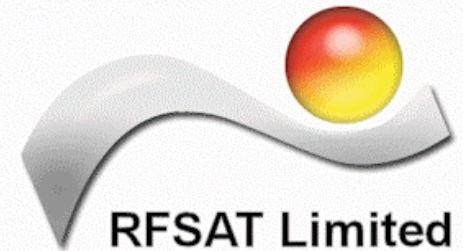


# *Research for Science, Art & Technology (RFSAT) Limited*



<https://www.rfsat.com>



Main  
offices



R&D  
offices



# Research for Science, Art and Technology (RFSAT) Limited

Research-active not-profit SME established in Ireland and R&D offices in Greece

## Departments and Activities:

- **"Future Technologies"** department, active in:
  - 3D Mixed-Reality Synthetic Environments and Immersive User Interfaces
  - Applied Digital Signal Processing (DSP) for Future 5G Mobile Communications
  - Micro-embedded devices for power autonomous communication, sensing and control
  - Management and surveillance technologies for protection of Critical Infrastructures (CI)
  - Health Care (e-Health) technologies including remote physiological and well-being monitoring
  - Cyber Security R&D for Telecommunications, Information Management and Protection
  - Satellite technologies: GNSS/EGNOS/Galileo, Earth Observation (Copernicus etc.)
  - Intelligent transport and new mobility services
- **"Unmanned Systems"** division, pursuing:
  - Advanced sensing and surveillance systems for (semi)autonomous micro-UAV/UAS
  - Aerial surveillance, Search and Rescue, environmental sensing etc.
  - 3D area / object modelling and analysis using autonomous systems
  - Autonomous and swarm operation of unmanned aerial systems (UAS)
- **"Arts and Technology"** department, active in:
  - Art & Culture: support for Cultural Events, Conferences and Workshops
  - Film & Video: Video Editing and Post Productions services
  - Performance Arts: applied New Media on stage for live Performing Arts
  - Arts & Technology: transfer of latest ICT & immersive reality for Arts, Cultural Heritage etc.



# EU Funded Research Projects (ongoing)

## H2020-EU.3.5.6 AgriBIT (#101004259) – RIA

*Title:* Artificial intelligence applied to precision farming by use of GNSS & integrated technologies

*Sub-programme:* [SU-SPACE-EGNSS-3-2019-2020](#)

EGNSS applications fostering societal resilience and protecting the environment

*Start/end dates:* 1<sup>st</sup> July 2021 to 30<sup>th</sup> June 2024 (36 months)

*Participation:* Partner/Beneficiary

- Technical and Innovation Management
- Technology developer:
  - Mixed-reality and 3D scanning/modelling
  - Environmental monitoring
  - Immersive User Interfacing
  - Artificial Intelligence and Machine Learning
  - Autonomous swarms of aerial drones
  - Development of custom GNSS receiver & augmentation services
  - Development of air and soil pollutions/condition sensing and monitoring
  - Development of innovative Copernicus-based services for Smart Agriculture



# EU Funded Research Projects (ongoing)



## **COST Action (ICT)**

### **PROCLIAS ([CA-19139](#))**

*Title:*

*Process-based models for climate impact attribution across sectors*

*Start/end dates:*

27<sup>th</sup> October 2020 to 26<sup>th</sup> October 2024 (48 months)

*Participation :*

Management Committee (MC) for Ireland



## **COST Action (ICT)**

### **GoodBrother ([CA-19121](#))**

*Title:*

*Network on Privacy-Aware Audio- and Video-Based Applications for Active and Assisted Living*

*Start/end dates:*

24<sup>th</sup> April 2020 - 23<sup>rd</sup> April 2024 (48 months)

*Participation :*

Management Committee (MC) Substitute for Ireland



## **COST Action (ICT)**

### **TOC ([CA-21102](#))**

*Title:*

*Toolkit of Care*

*Start/end dates:*

31<sup>st</sup> October 2022 – 3<sup>rd</sup> October 2026 (48 months)

