This project has received funding from "HORIZON 2020" the European Union's Framework Programme
for research, technological development and demonstration under grant agreement no 645220


# Road-, Air- and Water-based Future Internet Experimentation

| Project Acronym: | RAWFIE | | |
|---|---|---|---|
| Contract Number: | 645220 | | |
| Starting date: | Jan 1st 2015 | Ending date: | Dec 31st, 2018 |

| Deliverable Number and Title | D8.4: Open Calls, Final Report (b) | | |
|---|---|---|---|
| Confidentiality | CO | Deliverable type[1] | R |
| Deliverable File | | Date | 2018-04-30 |
| Approval Status[2] | WP leader | Version | 1.0 |
| Contact Person | Stathes Hadjiefthymiades | Organization | University of Athens |
| Phone | +302107275148 | E-Mail | shadj@di.uoa.gr |

[1] Deliverable type: P(Prototype), R (Report), O (Other)
[2]Approval Status: WP leader, 1st Reviewer, 2nd Reviewer, Advisory Board

## AUTHORS TABLE


| Name | Company | E-Mail |
|---|---|---|
| | | |
| Stathes Hadjiefthymiades | UoA | shadj@di.uoa.gr |
| Peggy Papadopoulou | UoA | peggy@di.uoa.gr |
| Vassilis Papataxiarhis | UoA | vpap@di.uoa.gr |
| | | |
| | | |
| | | |


## REVIEWERS TABLE

| Name | Company | E-Mail |
|---|---|---|
| Sotirios Glykofridis | HMOD | sglikofridis@dideap.mil.gr |
| | | |

## DISTRIBUTION

| Name / Role | Company | Level of confidentiality[3] | Type of deliverable |
|---|---|---|---|
| ALL | | PU | R |

## CHANGE HISTORY

| Version | Date | Reason for Change | Pages/Sections Affected |
|---|---|---|---|
| v01 | 18.05.2018 | Initial version for submission | - |
| | | | |
| | | | |

[3]Deliverable Distribution: PU (Public, can be distributed to everyone), CO (Confidential, for use by consortium members only), RE (Restricted, available to a group specified by the Project Advisory Board).

**Abstract:**
**This deliverable is the final report of the 2nd Open Call of RAWFIE. It presents the launch of the projects corresponding to the open call successful proposals, the project management process and the current status. It also presents the meeting that took place for the 2nd Open Call projects.**

**Keywords: open call, contract, meeting, testbed, UxV, software**

# Part II: Table of Contents

Part II: Table of Contents ..... 4
List of Figures ..... 5
List of Tables ..... 6
Part III: Executive Summary ..... 7
Part IV: Main Section ..... 8
1 Introduction ..... 8
2 Management process of Open Call 2 projects ..... 9
2.1 OC2 kick-off meeting ..... 19
2.2 OC2 coordination ..... 22
2.3 Communication ..... 22
2.4 Contracts ..... 22
2.5 Reviewers contracts and payment ..... 22
2.6 Deliverables submission and evaluation process ..... 22
3 Open Call 2 projects progress and status ..... 22
3.1 ALTU: Provision of All-Terrain UGVs ..... 23
3.2 DOGMA: Docile Generic Multi-Purpose Air Vehicle ..... 23
3.3 IGMAC: Intellingent Geo-MApping Copter ..... 23
3.4 UNSURPASSED: Unmanned Surface Vehicles as Primary Assets for the Coast Guard 24
3.5 GNFUV: Glasgow Network Functions for Unmanned Vehicles ..... 25
3.6 ATLAS: UxV-bAsed OpporTunistic Networks FaciLitating Connectivity in Remote AreaS 26
3.7 EXP-A.R.S.: Experimenting Autonomous Remote Sensing ..... 26
3.8 QoEST4CM: QoE SupporT for improved Crisis Management ..... 27
3.9 UTMEXP: UAS Traffic Management Experiments ..... 27
3.10 PARROT: Public Safety ExpeRimentation in RAWFIE Mobile IOT platform ..... 28
4 References ..... 28
5 Annex–Tables ..... 28

# List of Figures

Figure 1: RAWFIE devices available for experimentation from Open Call 1 projects................ 20
Figure 2: Experiment with RAWFIE USVs with the help of HMOD expert military staff......... 21
Figure 3: Experiment with RAWFIE USVs and platform at Skaramagas testbed....................... 21

# List of Tables

Table 1: RAWFIE Open Call 2 Projects .......... 9

# Part III: Executive Summary

This deliverable describes the several stages of the 2nd RAWFIE Open Call projects following the completion of the call and the selection of the successful proposals.
Initially, a general introduction of the call is presented. Then, the reader is provided with a description of the project management and the processes followed over the twelve-month period after the completion of the selection process and the announcement of the official results regarding the successful bidders.
As a next step, the deliverables submission process is described as well as the procedure followed for the evaluation, acceptance and payment of the submitted deliverables. A summary of the Open Call 2 deliverables that have been completed is also presented.

