute with limited delays on the different activities. The detail of the workshare re-distribution has been already given in the 2nd year periodic report, and it is resumed (with some tables) in the Project Management part of this report as well. Anyway evidence will be given here below to the *Grant Amendment* (submitted on 03/02/2017) which solved this specific issue, and some other minors arisen during the second and third year of the project. In parallel an Amendment Procedure was opened in the EU portal, with the implementation of the needed changes for all the contractual documents and for the DoW accordingly.

Here below the text of the Amendment itself:

Modification of the legal entity details (change of legal name of the Coordinator)

Old legal name	***New legal name***	***Effective date***
LEONARDO FINMECCANICA SPA	*LEONARDO - Società per azioni*	*01/01/2017*

Change of banking details

The coordinator's banking details indicated in Article 5.3 of the grant agreement are amended as follows:

Name of account holder: LEONARDO – Societá per azioni SPA
Name of bank: DEUTSCHE BANK
Account reference: IT52L 031040 160700 0000060292

Modification of Annex I (Description of Work)

The Fraunhofer Institute is part of the consortium with two separated institutes:

- *FHG-EMI Fraunhofer Ernst Mach Institut, involved in nine out of ten WPs first level;*
- *FHG-ICT Fraunhofer Institute for chemical Technology, involved in three out of ten WPs first level.*

FHG-EMI planned to start the work on AF3 with around one person in the first 6 months of the project: due to the DOW structure and the planned tasks the number of persons should have been increased successively and intensively up to 6 after project month 6.

From the beginning of AF3 FHG-EMI tried to acquire sufficiently qualified and motivated personnel, but FHG-EMI was not able to find enough personnel that is adequately qualified to perform the required tasks in AF3 for EMI.

As consequence FHG-EMI was understaffed since project month 6: despite recruiting activities new staff could not be found.

For the time after the first review an even significantly higher number of staff is required for the work than in the first year.

In addition to that, two of the just hardly acquired persons in terms of the project leader for EMI work packages quit as well as the co-worker who worked on AF3 fulltime.

This meant and means a strong loss of knowhow which cannot be easily and timely replaced, being FHG-EMI heavily understaffed: nevertheless FHG-EMI could finish all the deliverables in time and also with a suitable quality, because other work which was not due for the first review was set to low priority.

This underlines FHG-EMI willingness to perform but with the given situation that approach cannot be used for the future.

Based on those reasons FHG-EMI decided to drastically reduce the work on AF3 and stop work on most of FHG-EMI work-packages.

In addition to that, FHG-EMI listed the following additional reasons leading to the decision:

- *Even if new staff can be found, initial training needs time which leads to postponing of deliverables and tasks;*
- *No possibility to shift staff because of high workload in other projects;*
- *Delay of work cannot be foreseen;*
- *Parts of the activities will be continued by FHG-ICT*

FHG-EMI admits his responsibility towards the consortium and do not want to endanger the project due to delays caused by understaffed work and wants to release budget to consortium partners.

Under Fraunhofer suggestion and according to the consortium, the activities have been redistributed among some AF3 partners, as described in the following.

(the tables with the workshare re-distribution are in a following section, as already written)

RTD Activities and leadership new distribution

WP4 "Risk analysis prevention & safety" leadership - Leadership passes from Fraunhofer to POLITO

WP42 "Damage analysis" – Leadership passes to UPV

Tasks 4.2.1 "Damage analysis of impact of pellets, capsules and dispersion containers on persons", D421 "Damage modeling for persons: mechanical impact of pellets, capsules, distribution containers; report and software" – The leadership, the activities and the responsibility for the deliverable pass to ELBIT.

Tasks 4.2.2 "Damage analysis of persons exposed to heat, fire products, retardant and hazardous substances" - The activities related to the selection and implementation of models pass to UPV.

Task 4.2.4 "Damage analysis for vegetation, wildlife and environment" D424 Damage modeling for vegetation, environment and wildlife: report and software" – The activities related to selection and implementation of models and the responsibility for the deliverable pass to UPV.

WP43 "Safety and risk analysis of firefighting means "– Leadership passes to ELBIT.

Task 4.3.1 "Safety for risk analysis for firefighting with pellets", D431 "Safety and risk analysis for firefighting with pellets: report and software"

Task 4.3.2 "Safety and risk analysis for preventive firefighting with capsules", D432 Safety and risk analysis for preventive firefighting with capsules"

Task 4.3.3 "Safety and risk assessment of airborne firefighting platform"

The activities concerning the impact of pellet and capsules on persons are performed by ELBIT, also responsible for the deliverables.

WP4.4 Risk analysis for forest fires – Leadership passes to POLITO

Task 4.4.1 "Real time risk analysis", D441 "Real time risk analysis for forest fires: report and software"

Task 4.4.2 "Preventive risk analysis", D442 Preventive risk analysis for forest fires: report and software

Task 4.4.3 "Post fire/Long-term risk analysis", D443 Report on post firefighting/long-term risk/chance analysis and software prototype

All the activities of the previous tasks are performed by POLITO, also responsible for the deliverables.

WP6.3 "Risk analysis prevention & safety" leadership - Leadership passes from Fraunhofer to POLITO

Task 6.3.1 "Data fusion and visualization" – This task is related to WP4.4 and is performed by POLITO

Part of minor activities regarding Tasks 7.1.1 "Physics and chemistry of firefighting" and WP7.2 " Advanced aerial firefighting" are redistributed to ELBIT.

<u>Demonstration activities new distribution</u>

Task 8.1.1 "Subsystems testing"- This task is related to WP4.4. and is performed by POLITO. Standardization and Dissemination activities; new distribution

Task 9.2.1 "Standardization activities" and Task 9.3.1 "Exploitation" – The effort has been totally reallocated to ELBIT and TRAGSA

Activities on Task 9.1.1 "Dissemination" are reduced according to the new workload.

<u>Beneficiary 10 "PYRO FIRE EXTINCTION, S.L. Effort Redistribution</u>

Beneficiary PYRO proposed to redistribute man months and effort in the project to better cope with the expectations of the envisaged fire retardant analysis, the security of operations in fire scenarios in which capsules are used, and the mechanical design of capsules' subsystem.

PYRO's analysis of the End-User requirements has led to the need to design a modular system, able to assemble different capsules' configurations to adapt different end-user demands.
The development of a mechanical modular system demands additional efforts in CAD design, manufacturing engineering, and testing, which unavoidably requires additional man-months with respect to the initial allocation.
The proposed redistribution will have no effect on the budget, cost and EU contribution for PYRO. The original subdivision in RTD, DEMO and OTH remains unchanged. There will be no impact on the progress of work.
The new redistribution should ensure more effectiveness and optimized participation of PYRO in its participation through all the project phases, as well as in the quality of project results PYRO will rely on a balanced team of engineers to deliver results at the expected quality level stated in the DoW.

In addition to the previous assessment, PYRO is the new responsible of D43.2, previously under Fraunhofer responsibility.