*Participation :*

Management Committee (MC) member for Ireland



## **COST Action (ICT)**

### **CLEANFOREST ([CA-21138](#))**

*Title:*

*Joint effects of Climate Extremes and Atmospheric Deposition on European FORESTS*

*Start/end dates:*

27<sup>th</sup> October 2022 – 27<sup>th</sup> October 2026 (48 months)

*Participation :*

Management Committee (MC) member for Ireland



## **COST Action (ICT)**

### **FruitCREWS ([CA-21142](#))**

*Title:*

*Fruit tree Crop Responses to Water deficit and Decision Support Systems Applications*

*Start/end dates:*

17<sup>th</sup> October 2022 – 26<sup>th</sup> October 2026 (48 months)

*Participation :*

Management Committee (MC) member for Ireland



# EU Funded Research Projects (completed)



ARCH



Scan4Reco



sheldon  
smart habitat  
for the elderly



Arkwork  
cost-action - CA15201



REACHING OUT

## H2020-EU.3.5.6

Title:

Sub-programme:

Start/end dates:

Participation:

[ARCH \(#820999\)](#) – RIA

*Advancing Resilience of Historic Areas against Climate-related and other Hazards*

[H2020-EU.3.5.6](#) - Cultural heritage

1<sup>st</sup> June 2019 to 31<sup>st</sup> May 2022 (36 months)

Partner (mixed-reality and 3D scanning/modelling, environmental monitoring & immersive U/I)

## H2020-Reflective-7

Title:

Sub-programme:

Start/end dates:

Participation:

[Scan4Reco \(#621037\)](#) – RIA (completed)

*Multimodal Scanning of Cultural Heritage Assets for their multi-layered digitization and preventive conservation via spatiotemporal 4D Reconstruction and 3D Printing*

[REFLECTIVE-7-2014](#) - Advanced 3D modelling for accessing & understanding EU culture

1<sup>st</sup> October 2015 to 31<sup>st</sup> September 2018 (36 months)

Partner (3D mixed-reality systems, 3D multi-source modelling/printing & immersive U/I)

## COST Action

Title:

Start/end dates:

Participation :

[SHELD-ON \(CA-16226\)](#)

*Indoor living space improvement: Smart Habitat for the Elderly*

24<sup>th</sup> October 2017 - 23<sup>rd</sup> December 2021 (50 months)

Management Committee (MC) Substitute for the United Kingdom

## COST Action (ICT)

Title:

Start/end dates:

Participation :

[ArkWork \(CA-15201\)](#)

*Archaeological practices and knowledge work in the digital environment*

6<sup>th</sup> October 2016 - 5<sup>th</sup> December 2020 (50 months)

Management Committee (MC) Substitute for the United Kingdom

## H2020-SEC-2015

Title:

Sub-program:

Start/end dates:

Participation:

[Reaching-Out \(#700151\)](#) – IA (finished)

*REACHING OUT Supplier Platform*

[DRS-03](#): Comprehensive Approach Framework for experimentation & exercises in Crisis Mgt.

1<sup>st</sup> October 2016 to 30<sup>th</sup> November 2019 (38 months)

Partner (autonomous UAS surveillance, 3D area/object scanning/analysis, aerial relief drops) 6



# EU Funded Research Projects (completed)

## FP7-SEC-2013

*Title:*  
*Sub-programme:*  
*Start/end dates:*  
*Participation:*

## [AF3](#) (#607276) – IP project (completed)

*Title:* *Advanced Forest Fire Fighting*  
*Sub-programme:* [SEC-2013.4.1-6](#): Preparedness for and management of large scale forest fires  
*Start/end dates:* 1<sup>st</sup> May 2014 to 30<sup>th</sup> April 2017 (36 months)  
*Participation:* Subcontractor (UAV-based 3D sensing, 3D modelling of natural locations and forest fires)