# Part IV: Main Section

## 1 Introduction

RAWFIE (Road-, Air- and Water- based Future Internet Experimentation) is a project funded by the European Commission (Horizon H2020 programme) under the FIRE initiative aiming to provide research and experimentation facilities through the growing domain of unmanned networked devices. The **FIRE** initiative (**F**uture **I**nternet **R**esearch and **E**xperimentation) creates an **open research environment,** which facilitates strategic research and development of new Future Internet concepts, giving researchers the tools they need **to conduct large-scale experiments** on new paradigms.

The purpose of the RAWFIE project is to create a federation of different testbeds that will work together to make their resources available under a common framework. Specifically, it aims at delivering a unique, mixed experimentation environment across the space and technology dimensions. RAWFIE integrates numerous testbeds for experimenting in vehicular (road), aerial and maritime environments. Vehicular Testbeds (VT) will deal with Unmanned Ground Vehicles (UGVs) while Aerial Testbeds (AT) and Maritime Testbeds (MT) will deal with Unmanned Aerial Vehicles (UAVs) and Unmanned Surface Vehicles (USVs), respectively. The RAWFIE Consortium includes all the possible actors of this highly challenging experimentation domain, from technology creators to integrators and facility owners. The basic idea behind the RAWFIE effort is the automated, remote operation of a large number of robotic devices (UGVs, UAVs, USVs) for the purpose of assessing the performance of different technologies in the networking, sensing and mobile/autonomic application domains. RAWFIE features a significant number of UxV nodes for exposing the experimenter to an extensive test infrastructure. All these items are managed by a central controlling entity, which will be programmed per case and fully overview/drive the operation of the respective mechanisms (e.g., auto-pilots, remote controlled ground vehicles). Internet connectivity will be extended to the mobile units to enable the remote programming (over-the-air), control and data collection. Support software for experiment management, data collection and post-analysis will be virtualized to enable experimentation from anywhere in the world. The vision of Experimentation-as-a-Service (EaaS) is promoted through RAWFIE. The Internet of Things (IoT) paradigm is fully adopted and further refined for supporting highly dynamic node architectures.

The objective of the 2nd RAWFIE Open Call is twofold: first, to enhance certain parts and characteristics of the federated infrastructure in terms of UxV devices (RAWFIE-OC2-EXT-UGV, RAWFIE-OC2-EXT-UAV); second, to support cross-domain or domain-specific real-world applications and experiments (RAWFIE-OC2-EXP-SCI, RAWFIE-OC2-EXP-SME). Each proposal should target **exactly one** of the four types of activities (termed *directions of enhancement*), as stated in the next paragraphs. In case a proposer intends to cover more than one directions of enhancement, this should be addressed through the submission of separate proposals. All the proposals should fully comply with the public deliverables D3.1, D3.2, D4.1, D4.2, D4.4, D4.5, D6.1, D6.2 (can be found in http://rawfie.eu/deliverables) that have been produced so far by the RAWFIE Consortium and provide system requirements as well as technical description and implementation details for the RAWFIE architecture and specific components.

## 2 Management process of Open Call 2 projects

The 2nd RAWFIE Open Call resulted with the selection of ten proposals for the provision of financial support to third parties. The following table summarizes the proposals that have been accepted to be funded as projects in the context of RAWFIE from Open Call 2.

**Table 1: RAWFIE Open Call 2 Projects**

| # | Project | Organization | Abstract | Activity |
|---|---|---|---|---|
| **1** | **ALTU: Provision of All-Terrain UGVs** | Fible Non Profit Company | ALTU brings the value of ten (10) IoT Unmanned All Terrain Ground Vehicles with the ability to combine a diverse range of payloads and/or sensors. These include:<br>• long range (>10Km) and short range (max 1.5Km) Remote Control systems and First Person View Audio/Video feeds, simultaneously over IP streaming and Analogue RF transmission to the Ground Control Stations<br>• gimbal controlled HD and SD cameras with 0.0001 LUX minimum illumination capability<br>• static and 360o long range Laser rangefinders and mapping scanners/radars for simultaneous localization, mapping and multi-directional collision avoidance<br>• dual sensor (FLIR DUO) compact thermal and visible light imagers with live analogue and digital video output<br>• simultaneous 2.4 GHz and 5 GHz WiFi 3x3 MIMO mesh | RAWFIE-OC2-EXT-UGV |