Additional Deliverable

The second deliverable in WP5.3, "D53.2 Training scenarios, materials, tools and simulation specifications" is planned for Month 12, while the Training activities ends at M30.
There is not any deliverable scheduled in order to show the final scenarios selected, the training materials and the training tools selected. It is therefore planned to add an additional deliverable: "D53.4 Training scenarios, material, tools, and simulation report".
The delivery date is at month 30.
The man months and effort foreseen for the D53.2 are redistributed as follows:

Deliverable Number	***Deliverable Title***	***Lead beneficiary number***	***DoW MM allocation & delivery date***	***Proposed MM allocation***	***Proposed delivery date***
D53.2	*Training scenarios, materials, tools and simulation specifications*	*14*	*6* *M12*	*3*	*M12*
D53.4	*Training scenarios, material, tools, and simulation report*	*14*	*Not present*	*3*	*M30*

Modification of duration

The duration of the project specified in Article 3 of the grant agreement is modified as follows:

New duration: 39 months

All other provisions of the grant agreement and its annexes shall remain unchanged.

As last point written in the Amendment, there is the already mentioned extension (for 3 further months) of AF3 project.

3.3.2 Dissemination Activities

3.3.2.1 Summer School

In order to push the technology transfer of the AF3 system, the "AF3 Conference & Summer School on Forest Fire Management" has taken place on 20-22 September 2016 in Rome, Italy.

The event aimed at comparing the research and technical activities performed during the AF3 project with the state of art. This comparison was based on presentations from the AF3 consortium and from international experts outside the project. In particular 5 topics have been proposed: Forest fire management, fire detection, risk management, forest fire behavior, innovations in firefighting techniques. In addition, the AF3 Core Expert Engine was presented to the operators in order to collect additional input for the evaluation of the end-user requirements as well as to prepare the trials. The summer school has had 34 attendees.

The event was targeted at the operators involved in forest fires with the following goals:

- To Provide an overview of recent research and trends on forest fire management, particularly with respect to forest fire behaviour, fire detection, risks for the operators, innovation in firefighting techniques;
- To explain and demonstrate the approaches developed in the European FP7 Project AF3 in order to improve the current state of art;
- To provide the forest fire operators the opportunity of using the AF3 Core Expert Engine, which is a software system for the coordination of fire-fighting missions.

Presentations and program are available at the following link http://af3project.eu/past-events/

Some pictures taken during the event are shown in Figure 10 .

Figure 10: presentations during the international conference at the Summer School

3.3.2.2 AF3 Workshop

An International workshop on forest fire modeling has been organized on June 22, 2017 at the Istituto Superiore Antincendi (Rome). The event has been scheduled on the basis of the format already adopted for the Summer School. In the first part of the day an international conference with presentations from experts outside the project as well as from members of the AF3 consortium. The program of the workshop is shown in Figure Figure . The final part of the day has been used in order to collect feedbacks from the workshop participants.

Some pictures taken during the workshop are shown in Figure 12..

The international workshop had a total number of participants of about 110 people, mainly engineers and firefighting operators. The workshop has provided 2 credits to the participants belonging to professional societies.

09:30 Introduction

Welcome from Authorities

Dr. Stefano Scafè (Leonardo) - AF3 Project and fire modelling

Using meaningful data in prevention and firefighting operations

- **9:50 Dr. Edyta Wozniak** (Polish Academy of Sciences) - SATELLITE MAPPING OF VEGETATION
- **10:10 Dr. Nives Grasso** (Politecnico di Torino - IT) - GIS TECHNOLOGIES SUPPORT TO FOREST FIRE SIMULATION
- **10:30 Dr. Eng. Christophe Boullion** (Irstea) - RURAL-URBAN INTERFACE MAPPING AND IMPROVEMENT OF FOREST FIRE PREVENTION AND PREPAREDNESS
- **10:50 Dr. Maurizio Giovannini** (Leonardo) - FOREST FIRE SIMULATOR TO ENHANCE FIREFIGHTERS TRAINING

Modelling

- **11:30 Prof. Stefano Mazzoleni** (Università di Napoli Federico II - IT) - THE HERITAGE OF THE FIRE PARADOX PROJECT: TIGER PROPAGATION MODELS AS TRAINING AND PREVENTION TOOLS
- **11:50 Prof. Fabrizio Ferrucci** (Open University - UK; Università della Calabria - IT) - TERRITORIAL FIRES AND SATELLITE EARLY WARNING: THE TALED PROJECT
- **12:10 Dr. Davide Ascoli** (Politecnico di Torino - IT) - FOREST FIRE MODELS VALIDATION
- **12:30 Prof. David Caballero** (Meteogrid) - WILDLAND URBAN INTERFACE FIRES IN THE MEDITERRANEAN AREA
- **12:50 Dr. Paolo Fiorucci** (Fondazione Cima - IT) - PROPAGATOR: A SYSTEM FOR THE QUICK PROBABILITY ASSESSMENT OF THE EVOLUTION OF A FOREST FIRE

Research and Training

- **14.00 Dr. Lucia Russo** (CNR - Combustion Research Institute - IT) - A THEORETICAL APPROACH FOR THE SPATIAL DISTRIBUTION OF FIRE BREAKS IN HETEROGENEOUS FOREST LANDSCAPES FOR THE CONTROL OF WILDLAND FIRES
- **14.20 Dr. Eng. Carlo Metelli** (CNVVF- IT) **-** IGNIS PROJECT: COMMON RULES IN TRAINING ACTIVITIES
- **14. 40 Dr. Paolo Battelli** (Regione Toscana) - PLANNING AND INNOVATION FOR FOREST FIREFIGHTING IN TUSCANY

15:30 Conclusions

information and registration: relazioniesterne.isa@vigilfuoco.it
Istituto Superiore Anticendi - Roma, via del commercio, 13 - www.vigilfuoco.it

Figure 11: Program of the International Workshop

Figure 12: Some of the presentations during the international workshop

3.3.2.3 AF3 Final Project Meeting (Rome)

Following the work-share new distribution for the 3rd year and the need of some months more (the *extension* ones) for the consortium in order to fulfil all the project objectives, the, possibility was opened to conclude the whole program during the 2017 summer, but having some more time between the final trials session and the AF3 ending: so the opportunity was taken to organize a final project meeting (the only one held in the final year of the project, being the other 2 scheduled dates in the year specific for Trials) in June, a month later the drill in Israel, but at the same time a month in advance respect to the AF3 formal conclusion.

The event was organized at Istituto Superiore Antincendi (ISA) in Rome, it took 3 days, and in the last one of them the AF3 Workshop described above was held too. It was the opportunity for discussing more deeply than in other meetings about the fulfilment of the general project objectives, of result of the trials, about the specific WPs, about the economic/financial aspects of the project.