## FP7-SEC-2013

*Title:*  
*Sub-programme:*  
*Start/end dates:*  
*Participation:*

## [StrokeBack](#) (#288692) – IP project (completed)

*Title:* *Telemedicine System Empowering Stroke Patients to Fight Back*  
*Sub-programme:* ICT-2011.5.1 "Personal Health Systems"  
*Start/end dates:* 1<sup>st</sup> October 2011 to 31<sup>st</sup> December 2014 (36 months)  
*Participation:* Subcontractor (UAV-based 3D sensing, 3D modelling of natural locations and forest fires)



## COST Action (ICT)

*Title:*  
*Start/end dates:*  
*Participation :*

## [HDRi](#) ([IC-1005](#))

*Title:* *The digital capture, storage, transmission and display of real-world lighting*  
*Start/end dates:* 2<sup>nd</sup> December 2010 to 1<sup>st</sup> December 2014 (48 months)  
*Participation :* Management Committee (MC) Substitute for the United Kingdom



## Summary:

- 6 Funded projects (FP7/H2020/HE) as full partner
- 1 Funded project as subcontractor
- 8 COST Actions as full Management Committee (MC) member
- 1 Erasmus+ project (serious gaming)
- 13 Projects as Expert and/or SME Stakeholder

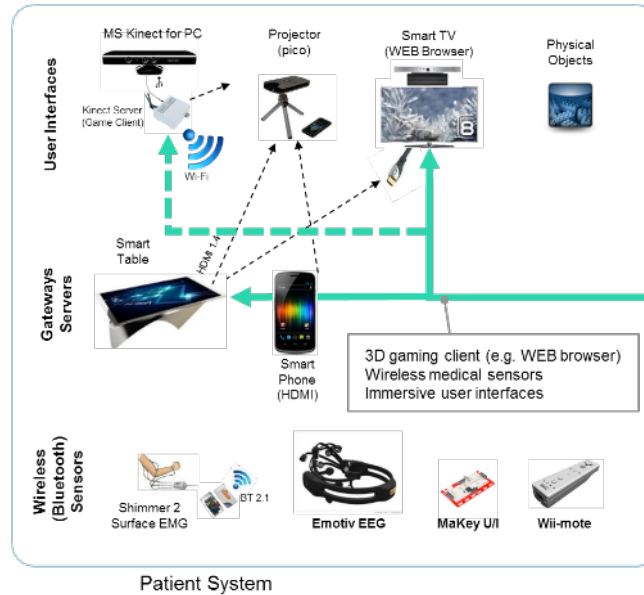
# e-Health game-based therapy (FP7-StrokeBack)



<http://www.strokeback.eu>

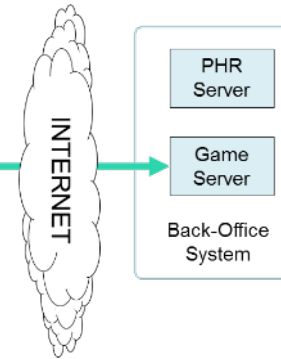
## Aims and Objectives:

- Remote (home) patient rehabilitation
- Game targets as incentive for rehabilitation
- Seamless remote monitoring by physicians
- Low-cost of home/clinician systems
- Lower costs on Public Health Care



## FP7-ICT-2011 StrokeBack (RIA)

Start/end dates: 2011-2014



## Kinect Server (RFSAT)

- Network access to 3D immersive U/I
- Supports any device via WEB browser



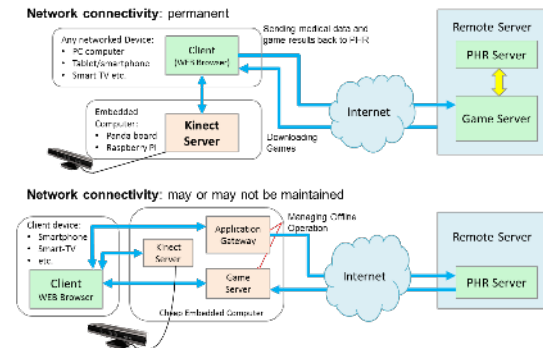
Playing with virtual objects



Avatar-based exercise [Online](#)