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| | | | networking Access Points with Mobile 4G/LTE Internet Connectivity and extended networking capabilities, like Firewall, Routing, VPN, etc.<br><br>ALTU UGVs' innovative design is ready to incorporate all existing and future RAWFIE's software requirements, comes with a full range of accessories and is coupled with state of the art electronics and network components.<br><br>ALTU uses a fully configurable auto-pilot controller running open-source software, utilizing all capabilities of the MAVlink and the RAWFIE AVRO schema protocols, enabling a plethora of possible experiments that will enhance the RAWFIE federation of different testbeds and expand the envisioned Experimentation-as-a-Service infrastructure. | |
| **2** | **DOGMA: Docile Generic Multi-Purpose Air Vehicle** | Ucandrone PC | DOGMA brings the value of 10 networked UAVs in 3 different configurations: Dual 45o positioned day & night vision cameras, FLIR dual-sensor thermal imagers and Parrot SEQUOIA multispectral sensors.<br><br>DOGMA UAVs' innovative design comes with a full range of accessories and is coupled with state of the art electronics and network components. Key feature is the unique combination of WiFi networking capabilities with Mobile Internet Connectivity | RAWFIE-OC2-EXT-UAV |

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| | | | for both cruise control and data transfer in various contexts.<br><br>DOGMA uses a fully configurable auto-pilot controller running open-source software, utilizing all capabilities of the MAVlink protocol, enabling a plethora of possible experiments that will enhance the RAWFIE federation of different testbeds and expand the envisioned Experimentation-as-a-Service infrastructure.<br><br>DOGMA's experts, subcontractors of previous FIRE community projects, have great experience in RTD & Commercial ventures and fixed interest in promoting innovation in their field. This assures correct and timely delivery of UAVs and support services, being a knowledgeable partner for RAWFIE and contributing to the advancement of experimentation activities and exploration of their real-world potential. | |
| **3** | **IGMAC: Intellingent Geo-MApping Copter** | ITCROWD CONSULTANTS LTD | IGMAC brings the value of twelve (12) networked UAVs in 3 different configurations: four (4) "Predator" UAVs equipped with thermal scanning payload, four (4) "Bat" UAVs equipped with multi-spectral camera payload and four (4) "3D-Mapper" equipped with 360o Long Range LIDAR.<br><br>The diverse range of IGMAC capabilities include:<br><br>• Remote Control systems and First Person View Audio/Video | RAWFIE-OC2-EXT-UAV |

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| | | | feeds via IP streaming to the RAWFIE management systems and Analogue RF transmission to the Ground Control Stations simultaneously.<br><br>• 360o long range Laser rangefinders and mapping scanners/radars for simultaneous localization, mapping and multi-directional collision avoidance<br><br>• dual sensor (FLIR DUO) compact thermal and visible light imagers with live analogue and digital video output<br><br>• multispectral sensor (Parrot SEQUOIA) that captures calibrated wavelength of Green, Red, Red-Edge and Near Infrared.<br><br>• simultaneous 2.4 GHz 2x2 MIMO WiFi Access Points with Mobile 4G/LTE Internet Connectivity and extended networking capabilities, like Firewal, Routing, VPN, etc.<br><br>IGMAC UAVs' innovative design comes with a full range of accessories and is coupled with state of the art electronics and network components and it is ready to incorporate all existing and future RAWFIE's software requirements.<br><br>IGMAC uses a fully configurable auto-pilot controller running open-source software, utilizing all capabilities of the MAVlink and the RAWFIE AVRO schema protocols, enabling a plethora of possible experiments that will enhance | |

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| | | | the RAWFIE federation of different testbeds and expand the envisioned Experimentation-as-a-Service infrastructure. | |
| **4** | **UNSURPASSED: Unmanned Surface Vehicles as Primary Assets for the Coast Guard** | Athens University of Economics and Business | UNSURPASSED will set the RAWFIE USV testbed in the service of the coast guard, showcasing the potential of USVs to perform surveillance and search-and-rescue tasks.<br><br>The work plan has two threads. The first involves the integration (in RAWFIE) of networking and security mechanisms that are based on distributed paradigms, i.e., ad hoc, delay-tolerant, and information-centric networking and identity-based encryption, which will turn USVs into real assets for the coast guard. The addition of these mechanisms to the testbed will significantly increase its reusability by other experimenters. The second thread consists in using these mechanisms to conduct experiments, of escalating complexity, their scope stretching from the radio channel up to networking functionality and above. | RAWFIE-OC2-EXP-SCI |
| **5** | **GNFUV: Glasgow Network Functions for Unmanned Vehicles** | University of Glasgow | In this proposal, we present GNFUV: an extension of the Glasgow Network Functions (GNF) framework to operate over UxV infrastructures. GNF is a Network Function Virtualization (NFV) suite that exploits Docker containers to turn potentially any device capable of running even a minimal (e.g., embedded) | RAWFIE-OC2-EXP-SCI |