Here below the agenda of the 3-day meeting, a kind of “first test” in sight to the project final review:

June, 20th

14.00-15.00 Welcome and Introduction

General overview: final outcomes of the project, summary of the trials, deliverable status, gaps toward the final review.

15.30-17.30 Plenary Session on budget/financial aspects

A general picture of the project from a financial point of view will be presented. Evidence will be given to the status of each WP, giving the possibility to all the partners to highlight any specific budget topics on tasks of their responsibility. Form-C like inputs have to be previously provided by all partners, in order to allow the discussion during the meeting around an already well-defined baseline.

June, 21st

The whole day will be dedicated to specific WP short meetings. Each of them will be moderated by single WPs coordinators, who will present the status, and then a brief discussion with the partners involved will follow.

9:10 - 09:15 WP1 - Program Management

9:15 - 10:00 WP2 - CONOPS requirements and system definition

10:00 -10:45 WP3 - Modelling & Simulation

11:00 -11:45 WP4 - Risk Analysis prevention & safety

11:45 - 12:30 WP5 - Integrated Crisis Management

14:00 - 14:45 WP6 - Monitoring & Detection

14:45 - 15:30 WP7 Advanced firefighting & preventive intervention

15:45 - 16:30 WP8 - Integration, Validation & Trials

16:30 - 17:00 WP9 - Dissemination & Exploitation

17:00 - 17:30 WP10 - Societal & Environmental framework

June, 22nd

9:30 -15:00: AF3 FOREST FIRE MODELS WORKSHOP

Workshop organized by Italian VVFF whose aim is to exploit the sinergies with AF3 project related to the specific topic of Forest Fire Simulation.

(specific information about the WS has been already sent to all AF3 partners)

15:15- 16:00

General picture given by separate WP meetings of the day before – Possibly feedback by Advisory Board Members

16:15 – 17:30

Actions toward the final review of September – Conclusions of the meeting

The final project meeting had the participation of all AF3 partners, and the significant attendance, as it can be seen from the schedule, of 3 members of the Advisory Board: Mr. **David Lane** (Pro-Rescue, UK) very familiar with AF3 from the beginning of the project; and Mr. **Fabrizio Ferrucci** (Open University – UK) and Mr. **David Caballero** (Meteogrid – SP), involved in AF3 due to the specific Workshop they were invited as speakers, who gave a useful contribution to the project itself, even if only in that specific meeting.

3.3.2.4 Other Dissemination Initiatives

Added to these main AF3 events, the project has been disseminated with many publications, and in several important conferences:

3.3.2.4.1 TECHNICAL CONFERENCES

The activities developed within the AF3 project have been promoted by the various partners through posters, stands, or technical presentations is technical conferences. A list of these conferences held during the last year of the project is presented below.

- 2017 ASME Summer Heat Transfer Conference, 9 - 12 July 2017, Bellevue, USA.

- *ECOS 2017, July 2-6 2017, San Diego, California, USA.*

- *ESREL European Safety and Reliability Conference, 18-22 June 2017, Portoroz, Slovenia*

- 12th World Congress of Structural and Multidisciplinary Optimization, 5 - 9 June 2017 Braunschweig, Germany

- 7th *Spanish Forestry Congress, 26-30 July 2017, Plasencia, Spain*

- *The 9th International Exergy, Energy and Environment Symposium (IEEES-9), 14-17 May 2017, Split, Croatia*

- SPIE Defence and Commercial Sensing 2017, Anaheim Convention Center, Anaheim, California, USA, 9–13 April 2017

- *International Conference on Wildland Fire Safety, 30 January – 3 February 2017, Barcelona, Spain*

- XXXVIII Forum INIA: “Forest Fires”, 30 November 2016, Madrid, Spain

- 2016 ASME International Mechanical Engineering Congress & Exposition November 11-17, 2016, Phoenix, Arizona, USA

- ASITA conference, 8-10 November 2016, Cagliari, Italy

- 2nd ARTEMIS Technology Conference, 4-6 October 2016, Madrid, Spain

- GEOBIA. 14-16 September 2016, Enschede, The Neaderlands

- VGR Conference, Risk Evaluation in Civil and Industrial Sites, 13–15 September 2016, Rome, Italy

- Partnerships and Innovation in Science and Technology Event, 20/06/2016, University of Westminster, UK

- International Conference on Forest Fires and WUI Fires, 25-27 May 2016, Aix en Provence, France

Figure 13 shows the activities developed by some of the partners during the exhibitions at international conferences.

Figure 13: Presentation of the AF3 project at the Aerial Firefighting International 2016 Conference

The poster presented by the AF3 consortium at *ESREL* (European Safety and Reliability Conference) resulted as the winner of the competition “Images of risk”. The poster is shown in Figure 14.

Figure 14: Poster presented at ESREL 2017

3.3.2.4.2 Papers submitted to scientific journals

The following papers have been published in national or international scientific journals (6):

Elisa Guelpa and Vittorio Verda (2017) Entropy Generation Analysis of Wildfire Propagation. Entropy 19, 433; doi:10.3390/e19080433

M. Zambrano, I Pérez, F. Carvajal, M. Esteve and C. Palau (2017). Command and Control Information Systems Applied to Large Forest Fires Response. IEEE Latin America Transaction http://www.ewh.ieee.org/reg/9/etrans/eng/

Víctor Gonzalvo Morales, Felipe Aguirre Briones, Alvaro Carrillo Patiño, Jorge López-Satué, David González Sancho, Mafalda Díaz Romero, Ignacio Benito Roberti (2017). El Grupo Tragsa y los incendios forestales. Proyecto AF3. Integración de tecnologías de apoyo en la gestión de incendios. Montes Journal N. 127. 29-35. http://www.revistamontes.net/Buscador.aspx?id=14507

Jorge López-Satué, Rafael Gómez Molino, Felipe Aguirre Briones, Álvaro Carrillo Patiño, Ignacio Benito Roberti (2017). Valoración integral de los factores condicionantes del rendimiento del personal especialista en extinción de incendios forestales y ejercicio demostrativo AF3. Montes Journal N. 128 [87].

Elisa Guelpa , Adriano Sciacovelli, Vittorio Verda, and Davide Ascoli (2016). Faster prediction of wildfire behaviour by physical models through application of proper orthogonal decomposition. International Journal of Wildland Fire 25(11) 1181-1192. https://doi.org/10.1071/WF15150

Artur Krukowski and Emmanouela Vogiatzaki (2015) “Adaptations of Personal Health Record Platform for Medical Research on Chronic Diseases”, EAI Endorsed Transactions, Special issue on Mobile and Wireless Technologies for Healthcare (http://eudl.eu/doi/10.4108/phat.1.1.e5)

In addition, the following papers have been submitted for possible publication (4):

Artur Nowakowski, Stanisław Lewiński. Classification Inconsistency Index and its Application to Automatic Threshold Calculation in Change Detection. European Journal of Remote Sensing (submitted)

Edyta Woźniak, Sebastian Aleksandrowicz. Self-adjusting thresholding for burnt area detection based on optical images - a step forward for automatic global high-resolution mapping. ISPRS Journal of Photogrammetry and Remote Sensing (submitted)

Artur Krukowski and Emmanouela Vogiatzaki, “Autonomous 3D Damage Analysis to Natural Heritage from Forest Wildfires”, Journal of Aerospace Technology and Management (http://www.jatm.com.br). (submitted)

Elisa Guelpa, Vittorio Verda. Second law analysis of wildfire evolution under wind and slope effect. International Journal of Exergy. (Submission code: IJEX-188638).