Real rehabilitation exercise





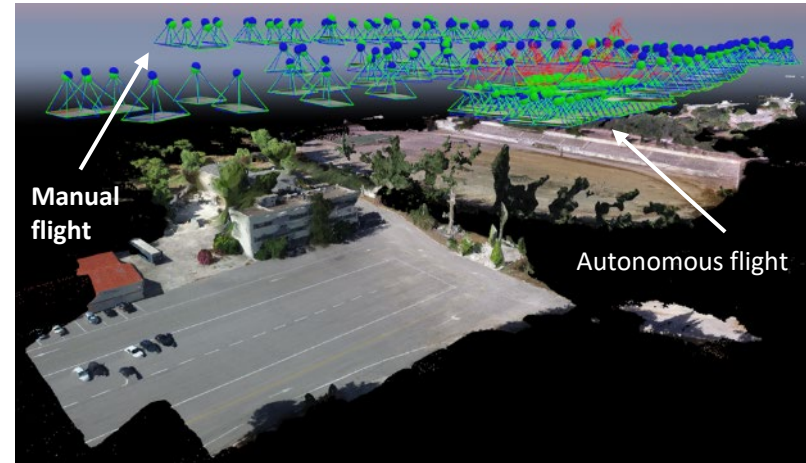
# 3D Surveillance for Crisis Management (FP7-AF3)



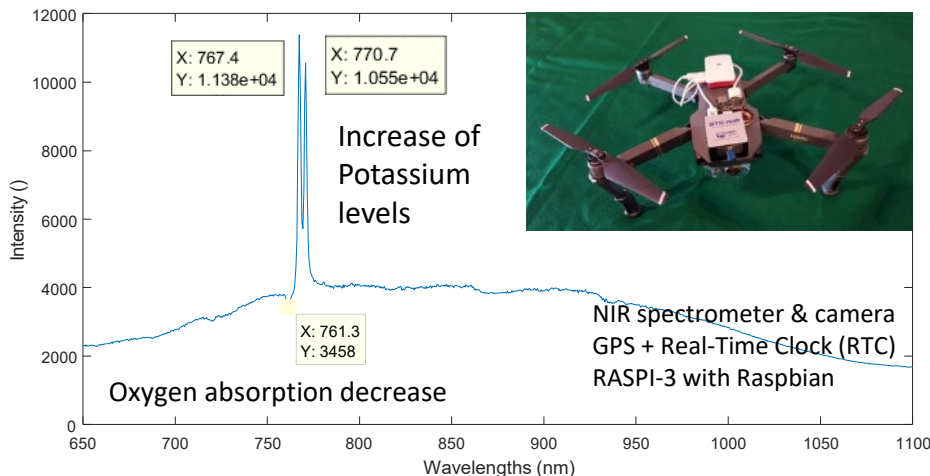
<http://af3project.eu>

Autonomous UAV-based aerial surveillance, fire detection and 3D area modelling system has been developed and successfully tested in the first trials in Scaramanga (Athens):

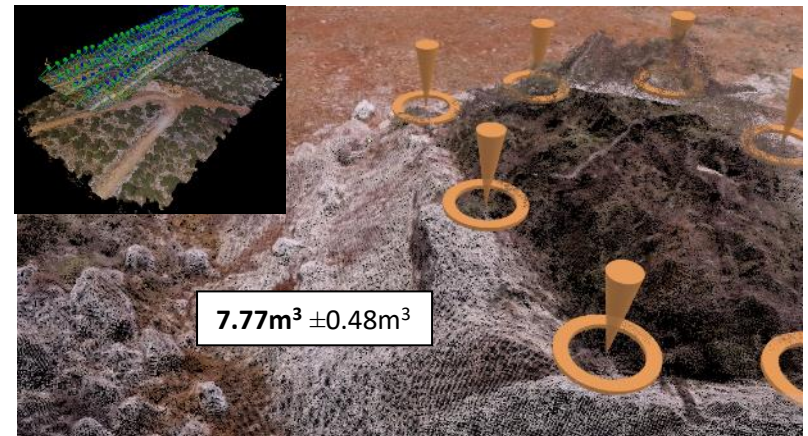
1. Embedded (RASPI) with STS-NIR spectrometer, detecting changes in atmospheric oxygen absorption & ionised potassium over biomass (forest) fires. **Future work** will use UP embedded Win10-based board.
2. Autonomous UAV surveillance, 3D modelling and volumetric estimation of e.g. biomass (fuel)  
**Future work:** add FLIR camera to UAV