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| | | | Linux kernel into a NFV hosting platform, hence being particularly well-suited for operating over resourced-constrained and (mobile) IoT environments. GNFUV will leverage the RAWFIE infrastructure as a target platform to host diverse virtualised network functions across numerous physical UxV deployments in a transparent way. The proposed project aims to showcase the capabilities of UxVs as hosting platforms for (virtualised) tasks, ranging from always-on monitoring and network topology self-management, to novel algorithms for edge-computing predictive analytics. | |
| **6** | **ATLAS: UxV-bAsedOpporTunistic Networks FaciLitating Connectivity in Remote AreaS** | N.C.S.R. "Demokritos" | Recently, the use of opportunistic networks for providing delay tolerant services to remote areas without Internet connectivity has gained considerable traction. Several solutions have been proposed, but they aim at specific settings and make limiting assumptions, so they are not generally applicable. The progress of UxV-related technology opens the possibility of providing more versatile and generally applicable opportunistic networking solutions. This approach has many merits (capability for rapid and low-cost deployment, high configurability, lack of requirements for preexisting infrastructure or human operators), but comes with | RAWFIE-OC2-EXP-SCI |

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| | | | another set of challenges: The versatility and generality of the new setting creates the requirement that the message routing protocol employed by the UxV-based opportunistic network be capable of maintaining efficient operation in a wide range of network density and mobility conditions. However, most relevant routing protocols have been designed to accommodate a restricted set of possible network conditions and yield satisfactory performance only when the actual conditions fall within this restricted set.<br><br>Recently, the MAD routing protocol was introduced to address this limitation. Despite being a 'lightweight' protocol, MAD can self-adapt to diverse settings and perform optimally in a very wide range of network density and mobility conditions. At the same time, it possesses several other features that make it very suitable for use in UxV-based opportunistic networks. In light of all these characteristics, the ATLAS project aims (1) to integrate the appropriate mechanisms for equipping the RAWFIE infrastructure with up to date opportunistic networking capabilities based on the MAD protocol and (2) to engage the enhanced infrastructure in experiments, towards assessing the performance of MAD in a variety of real-world conditions and towards evaluating the potential of ATLAS-enhanced USV-based opportunistic | |

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| | | | networks in connection with the relevant use-case of providing connectivity to remote maritime areas.<br><br>The findings of the aforementioned experimental investigations, along with experiences obtained from the integration of the ATLAS mechanisms into RAWFIE and the use of the RAWFIE's facilities and tools, will be provided as feedback to the RAWFIE community, together with suggestions for potential improvements. Moreover, the testbed enhancements and the set of the obtained results will be made available to RAWFIE and the research community in general, allowing further large-scale experimentation in an important and timely topic. | |
| **7** | **EXP-A.R.S.: Experimenting Autonomous Remote Sensing** | WPWEB | WPWEB recently had a specific request, coming from one of the largest power supplying company in Northern Italy (end-user), to verify the applicability of drones for monitoring its plants both indoor and outdoor.<br><br>Under the light of this request, WPWEB has been selected for managing a R&D project by the Piedmont Region (Italy), with the aim to implement the adoption of "remote sensing" techniques through the use of UAVs for autonomous or semi-autonomous inspection of confined spaces, for monitoring infrastructures and tunnels. | RAWFIE-OC2-EXP-SME |
| **8** | **QoEST4CM: QoESupporT for** | ITTI | The proposal is focused on evaluating key enablers that | RAWFIE-OC2-EXP- |

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| | **improved Crisis Management** | | shall guarantee successful integration of the drones with the crisis management software. The main orientation of the proposed experiment is to treat group of drones (e.g. 5-10) as deployable video sensors for crisis event management, training and decision support. Owing to company's track record of crisis related project (see B1.1, B2.1) we see great potential in integrating drones with decision support systems that we currently develop in R&D projects.<br>We are bringing in-house SW solutions from the area of context-based video adaptation in the uplinkdirection, as well as cellular networks coverage mapping and probing and aim at deploying it on the drones. On the other hand we target complete use-cases which are sought be end-users in the domain of"crisis mapping", "providing remote video reconnaissance" and especially introducing optimizations that will maximize quality of multimedia given particular needs of crisis operators. Particular group of such needs is connected with enhancing our in-house developed tools for managing flooding events with video/picture inputs from area of crisis to improve quality of decision making and crisis modelling | SME |
| **9** | **UTMEXP: UAS Traffic Management Experiments** | Wyenor Ltd | The experimentation done by the UTMEXP project will test the principles underlying the proposed Unmanned Airborne | RAWFIE-OC2-EXP-SME |