3.3.2.4.3 <u>Papers published on conference proceedings or presented in international conferences</u>

The following papers have been published in conference proceedings (23):

López-Satué, J., Aguirre Briones, F., Gómez Molino, R., Carrillo Patiño, A., Carballo Leyenda, Ab., Villa Vicente, Jg., Fernández Fernández, Jv., Pérez Segura, I. (2017). Monitorización en tiempo real de las constantes vitales del Personal Especialista en Extinción de Incendios Forestales (PEEIF). #7 Spanish Forestry Congress, 2017, Plasencia, Spain. 26-30 July

LópezSatué, J., Carballo Leyenda, A.B., Aguirre Briones, F., Gómez Molino, R., Carrillo Patiño, A., Villa Vicente, J.G. (2017). Metodología y resultados sobre los efectos del calor radiante en el Personal Especialista en Extinción de Incendios Forestales (PEEIF). #7 Spanish Forestry Congress, 2017, Plasencia, Spain. 26-30 July

Gonzalvo Morales, V., Hombrados Carrillo, E., Aguirre Briones, F. y Carrillo Patiño, A. (2017). ERVIN: un entrenador virtual para los incendios forestales. #7 Spanish Forestry Congress, 2017, Plasencia, Spain. 26-30 July

Gonzalvo Morales, V., Aguirre Briones, F., Carrillo Patiño, A., López-Satué, J., Díaz Romero, M. , Benito Roberti, I. (2017). AF3: integración de tecnologías de apoyo en la gestión de incendios. #7 Spanish Forestry Congress, 2017, Plasencia, Spain. 26-30 July

S.Abdullah, S.Bertalan, S.Masar, A.Coskun, and I.Kale "A Wireless Sensor Network for Early Forest Fire Detection and Monitoring as a Decision Factor in the Context of a Complex Integrated Emergency Response System". IEEE Workshop on Environmental Energy and Structural Monitoring Systems, Milan, Italy, 24-25 July 2017.

Guelpa, E., Verda, V. (2017). Second Law Analysis applied to grassfire evolution. Proceedings of ECOS 2017. San Diego, USA. July 2-6.

C. Vivalda, M.A. Musci, N. Grasso, E. Guelpa, M. Piras, V. Verda (2017). Forest wildfire risk mapping and the influence of the weather and geomorphological input data. ESREL 2017 Conference Portoroz, June 18 – 22.

Guelpa, E., Verda, V. (2017). Wind and slope contribution in a grassfire second law analysis. 9th International Exergy, Energy and Environment Symposium (IEEES-9), May 14-17, 2017, Split, Croatia.

Guelpa, E., Verda, V. (2017). Entropy generation transient analysis of a grassfire event through numerical simulation. 9th International Exergy, Energy and Environment Symposium (IEEES-9), May 14-17, 2017, Split, Croatia.

Thanos K. G. , Skroumpelou K., Rizogiannis K., Kyriazanos D. M., Astyakopoulos A., Thomopoulos S. C. A., "Fire detection and incidents localization based on public information channels and social media", to be published Proc. SPIE Defense and Commercial Sensing, USA, 2017

Rizogiannis K., Thanos K. G., Astyakopoulos A., Kyriazanos D. M., Thomopoulos S. C. A, "Sensor data monitoring and Decision level fusion scheme for early fire detection", to be published Proc. SPIE Defense and Commercial Sensing, USA, 2017

Daniele Cagliero, Cristiana Dell'Erba, Nives Grasso, Maria Angela Musci, Francesca Noardo, Marco Piras, Vittorio Verda, Claudia Vivalda (2016). Qualità dei modelli digitali del terreno per la valutazione del rischio nella gestione degli incendi boschivi. XX Conferenza Nazionale ASITA, 8 - 10 novembre 2016, Cagliari, Italy.

Guelpa E., Verda V. (2016). Entropy Generation for Porest Fire propagation through Preferential Direction Analysis. ASME International Mechanical Engineering Congress & Exposition November 11-17, 2016, Phoenix, Arizona, USA

Thomopoulos S. C. A., Kyriazanos D. M., Astyakopoulos A., Dimitros K., Margonis C., Thanos G. T., Skroumpelou K. "OCULUS fire: a control and command system for fire management with crowd sourcing and social media interconnectivity", Proc. SPIE 9842, Signal Processing, Sensor/Information Fusion, and Target Recognition XXV, 98420U (May 17, 2016); doi:10.1117/12.2223996, 2016

Thanos G. T., Karafylli C., Karafylli M., Zacharakis D., Papadimitriou A., Dimitros K., Kanellopoulou K., Kyriazanos D. M., Thomopoulos S. C. A., "SYNAISTHISI: an IoT-powered smart visitor management and cognitive recommendations system", Proc. SPIE 9842, Signal Processing, Sensor/Information Fusion, and Target Recognition XXV, 984219 (May 17, 2016); doi:10.1117/12.2224045, 2016

Edyta Woźniak, Sebastian Aleksandrowicz. (2016). An object-based burnt area detection method based on landsat images - a step forward for automatic global high-resolution mapping. In: GEOBIA 2016: Solutions and Synergies., 14 September 2016 - 16 September 2016, University of Twente Faculty of Geo-Information and Earth Observation (ITC) .

Aldrovandi M., Serafino G., Coveri C., Giovannini M (2016). Il Programma Europeo AF3 (Advanced Forest Fire Fighting) Sistemi di Comando, Controllo e Supporto alla Decisione. VGR 2016 Valutazione e Gestione del Rischio negli Insediamenti Civili ed Industriali. Rome, Italy. September 13-15.