Complete 3D model (300 x 200 meters) for area #1



Analysis of real-time data from the NUR spectrometer



3D volume analysis of aerial targets in area #5 (195 x 40 meters)  
NOTE: real weight of biomass needs to consider wood density



# Cultural Heritage Protection (H2020-Scan4Reco)

- Sub-millimetre 3D scanning and modelling of Cultural Heritage objects using photogrammetric techniques
- Dealing with point clouds exceeding 100 million converging to 3D models with more than 10 million faces
- Potential for achieving model accuracy better than 57 micrometres with 50MP Canon EOS 5D camera
- Simulated ageing of CH using model deformation based on rules derived from real accelerated ageing



Sub-millimetre 3D scans  
e.g. paintings (test object)



Geometrical defects: holes (L) and scratches (R)

Geometrical defects  
(Byzantium icon)



3D Geometry  
for small/large objects  
(Italian sculptures)

- Research: taking advantage of depth data associated with raster images for reduction of borderline effects to negligible levels, increase of model precision and lower model complexity
- Research: accommodate penetrating imaging including thermal, ultrasonic, X-ray and Raman.
- Development: development of custom CUDA-accelerated (dual VIDIA Titan X with 3584 CUDA cores each), featuring reduction of 3D modelling times at least quad-fold.
- Target accuracy: better than 57 micrometres with 50MP Canon camera, down to 25 micrometres when using 100MP camera from Phase ONE.

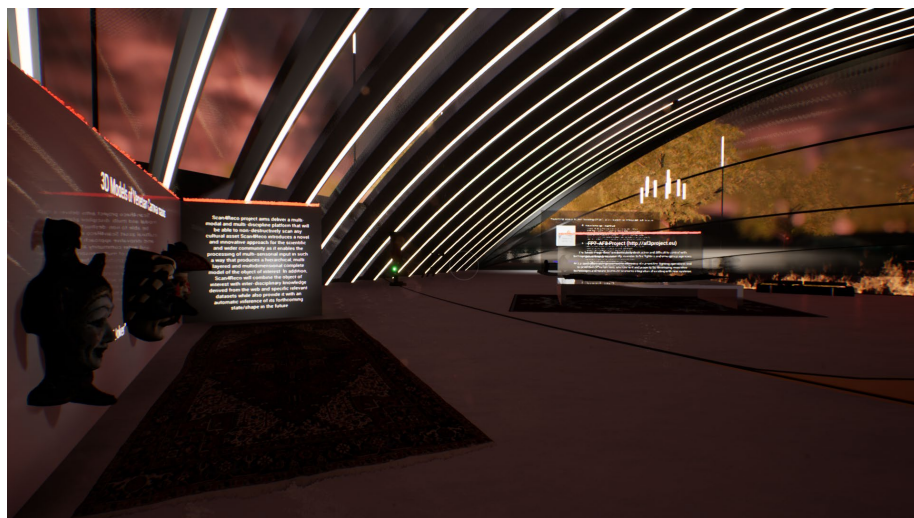
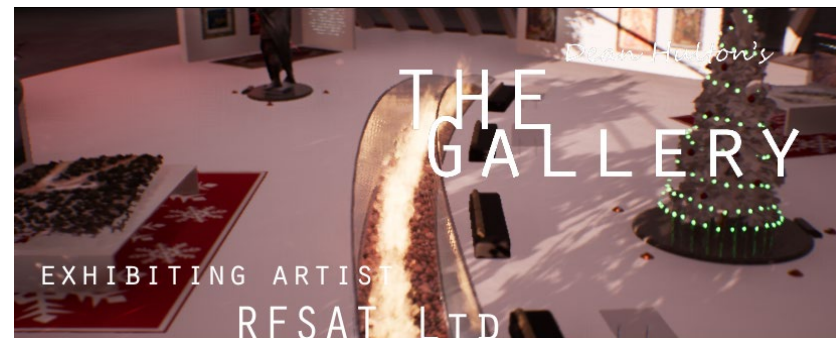