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| | | | System (UAS) Traffic Management (UTM) concept. The questions to be answered by the experimentation, directly or indirectly, are highly technological and appropriate to the capabilities of the RAWFIE mobile IoT UAV testbeds. The answers delivered by the experiments will contribute directly to UTM standards.<br><br>To do the experiments it is necessary to fly a “flock” of Unmanned Airborne Vehicles (UAVs) that are able to communicate with each other and with a management system to exchange command and control (C2) messages, management data, payload and other information. The experiments will also demonstrate the capabilities of the RAWFIE platform for execution of a complex mobile IoT application. | |
| **10** | **PARROT: Public Safety ExpeRimentation in RAWFIE Mobile IOT platform** | Feron Technologies P.C. | Reliable and rich communications support in the strike of emergency events is considered a critical feature of mobile networks. Latest developments in the IoT and unmanned vehicles domains open up new opportunities for revolutionizing public safety networks deployment. PARROT is a project targeting the integration and demonstration upon the RAWFIE test-bed, of a hardware and software prototype tailored to end-to-end public safety operations support. PARROT proposes the | RAWFIE-OC2-EXP-SME |

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| | | | enhancement of UxV nodes with existing and emerging radio components/technologies (4G/4.5G/D2D/WiFi) leveraging the software radio paradigm. The project will be carried out by Feron Technologies and builds upon previous experience and solutions portfolio regarding the integration of radio and IT technologies for building custom systems, and the implementation of telecom technologies in general purpose computing/radio equipment. FERON will bring to RAWFIE a set of diverse skills and competences, demonstrate the testbed potential to support challenging use-cases such as public safety, and highlight the value of the RAWFIE as a means for testing novel solutions at a pre-product phase. | |

The following paragraphs describe the action and process that has been followed for the management of the Open Call 2 (OC2) projects.

## 2.1 OC2 kick-off meeting

A kick-off meeting for the Open Call 2 projects was held on November 24, 2017 in Athens. It was kindly hosted at Skaramagas Naval Base premises, after permission granted by the Hellenic Ministry of National Defence (HMOD), partner of RAWFIE. The meeting had the form of a workshop which enabled the exchange of ideas and the discussion of issues and questions among the OC2 project partners in order to explore collaboration opportunities and challenges. Twenty six people participated in the meeting; fifteen participants from the ten projects attended the meeting, together with seven participants from the University of Athens. Two RAWFIE partners, HMOD and Hellenic Aerospace Industry (HAI), both RAWFIE testbed operators, were also present in the meeting, with three participants from HMOD and two participants from HAI.

Each project was presented in detail to all participants so that all parties of the OC2 could have a clear understanding of every project. During the kick-off meeting contact points on behalf of UoA were defined and assigned to third parties. Regular skype calls between the contact points and the OC2 beneficiaries were also agreed to be established on a twice-per-week basis for resolving questions and efficiently overviewing each project lifecycle.

In the context of the meeting, there was an opportunity for a live demonstration of RAWFIE devices tools and platform to the OC2 project participants. RAWFIE devices available for experimentation from Open Call 1 projects, UAVs and USVs, were demonstrated to the meeting participants (Figure 1). In addition, the RAWFIE platform was demonstrated through three actual experiments that took place in one of the RAWFIE testbeds in front of the meeting participants. The experiments were planned and conducted by the University of Athens with the valuable help of HMOD expert military staff (Figure 2). The three experiments were defined and implemented with the use of RAWFIE tools and they were performed with 2 USVs from FLEXUS project from Open Call 1, in the sea of Skaramagas Naval Base. The meeting participants were able to watch the two devices moving in the sea, while being remotely driven with the use of the RAWFIE tools and platform (Figure 3). The participants were also given a demonstration of the RAWFIE platform functionality while the experiments were in progress.


**Figure 1: RAWFIE devices available for experimentation from Open Call 1 projects**


**Figure 2: Experiment with RAWFIE USVs with the help of HMOD expert military staff**

**Figure 3: Experiment with RAWFIE USVs and platform at Skaramagas testbed**

## 2.2 OC2 coordination

Four teams from RAWFIE project members of the University of Athens were formed for the management of the OC2 projects, with each team being responsible for two or three projects of similar focus. Each team has a close collaboration with the respective projects, monitoring the progress of the projects, facilitating the project work and the cooperation with other projects and addressing possible problems.

## 2.3 Communication

A separate mailing list was created for each project in order to facilitate communication and collaboration among the people involved in each project. In addition to the use of the mailing lists, communication is made with each project partners on a regular basis, with conference calls that are scheduled within each project every two weeks, as well as emails and ad-hoc conference calls whenever needed.

## 2.4 Contracts

A contract was prepared for each project between the RAWFIE project coordinator and the third party. Each contract was signed by the legal representatives of the contractor – third party and the University of Athens. Due to a delay in the resolution of certain legal issues related to the contract, the start of extensions projects was delayed by two months.