D. Böhm, M. Weinert, V. Gettwert, S. Stegmüller (2016). Investigation and evaluation of flame retardants for forest fire fighting within the framework of the European project AF3. ForestFire2016 - International Conference on Forest Fires and WUI Fires, Aix-en-Provence, France, May 25-27. (ISBN 979-10-94074-05-3)

D. Böhm, M. Weinert, V. Gettwert (2016). Evaluation of the efficiency and environmental impact of fire suppressants for forest fire fighting. ForestFire2016 - International Conference on Forest Fires and WUI Fires, Aix-en-Provence, France, May 25-27. (ISBN 979-10-94074-05-3)

Thanos G. T., Thomopoulos S. C. A., "WayGoo recommender system: personalized recommendations for events scheduling, based on static and real-time information ", SPIE Defence and Security 2016, Baltimore Convention Center, Baltimore, United States, 17/04/2016, v. 9842

Thomopoulos S. C. A., Karafylli C., Karafylli M., Motos D., Lampropoulos V., Dimitros K., Margonis C., "WayGoo: a platform for geolocating and managing indoor and outdoor spaces", SPIE Defence and Security 2016, Baltimore Convention Center, Baltimore, United States, 17/04/2016, v. 9842

Kountouriotis V., Paterakis M., Thomopoulos S. C. A., "iCrowd: agent-based behavior modeling and crowd simulator ", SPIE Defence and Security 2016, Baltimore Convention Center, Baltimore, United States, 17/04/2016, v. 9842

Guelpa E., Sciacovelli A., Verda V., Ascoli D. (2014). Model Reduction approach for wildfire multi-scenario analysis. 7th International Conference of Forest Fire Research. Coimbra, Portugal. November 17-20.

3.3.2.5 Questionnaires

A questionnaire, originally based on the verification of the end-user requirements only, was enlarged including also After-Action-Review questions. The questionnaire was distributed to the Greek trials participants (including end-users and Advisory board members) that were requested to fill in the sections within their experience.

The questionnaire, available in print and electronic format (http://af3project.eu/questionnaire/), concerned demographic questions, user requirements questions and system usability questions. A first analysis of the results was presented during the second annual review. The system usability ratings was generally positive, although some system interoperability aspects should be carefully examined.

The structure of the questionnaires has been continuously improved and used during Spain and Israel trials, and a summary of its results is evidenced in the final project deliverables relevant to WP8 (User Evaluation of the Trials) and WP2 (Requirements fulfilment).

4. PROJECT MANAGEMENT

4.1 CHANGES IN THE CONSORTIUM

Selex ES was merged into Finmeccanica S.p.A. (the merging company) the 1st of January 2016, then to LEONARDO S.p.A. at the beginning of 2017.

LEONARDO is the "new" entity that assumes universally all rights and obligations of the old legal entity. The formal information has been sent to EC – REA via the Amendment of February/2017.

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4.2 CONSORTIUM MANAGEMENT TASKS AND ACHIEVEMENTS

The management structure and tasks are defined in detail in the Consortium Agreement. All partners are included within that agreement according to the management structure described in the Description of Work. In particular, financial and technical actions were planned, the meetings and phone conferences of appropriate level were scheduled, the technical description of the work and the Consortium Agreement were maintained, the electronic media were maintained including website, collaborative tools, document repository and e-mail list. Contact and exchange of information between partners were provided on daily basis by means of email and phone calls.

The new and final organization of the project activities, shown with more detail in last year' report, is more briefly described in the following paragraphs:

4.3 WORKSHARE RE-ALLOCATION

4.3.1 Activities and leadership: new distribution

After some contacts with partners of the consortium the following distribution was agreed:

- WP4 "Risk analysis prevention & safety" leadership - Leadership passed to POLITO.
- WP42 "Damage analysis" – Leadership passed to UPV

  Tasks 4.2.1 "Damage analysis of impact of pellets, capsules and dispersion containers on persons", D421 "Damage modelling for persons: mechanical impact of pellets, capsules, distribution containers; report and software" – The leadership, the activities and the responsibility for the deliverable passed to ELBIT.

  Tasks 4.2.2 "Damage analysis of persons exposed to heat, fire products, retardant and hazardous substances", - The activities related to the selection and implementation of models passed to UPV.

  Task 4.2.4 "Damage analysis for vegetation, wildlife and environment" - The activities related to selection and implementation of models and the responsibility for the deliverable passed to UPV.
- WP43 "Safety and risk analysis of firefighting means "– Leadership passed to ELBIT.

  Task 4.3.1 "Safety for risk analysis for firefighting with pellets", D431 "Safety and risk analysis for firefighting with pellets: report and software"

Task 4.3.2 “Safety and risk analysis for preventive fire fighting with capsules”, D432 Safety and risk analysis for preventive firefighting with capsules”

Task 4.3.3 “Safety and risk assessment of airborne firefighting platform”

The activities concerning the impact of pellet and capsules on persons are led by ELBIT, responsible for the deliverable D431, while PYRO is the responsible for D432. D433 remained under EADS responsibility.

- WP4.4 Risk analysis for forest fires – Leadership passed to POLITO

  Task 4.4.1 “Real time risk analysis”, D441 “Real time risk analysis for forest fires: report and software”

  Task 4.4.2 “Preventive risk analysis”, D442 Preventive risk analysis for forest fires: report and software

  Task 4.4.3 “Post fire/Long-term risk analysis”, D443 Report on post firefighting/long-term risk/chance analysis and software prototype

  All the activities of the previous tasks were performed by POLITO, also responsible for the deliverables.

- Task 3.1.2 “Modelling of effects of water”, -This task was performed by ELBIT, and the model was provided if relevant, as from the DoW.
- Task 6.3.1 “Data fusion and visualization” – This task is related to WP4.4 and so was performed by POLITO
- Part of minor activities regarding Tasks 7.1.1 “Physics and chemistry of firefighting” and WP7.2 “Advanced aerial firefighting” were redistributed to ELBIT.
- WP8 Demonstration activities

  Task 8.1.1 “Subsystems testing”- This task is related to WP4.4. and was performed by POLITO.

- WP9 Standardization and Dissemination activities

  Task 9.2.1 “Standardization activities” and Task 9.3.1 “Exploitation” – The effort was totally reallocated to ELBIT and TRAGSA

  Activities on Task 9.1.1 “Dissemination” have been reduced according to the new workload.

4.3.2 Updated structure of WP4

4.3.2.1 WP4 change of responsibility: summary

According to the updated structure of WP4, the changes on responsibility of work packages and tasks are listed in the following table. For the others WP/Task the leadership remains unchanged. WP4 was the WP more impacted by the changes, so the final picture of it with the specific responsibilities are detailed again in the picture here below:

WP	Final beneficiary
4	**POLITO**
42	**UPV**
T421	**ELBIT**
43	**ELBIT**
T431	**ELBIT**
T432	**ELBIT**
44	**POLITO**
T441	**POLITO**
T442	**POLITO**