<http://scan4reco.eu>



# Gaming Environments (H2020-Scan4Reco)

**3D Gallery** software, developed with Unreal Engine version 4+, demonstrates 3D modelling technologies from EU funded research projects of RFSAT



Standard version



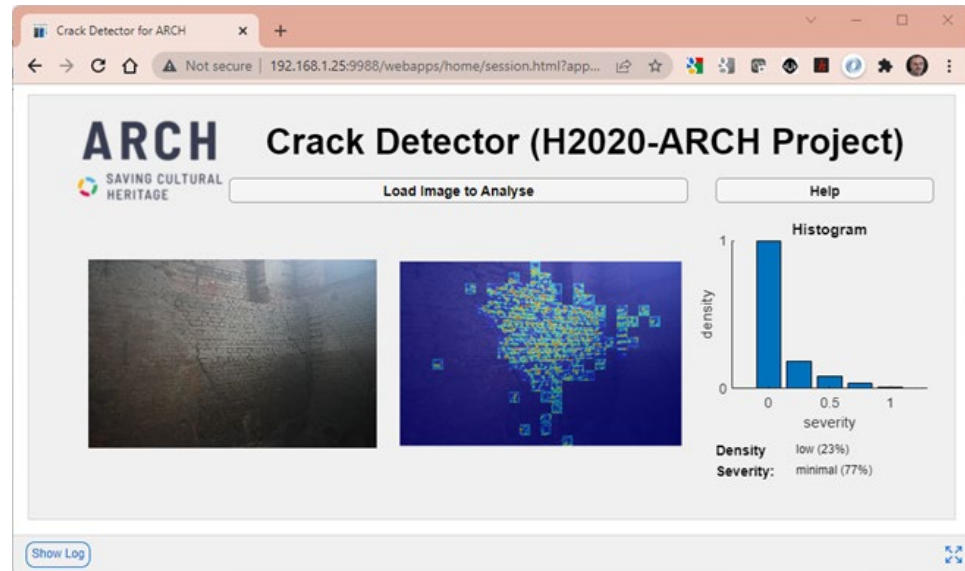
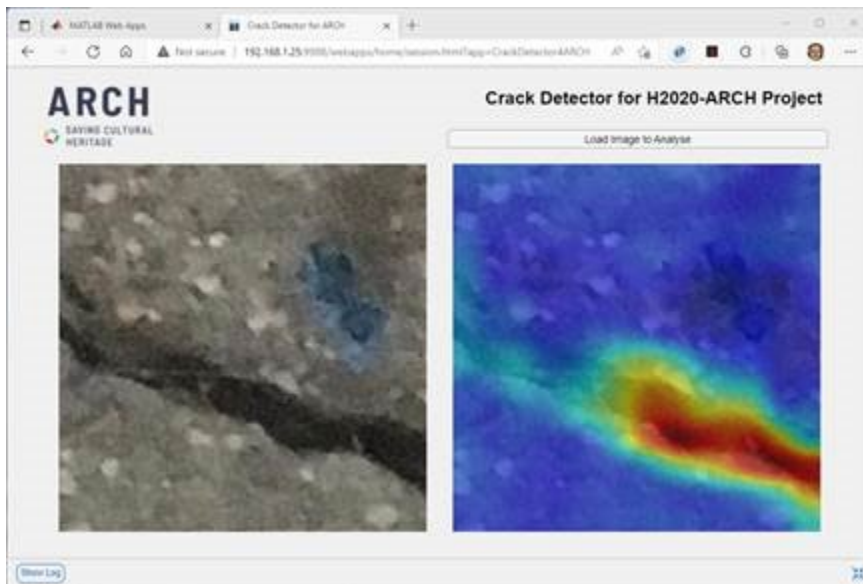
Christmas Edition