## 2.5 Reviewers contracts and payment

The Open Call 2 proposals were evaluated by 16 reviewers from various countries, including France, U.K., Italy, Spain, Greece, Norway, Serbia and Belgium. Each reviewer signed a contract for the reviews conducted and the remuneration was €185 per reviewed proposal. Each reviewer was assigned with 3 proposals at most, thus the maximum amount a reviewer received was €555.

## 2.6 Deliverables submission and evaluation process

The deliverables of the OC2 projects are submitted according to the time plan that is part of every project's contract. A separate monitoring and acceptance committee was created for each project, consisting of faculty members of the University of Athens with expertise in the project fields. The deliverables submitted from each project are checked by the respective monitoring and acceptance committee with regards to the quality and completeness of their content. In case there are comments about requested changes in the submitted deliverables, they are communicated to the project. When a deliverable is approved by the monitoring and acceptance committee of the respective project, an acceptance letter is sent to the project manager.

# 3 Open Call 2 projects progress and status

The following paragraphs provide a description of the progress and the current status of the OC2 projects

## 3.1 ALTU: Provision of All-Terrain UGVs

The company has undertaken the construction and delivery of ten (10) Unmanned All Terrain Ground Vehicles in two basic models.

- Four (4) “Endeavor” UGVs (scale 1/4)
- Six (6) “Voyager” UGVs (scale 1/5)

The USVs will accommodate long-range or short-range communication equipment, gimbal-controlled HD and SD cameras, static and 360$^{o}$ Laser finders and mapping scanners etc.

The frames are assembled and the “Voyager” UGVs will be ready to be delivered shortly. The “Endeavor” will follow (the frames are assembled) and the company will have completed the delivery by late July or beginning of August. The lack of certain parts is the reason that the delivery will not be completed earlier. The training period will follow as planned.

## 3.2 DOGMA: Docile Generic Multi-Purpose Air Vehicle

The company has undertaken the construction and delivery of ten (10) UAVs (fixed wing) in three mixed configurations:

- Dual day & night vision cameras (four units)
- FLIR thermal imagers (four units)
- Parrot SEQUOIA multispectral sensors (four units)
- Long range communication (six units)
- Short range communication (four units)
- Dual day & night vision cameras at 45$^{o}$ angle view for area patrolling & surveillance, fire protection, real time monitoring, natural disaster damage assessment. (two units)

The UAVS are almost ready to be delivered. There are minor missing items (i.e., carrying bags). The documentation is also in an advanced stage and will be ready in time. Training period will follow, as planned.

## 3.3 IGMAC: Intellingent Geo-MApping Copter

The company has undertaken the construction and delivery of twelve (12) networked UAVs in three different configurations:

- Four (4) “Bat” UAVs equipped with multi-spectral camera
- Four (4) “Predator” UAVs equipped with thermal scanning payload
- Four (4) “3D-Mapper” UAVs equipped with 360$^{o}$ LIDAR.

The company replaced the analogue First Person View camera on all of the UAVs with a digital one, following the request and the consequent approval of the UoA. The construction of the devices is reaching its final stage. Minor technical details – i.e., the cable of the FLIR camera’s cable is too short and must be extended – remain to be addressed. The documentation is also progressing and the company estimates that by July all of the UAVs along with the accompanying documentation will have been delivered. Following the delivery, a training period of the UAV's pilot will follow, as planned.

## 3.4 UNSURPASSED: Unmanned Surface Vehicles as Primary Assets for the Coast Guard

UNSURPASSED will set the RAWFIE USV testbed in the service of the coast guard, showcasing the potential of USVs to perform surveillance and search-and-rescue tasks.

The work plan has two threads. The first involves the integration (in RAWFIE) of networking and security mechanisms that are based on distributed paradigms, i.e., ad hoc, delay-tolerant, and information-centric networking and identity-based encryption, which will turn USVs into real assets for the coast guard. The addition of these mechanisms to the testbed will significantly increase its reusability by other experimenters. The second thread consists in using these mechanisms to conduct experiments, of escalating complexity, their scope stretching from the radio channel up to networking functionality and above.

During the first half of the project (from its start, Oct. 1st, 2017, to May 1st, 2018), the project hired most of the required personnel, purchased the necessary equipment (notably 10 Raspberry Pi's and associated equipment, like WiFi dongles, etc.) to supplement the equipment already available in the AUEB lab, and has started the development of the necessary software, as well as the experimentation, in line with the project proposal.

Notably, the project developed a distributed platform for performing experiments, both on AUEB lab network and also on the Skaramagas testbed, called Dedalus. Dedalus creates a distributed system comprising of three kinds of entities, Clients, Workers, and Brokers, running at the nodes of the network. Workers create, receive, and forward traffic, and report their status to Brokers. Brokers assign tasks to workers according to instructions received from the Clients. Finally, Clients monitor the conditions of the network and assign tasks to Workers by communicating with the Brokers. The Dedalus application itself can be run in four main modes, one mode for each kind of entity and a mode combining two entities. Dedalus is described in greater detail in Deliverable D1.1. The details of how Dedalus will be integrated to the testbed have been ironed out.