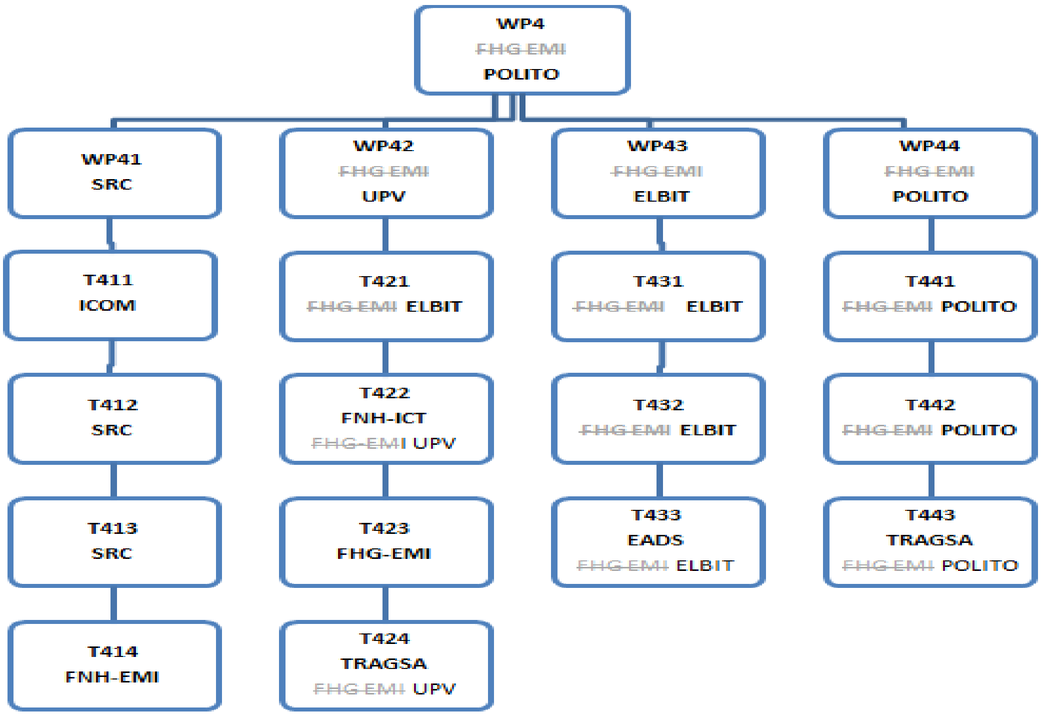

Figure 15: Updated structure of WP4

4.3.3 Man Months and responsibility reallocation

Of course the new allocation of specific task and activities has taken, as a consequence, a different work-share among the AF3 partners, in term of MMs.

Here below the major differences will be highlighted, all the detail was anyway discussed, and the DOW was updated with the new overall picture.

In some few cases there were slight changes, as well, in term of tasks to be performed by some partners, who have demonstrated to be capable to lead, in some cases, different activities respect to the ones foreseen at the beginning. But this is related, as already said, to a not so strong amount of MMs, and was completely and exhaustively described in the DOW itself.

4.3.3.1 Fraunhofer MM reduction

WP	Type of activity	Old allocation (DoW)	New allocation
WP1.1	MGT	0	0
WP2.1	RTD	5	5
WP2.2	RTD	3	3
WP2.3	RTD	2	2
WP3.1	RTD	17,5	14,5
WP4.1	RTD	25	25
WP4.2	RTD	37,7	18,7
WP4.3	RTD	24	0
WP4.4	RTD	39	1
WP5.1	RTD	3,5	3,5
WP5.2	RTD	1,5	1,5
WP6.3	RTD	3	0
WP7.1	RTD	61,5	60,7
WP7.2	RTD	1,5	1
WP10.2	RTD	2	2
Total RTD		**226,2**	**137,9**
WP8.1	DEM	3,5	1,5
Total DEM		**3,5**	**1,5**
WP9.1	OTH	8	6
WP9.2	OTH	3,5	0
WP9.3	OTH	3	0
Total OTH		**14,5**	**6**
Total MMs		**244,2**	**145,4**

Table 2: FRAUNHOFER updated allocation of PMs

4.3.3.2 ELBIT MM reallocation

WP	Type of activity	Old allocation (DoW)	New allocation
WP1.1	MGT	2	2
WP2.1	RTD	6	6
WP2.2	RTD	6	6
WP2.3	RTD	1	1
WP3.1	RTD	6	8
WP3.2	RTD	6	6
WP3.3	RTD	2	2
WP4.1	RTD	0	0
WP4.2	RTD	3	13
WP4.3	RTD	4	25,7
WP4.4	RTD	3	3
WP5.1	RTD	8	8
WP5.2	RTD	36	36
WP5.3	RTD	9	9
WP6.1	RTD	58	58
WP6.2	RTD	12	12
WP6.3	RTD	6	6
WP7.1	RTD	4	4,8
WP7.2	RTD	55	55,5
WP7.3	RTD	2	2
WP7.4	RTD	1	1
WP10.2	RTD	3	3
Total RTD		**231**	**266**
WP8.1	DEM	27	27
WP8.2	DEM	26	26
WP8.3	DEM	1	1
Total DEM		**54**	**54**
WP9.1	OTH	11	11
WP9.2	OTH	4	5,5
WP9.3	OTH	8	8,5
WP10.1	OTH	2	2
Total OTH		**25**	**27**
Total MMs		**312**	**349**

Table 3: ELBIT updated allocation of PMs

4.3.3.3 POLITO MM reallocation

WP	Type of activity	Old allocation (DoW)	New allocation
WP1.1	MGT	1	1
WP2.1	RTD	6	6
WP2.2	RTD	6	6
WP2.3	RTD	10	10
WP3.1	RTD	12	12
WP3.3	RTD	6	6
WP4.4	RTD	12	50
WP5.2	RTD	2	2
WP6.2	RTD	6	6
WP6.3	RTD	0	3
WP7.1	RTD	10	10
WP7.3	RTD	5	5
Total RTD		**75**	**116**
WP8.1	DEM	0	1
WP8.2	DEM	3	3
WP8.3	DEM	4	4
Total DEM		**7**	**8**
WP9.1	OTH	28,5	29,5
WP9.2	OTH	1	1
WP9.3	OTH	3,5	3,5
Total OTH		**33**	**34**
Total MMs		**116**	**159**

Table 4: POLITO updated allocation of PMs

4.3.3.4 PYRO MM redistribution and reallocation

Beneficiary 10 “PYRO FIRE EXTINCTION, S.L.” has proposed to redistribute man months and effort in the project to better cope with the expectations of the envisaged fire retardant analysis, the security of operations in fire scenarios in which capsules are used, and the mechanical design of capsules’ subsystem.

PYRO’s analysis of the End-User requirements has led to the need to design a modular system, able to assemble different capsules’ configurations to adapt different end-user demands. The development of a mechanical modular system demands additional efforts in CAD design, manufacturing engineering, and testing, which unavoidably requires additional man-months with respect to the initial allocation. The proposed redistribution will have no effect on the budget, cost and EU contribution for PYRO. The original subdivision in RTD, DEMO and OTH remains unchanged. There will be no impact on the progress of work.

The new redistribution ensured more effectiveness and optimized participation of PYRO in its participation through all the project phases, as well as in the quality of project results. In addition to the previous assessment, PYRO iwas the new responsible of D43.2, previously under Fraunhofer responsibility.

WP	Type of activity	Old allocation (DoW)	New allocation
WP2.1	RTD	2	3,2
WP2.2	RTD	1	1,4
WP2.3	RTD	1	2
WP3.1	RTD	1	1,8
WP4.2	RTD	4	7,3
WP4.3	RTD	2	6
WP7.1	RTD	8	15
WP7.4	RTD	22	40,6
Total RTD		**41**	**77,3**
WP8.1	DEM	1	1,8
WP8.2	DEM	1	1,9
Total DEM		**2**	**3,7**
WP9.1	OTH	3	5,5
Total OTH		**3**	**5,5**
Total MMs		**46**	**86,5**

Table 5: PYRO updated redistribution and reallocation of PMs

4.3.3.5 Final MM reallocation and redistribution table

The summary of staff effort has been recalculated according to the updated involvement of partners N.2, N.4, N.8, N.10, N.11, N.14, N.15, N.16 and N.19. The figures in bold are related to the work package, first level, of which each partner is responsible. The complete table, as in the DoW, is show in the following. The table includes the old MMs allocation in the last column.

Part no.	Participant short name	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	WP10	Total person months	Old MMs allocation
1	FNM	**23**	6	**49**	0	4	4	4	13	4	2	109	109
2	ELBIT	2	13	16	41,7	**53**	76	**63,3**	54	25	5	349	312
3	EFPC	2	0	0	0	0	0	0	0	8	**28**	38	38
4	FNH	0	10	14,5	44,7	5	0	61,7	1,5	6	2	145,4	244,2
5	ICOM	0	4	0	18	30	0	0	12	8	0	72	72
6	NCSRD	0	7	16	3	28	**78,03**	0	26,32	14	2	174,35	174,35
7	SKYTEK	0	0	0	0	14	4	4	2	6	0	30	30
8	POLITO	1	**22**	18	**50**	2	9	15	8	**34**	0	159	116
9	SRC	0	0	8	44	8	25	0	0	14	0	99	99
10	PYRO	0	6,6	1,8	13,3	0	0	55,6	3,7	5,5	0	86,5	46
11	UoW	0	0	13,5	6	13,5	37,5	0	10,5	12,5	0	93,5	93,5
12	EADS CASA	0	4	2	10	0	0	20	**40**	0	0	76	76
13	MOD	2	4	0	0	8	12	5	7	4	0	42	42
14	UPV	0	4	12	9	34,5	9	0	11	4	0	83,5	72,5
15	TRAGSA	1	3	21	31	38	18	0	6	8,5	0	126,5	122
16	LIU	0	8	0	0	8	0	0	6	2	0	24	24
17	ARIA	0	1	13	0	12	1	0	3	0	0	30	14,6
18	MOPS	0	2	0	0	3	0	2	3	0	0	10	10
19	CNVVF	0	8	0	0	8	3	0	10	9	1	39	39
	TOTAL	31	102,6	184,8	270,7	269	276,53	230,6	217,02	164,5	40	1786,75	1734,15

Table 6: Summary of staff effort at WP first level per partner

4.3.3.6 Breakdown of costs reallocation

In the following the updated breakdown of AF3 costs, per partners, is presented, in the same format as the DOW, including the requested EU contribution. The partners for which the budget has been modified, are highlighted in light green.

The total requested EU contribution was not increased[1]. After the conclusion of the project the consortium was able to remain within its budget, even taking into account the 3 months of extension of the project.

Beneficiary short name	Personnel (€)	Consumables (€)	Travels (€)	Equipments (€)	Sub-contracting (€)	Other (€)	Indirect costs (€)	Total (€)	Requested EU contribution	Old Total (€)	Old Requested EU contribution
FNM	648.550	0	57.000	100.000	4.500	37.000	453.985	1.301.035	823.377,50	1.301.035	823.378
ELBIT	2.092.077	85.000	118.500	40.000	261.000	15.000	2.080.182	4.691.759	2.532.501,00	4.258.500	2.301.000
EFPC	323.000	0	49.333	0	2.000	0	223.400	597.733	571.399,60	597.733	571.400
	0	0	0	0	0	0	0	0		0	
FHG - EMI	313.062	0	18.250	0	3.000	0	272.267	606.579	1.366.158,25	1.802.035	2.150.499
FHG - ICT	549.684	65.000	34.225	0	26.000	5.000	516.703	1.196.612		1.023.013	
ICOM	360.000	0	17.600	0	3.000	0	377.600	758.200	424.600,00	758.200	424.600
NCSRD	784.580	1.500	20.260	24.000	9.000	0	580.589	1.419.929	1.047.020,08	1.419.929	1.047.020
SKYTEK	262.500	0	17.813	0	0	0	168.188	448.501	351.500,80	448.501	351.501
POLITO	759.000	30.000	68.660	43.000	26.000	11.000	537.996	1.475.656	1.168.922,00	1.060.656	859.272
SRC	445.500	18.800	11.000	3.000	2.000	4.500	289.680	774.480	612.760,00	774.480	612.760
PYRO	283.544	10.000	9.000	15.000	63.000	12.000	197.136	589.680	443.810,00	578.200	435.200
UOW	444.125	7.500	38.000	45.850	52.202	0	321.285	908.962	688.332,00	908.962	688.332
EADS CASA	446.880	0	7.000	0	3.500	75.000	384.316	916.696	456.598,00	916.696	456.598
HMOD	126.000	2.000	44.000	0	0	200.000	223.200	595.200	448.000,00	595.200	448.000
UPVLC	501.000	10.000	26.000	0	3.500	0	323.240	863.740	629.969,50	750.564	544.957
TRAGSA	525.900	73.000	27.300	0	94.000	0	124.040	844.240	606.200,00	813.040	575.000
TRAGSATEC	233.100	0	8.700	0	0	0	48.360	290.160		290.160	
LIU	139.200	0	17.100	0	0	0	93.780	250.080	182.520,00	250.080	182.520
ARIA	155.125	0	9.000	3.000	8.000	8.000	109.875	293.000	199.800,00	293.000	199.800
MOPS	60.000	0	0	0	0	0	36.000	96.000	64.800,00	96.000	64.800
CNVVF	195.000	0	14.000	0	0	0	125.400	334.400	248.400,00	334.400	248.400
Total	9.647.827	302.800	612.741	273.850	560.702	367.500	7.487.221	19.252.641	12.866.668,73	19.270.383,52	12.985.486,14

Table 7: AF3 updated total costs

[1] .

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4.4 PROJECT PLANNING AND STATUS SUMMARY

As already shown in the 3rd Periodic Report, all the deliverables foreseen during the third and final year of the project have been delivered by July 2017, with the exception of September 2017 only for the last 4 originally due at M36 (and so moved to M39 as for the end of the project itself).