The project team has also experimented with a variety of protocol implementations covering all four main tasks of the project. In some cases, the integration of these protocols with Dedalus has been completed; in others, it is pending

- Regarding ad hoc protocols, the project has experimented extensively with the BABEL and BATMAN protocols (see Deliverable D1.1), in experiments involving multihop transmission and mobility, and we have gained experience with other protocols as well.
- Regarding delay-tolerant protocols, project attention has focused, for now, to the IBR-DTN protocol (see Deliverable D1.3), which is the most mature implementation publicly available.
- Regarding information-centric networking, the project has installed and tested CCN-Lite in fully-connected networks and multi-hop scenarios (see Deliverable D1.3).

- Finally, regarding security protocols, the project has experimented with a message encryption application using the Green and Ateniese IBE-PRE scheme as implemented by the Charm-Crypto library (see Deliverable D1.1).

The following scientific publications have arisen from the work in the context of the project, specifically on the modelling and performance evaluation of wireless networks, taking into account the project team experience with working with the network, and also being motivated by the envisaged applications that their network platform can support.

- R. Cavallari, S. Toumpis, and R. Verdone, "Analysis of Hybrid Geographic/Delay-Tolerant, Routing Protocols for Wireless Mobile Networks", in Proc. IEEE Infocom, 2018, Honolulu, HI. (status: accepted and presented)
- Kontoyiannis, S. Toumpis, R. Cavallari, and R. Verdone, "Asymptotics of the Packet Speed and Cost in a Mobile Wireless Network Model", in Proc IEEE ISIT, 2018, Vail, Co (status: accepted, to be presented)
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More publications are planned, especially on the project work collecting and interpreting data measurements, both on the network based on our premises, as well as the testbed of the Skaramagas site.

Also, the following deliverables have been submitted:

- D1.1: Draft software extensions for Tasks 1,4
- D1.2: First progress report
- D1.3: Draft software extensions for Tasks 2,3

We note that the first round of experiments in the Skaramagas testbed have been scheduled for the month of May ($17^{th}$, $24^{th}$, and $31^{st}$) and will be reported in Deliverable D1.4.

## 3.5 GNFUV: Glasgow Network Functions for Unmanned Vehicles

During the last month of the project, the GNFUV team in Glasgow designed the architecture of the platform that is extending the current RAWFIE platform with the enablement of using edge computing on UxVs. The design of the architecture was introducing Raspberry Pis which are placed on the vehicles to form a network that is able to react based on sensor readings. The platform is able to use edge analytics to identify outliers and perform analytics at the sensing device (UxV). The GNFUV Team further conducted the first experiment in Athens test-bed at Skaramagas (March 2018) with the purpose to explore the RAWFIE platform with the extension of the platform and the ability of using edge computing on the UxVs.

During the last phase of the GNFUV project, it is intended to analyse the conducted data from the Athens experiment to identify the ability and improvement of using edge computing on UxVs. The project is then intending to run another experiment on UxVs on another testbed to verify the diversity and generalisation of the usage of edge computing and analytics on UxVs. Currently the project is planning on running the experiments in the next months on the test-bed in Germany, Bremen. They will place again the Raspberry Pis on the UxVs and further proceed with enhanced analytic tasks during that experiment. After the final experiment there they will finalise the data analysis of the collected data with the results from the testbed in Athens.

## 3.6 ATLAS: UxV-bAsed OpporTunistic Networks FaciLitating Connectivity in Remote AreaS

ATLAS - UxV-bAsed OpporTunistic Networks FaciLitating Connectivity in Remote AreaS, group have acquired most of the needed equipment and have developed the MAD routing protocol in Python modules and tested its ad-hoc capabilities in a research laboratory. The software has been developed in order to be ported in a Raspberry Pi (R-Pi 2 model B) that has been equipped with a WiFi USB adapter. For the next steps the project will try to use the integrated GPS module of the USV devices instead of the adapter on Raspberry and Pis, communicate with the RAWFIE platform in order to test different modes of moving devices such as swarm mode and perform experiments with the FLEXUS machines. The developed software aims to facilitate the networking and communication among proximal ATLAS nodes in order for each node that carries a packet to be transmitted to discover its neighbors and to assess the benefit of either forwarding the packet to one of its neighbors or of keeping the packet in order to forward it later to another suitable neighbor or to the destination itself. The developed experimentation system allows opportunistic/delay tolerant message transmission between a pair of fixed nodes (a source and a destination) that will be located in specific end points in the experimentation area. The actual experimentation area between these two endpoints will be a rectangular-shaped sea area of approximate size 100x100 m^2 and will contain up to 10 FLEXUS USVs that will be 'MAD aware' (by having onboard Raspberry Pi modules that will be ported with the developed software) and will be moving independent of each other.

## 3.7 EXP-A.R.S.: Experimenting Autonomous Remote Sensing

EXPRAS aims at experimenting different SLAM (Simultaneous Localization and mapping) based on VINS (Vision-aided Inertial Navigation Systems) approaches for adopting the best solution to be implemented in a UAV (Unmanned Aerial Vehicle) platform, specifically deployed for autonomous or semi-autonomous inspection of confined spaces and infrastructure monitoring. EXPRAS project is under the development phase. The following aspects have been executed:

a) Connection to RAWFIE VPN, which is needed in order to establish a connection with RAWFIE project.
b) Testing of different visual slam in Gazebo simulator and with registered handheld camera video.
c) Testing of different visual slam with inertial fusion in Gazebo simulator and with registered handheld camera video.
d) Implemented ROS nodes for each slam to execute them in ROS environment.

The future actions include the connection to Kafka service, messages decoding and developing ROS nodes to consume messages. Afterwards, EXPRAS project shall test different visual slam with or without inertial fusion in real-time environment (may be handheld camera + IMU + GPS for ground-truth connected via wi-fi to ground station). The outcome will be the setup of a holistic experiment performed in RAWFIE platform.

## 3.8 QoEST4CM: QoE SupporT for improved Crisis Management

Until now, as a part of the project, an independent laboratory device for mapping the network coverage has been developed. The device is based on the Rapsberry Pi module. Thanks to the small dimensions of this device, it can be attached to different means of transport including UAVs. In addition, the algorithm of processing collected data into regular grid (with specific sizes) was developed and implemented in Python language.

In the field of video streaming, the functionalities of controlling and sending video produced by Raspberry Pi dedicated camera were implemented and tested. Currently the algorithm of processing collected data on network coverage into video parameters is in the development stage.

The work on offline video analysis software is close to completion. The software is implemented in JAVA and can be running on Windows and Linux-based systems (Ubuntu 16.04 was tested).

For the testing and demonstrating purposes, a software for simulating network conditions was developed. The software allows changing network interface parameters using logged data on network conditions.

## 3.9 UTMEXP: UAS Traffic Management Experiments

The Initial Proof-of-Concept has been largely achieved during the first 6 months of the UTMEXP project. The final integration task is now in progress. The only change in initial estimated requirements has been the reduced dependency on specific hardware. This has opened more opportunities for relevant experimentation.

Several issues were identified with the QS-FLT-DEV platform. None are blocks to progress but resolving them has consumed more effort than expected, even though overall effort is less than planned. Several risks remain under review. One new one has been added.

The UTMEXP project is running within planned time and cost. The available effort will be used during the remainder of the project.

The UTMEXP Workplan envisaged the following activities below to establish an initial proof-of-concept:

- T2.1 Software development and integration (M1-M4): The project will do the initial development of software to make the information generated by the QS-FLT-DEV sub-system available using AVRO and exchanged via Kafka to be collected at monitoring points in the RAWFIE platform. The QS-FLT-DEV sub-system will be integrated with the Raspberry Pi at the applicant’s laboratory. Advice will be needed from the VENAC supplier on the best way to do this.
- T2.2 Hardware integration (M4-M5): The project will work with the VENAC supplier to achieve mechanical and electrical integration of the modified UAV platform.
- T2.3 Ground test (M6): The integrated system will be tested under laboratory conditions to verify intended functionality.

- T2.4 Use-case #1 - initial PoC (M6): The integrated system will be tested in the field to provide a validation of the intended functionality in the UAV and the RAWFIE platform.

### 3.10 PARROT: Public Safety ExpeRimentation in RAWFIE Mobile IOT platform

PARROT - Public SAfety ExpeRimentation in RAWFIE Mobile IOT platform, aims at demonstrating a set of communications solutions customized for public safety scenarios, where the public communications infrastructure cannot be (fully or not at all) used to serve a remote area of interest. PARROT proposes two radio access solutions for establishing a private communications facility. During the first prototype stage, a lab-based setup for both solutions has been prepared and tested. They have been introduced to the platform, and in particular the various UxV node types and the supporting software infrastructure for controlling and performing an experimentation activity. A set of basic applications for producing and consuming information to and from the RAWFIE broker has been developed. The concepts of schemas and AVRO serialization have been also investigated. These are the basic building blocks for realizing advanced experiments during the full demonstration stage. Also a generic UDP-to-Kafka packet forwarding application has been developed for interconnecting either a Kafka Consumer or a Kafka Producer with the radio modem. The particular bridging application was successfully tested in lab-based conditions. We have to point out that other approaches will be also investigated in the way forward, taking into account the challenges that will arise while moving from lab to the field.

# 4 References

# 5 Annex