The following table summarizes the list of all deliverables remaining after the first 2 years, with the original delivery dates:

N.	Title	Lead beneficiary	Planned deadline
D4.4.1	Real time risk analysis for forest fires: report and software	POLITO	27
D10.1.3	AF3 Required Ethical Approvals	EFPC	30[2]
D5.1.3	Safety Management of Responders, Public and Wildlife	ICOM	28
D5.1.4	Public information Channels - final report and suggested CONOPS	NCSRD	28
D5.2.2	Prototype ready for testing - Situation awareness, C4I and Decision Support Tools	UPVLC	28
D7.1.2	Physics and chemistry of cooling, retarding and firefighting agents comprehensive test report for models	FHG-ICT	28
D7.2.3	AAFF Integration and Ground Functional Test Report of AAFF on platforms	ELBIT	28
D7.4.3	Final Capsule Subsystem Development Report.	PYRO	28
D8.1.2	AF3 Integration Test Report	EADS CASA	28
D2.3.2	Traceability Matrix system requirements with test cases	POLITO	30
D4.3.1	Safety and risk analysis for firefighting with pellets: report and software	ELBIT	30
D4.4.2	Preventive risk analysis for forest fires: report and software prototype	POLITO	30
D5.3.3	Training center readiness report for the evaluation tests	ELBIT	30
D8.2.1	AF3 integrated trials test plan	ELBIT	30
D9.1.1	Webinar	POLITO	30
D5.3.4	Training scenarios, material, tools and simulation report	UPV	30
D3.3.1	Simulation Host and MMI	FNM	32
D9.1.2	White paper on forest fire	POLITO	32
D4.3.3	Safety and risk assessment of airborne firefighting platforms: report	EADS CASA	33
D4.4.3	Report on post firefighting/long-term risk/chance analysis and software prototype	TRAGSA	33

[2] Or as soon as receiving them before each trial.

D6.1.1_rev C	Airborne, Space & Clouds Monitoring observation data and system components	ELBIT	33
D6.2.1_revC	Ground & ancillary observation data and system components	NCSRD	33
D6.3.1_revC	Data fusion specifications and monitoring system integrated architecture	NCSRD	33
D6.3.3	Monitoring visualisation for command and control, ground personnel and first responders	NCSRD	33
D8.2.2	AF3 integrated tests and evaluation report	ELBIT	36
D8.3.1	Test results evaluation report	FNM	36
D9.1.3	Final Report on dissemination	POLITO	36
D9.3.2	Business plan	ELBIT	36
D10.1.1_revC	Ethical Monitoring of Research report	EFPC	36
D10.1.5_revB	Minimising misuse of research activities report	EFPC	36

Table 8: Deliverables –3rd year

All the documents planned during the 3rd year have been delivered updating a recovery plan on the schedule which had started at the end of the previous one, when due to the anticipation of the Greek trials, some documents had to be delivered a bit late.
Following to this shift, and due to the extension of the project which modified the whole project schedule, all the plan of the deliveries has had a slight shift.

As a conclusion for this, all the final deliverables foreseen for M36 (originally the final month of the project) have been shifted to M39.

After the end of the project, as agreed the 3rd year Periodic Report and the Final Report (this document) have been completed and delivered, together with the –few- documents to be resubmitted after the feedback coming from the Final Review.

Here below the table of the Project Milestones is presented as well: for that one the same slight differences respect to the original program have been managed.

N.	Milestone name	Lead	Planned deadline	Mean of verification	WP
MS9	Safety management of responders, public and wildlife: Procedure, services and tools ready for integration	5	M28	Proven advancements of methods and procedures relevant to safety management of the public, responders, wildlife, vegetation and environment during considered crisis situations	WP51
MS10	Public information channels: procedures, services and tools ready for integrated tests of WP8	6	M28	A social network testbed is established and available on line	WP51
MS17	Capsules ready for evaluation tests	10	M28	Capsules subsystem and all its elements will be ready for the Overall firefighting	WP74
MS11	Prototypes ready for testing- Situation Awareness, C4I and Decision Support Tools	14	M28	Prototypes each tested stand-alone successfully and tests reports with compliance tables submitted demonstrating compliance with requirements	WP52
MS12	Training centre readiness for evaluation tests	2	M28	The C4I training centre will successfully integrated, tested with simulations and training systems. Tests reports with compliance tables submitted demonstrating compliance with requirements	WP53
MS16	Prototypes of AAFF systems installed on platforms and on the selected Helicopter ready for flight	12	M28	Prototypes production, successful functional and SOF ground tests and approval of the integration and test reports	WP72
MS18	Completion of AF3 System integration and readiness to evaluation tests	12	M28		WP81
MS15	Integrated monitoring and visualization for C2, ground personnel and first responders	6	M33	D6.1.1, D6.2.1, D6.3.1 and D6.3.2 final version report reviewed internally and submitted to the EC. Integrated monitoring and visualization prototype system ready	WP63
MS5	Simulation environment available	1	M32	Capability of the Simulation Host Computer with MMI to do advanced forest firefighting mission simulation	WP33
MS19	Completion of AF3 integrated tests	2	M36	Successful criteria for the integrated tests will be defined in the test plan and will be examined accordingly	WP82
MS20	Results evaluation	1	M36	The evaluation report was submitted confirming the compliance of the demonstrated AF3 system with the project goals in terms of the projected overall efficiency, cost effectiveness and improvements	WP83

Table 9 Project Milestones – 3rd year

5. CONCLUDING REMARKS

AF3 is an answer to the need to possess a situational awareness about the wildifres in order to understand how information, events, and actions may affect the goals, both now and in the near future. In the context of planning, preparation and suppression of wildfires it is important to detect early the fire, know the fire locations, and understand its current and future growth and behavior.

The development of an advanced integrated system for wildfire management, able to integrate in an optimal way the information coming from the field, evaluating the possible risks and the effects of fire attacks and allowing the commander to take effective decisions, was the first main outcome from AF3 project. The second one was the development of innovative active and passive countermeasures able to significantly improve the effectiveness of firefighting, more specifically the pellets and the capsules.

The best way to avoid potential damages from a forest fire is always to impede it from occurring. Therefore prevention is a crucial aspect to be considered. The technology developed within the AF3 project has been mainly oriented towards firefighting, but it can be also redirected towards prevention through proper integration of additional features. In this regard, it is also crucial to develop effective communication means, such as social media, in order to inform people about the risks and good practices both to prevent from accidental fires and to evacuate risky areas.
Another important aspect is related to the development of proper simulation tools; in particular, it is crucial to enforce the applicability of physical-based simulation models to operational management through proper reduction techniques. Such approaches should be accompanied by further research on input data evaluation on large territories and by medium-to-large scale fire tests.
A further topic that deserves further consideration consists in the adoption of unmanned vehicles, both ground and aerial vehicles. The AF3 project has highlighted the flexibility of UAVs for detecting a forest fire and providing information about the scenario. Further uses of unmanned vehicles can be related to rescue, creating firebreaks, and operate firefighting in critical areas. These latter missions could be coupled with the active and passive countermeasures developed in the AF3 project.

The experience acquired during the development of the AF3 project, particularly multiple trials that have been performed and the continuous interchanges with the end-users and advisory board, has permitted the various partners to focus the areas that deserve further development as well as issues that should be carefully considered.