# Machine Learning & Artificial Intelligence for Detection of physical degradations (H2020-ARCH)

RFSAT conducts applied research and development work in the H2020-ARCH project on Artificial Intelligence applications combined with Machine Learning, using 3D models derived via 3D photogrammetry from 2D raster images captured by drones for detection of physical deteriorations of tangible Cultural Heritage objects, e.g. cracks in cliffs (Bratislava), objects (Camerino/Valencia), other (underwater issues with pillars in Hamburg). This combines Machine learning, showing below results for concrete and brick wall in Hamburg canals.

 ARCH





# Environmental Sensing in Smart Cities (H2020-ARCH)



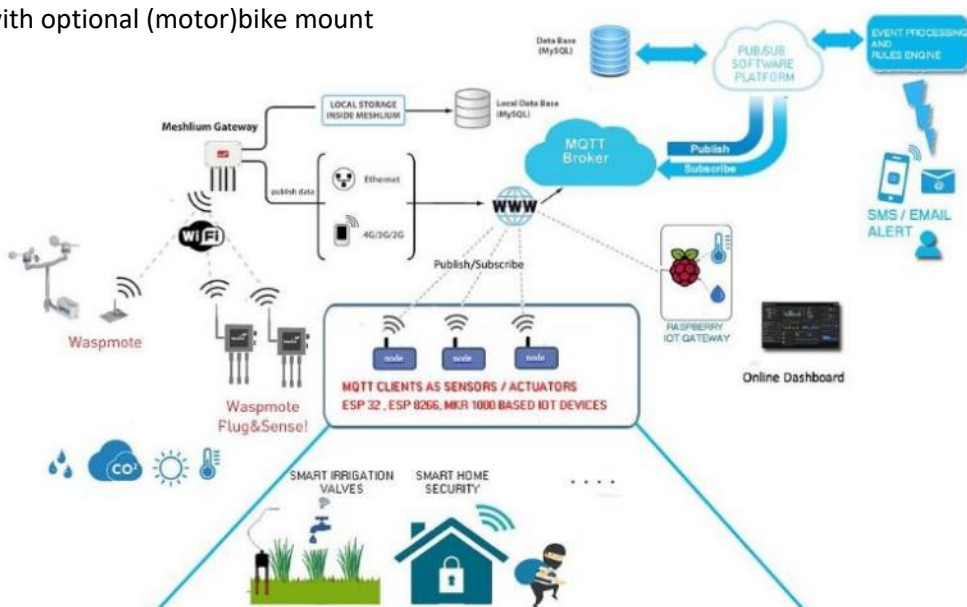
Libelium P&S Environmental With Meshlium IoT server



Screenshots from mobile (left) and WEB (right) applications

Station: Meteo_Station		
Sensor	Value	Time
Anemometer	0.00 km/h	20-07-2018 05:48:53+02:00
Battery Level	93.00 %	20-07-2018 05:48:51+02:00
Battery Voltage	4.12 Volts	20-07-2018 05:48:51+02:00
Pluviometer (last 24h)	0.00 mm/day	20-07-2018 05:48:53+02:00
Pressure	107.22 KPascals	20-07-2018 05:48:50+02:00
Wind Vane	8 Direction	20-07-2018 05:48:52+02:00

RFSAT environmental IoT sensor based on RASPI-Zero with optional (motor)bike mount



- Focuses on remote environmental monitoring
- Uses Libelium Meshlium Server as core platform
- Offers diverse range of IoT sensing & control devices
- Integrates with Home Automation System
- Can employ autonomous S&C devices (UAV/UAS)
- Support 3D monitoring, modelling & AI prediction
- Offers AR/VR visualisation & ambient U/I

### Extendable to:

- Crowd activity monitoring (anonymous) in events
- Smart parking services for Smart Cities
- Car/bicycle pulling for Smart Cities

# AD-based MVP sensor node (H2020-ARCH)

## Generic MVP for Cloud Applications

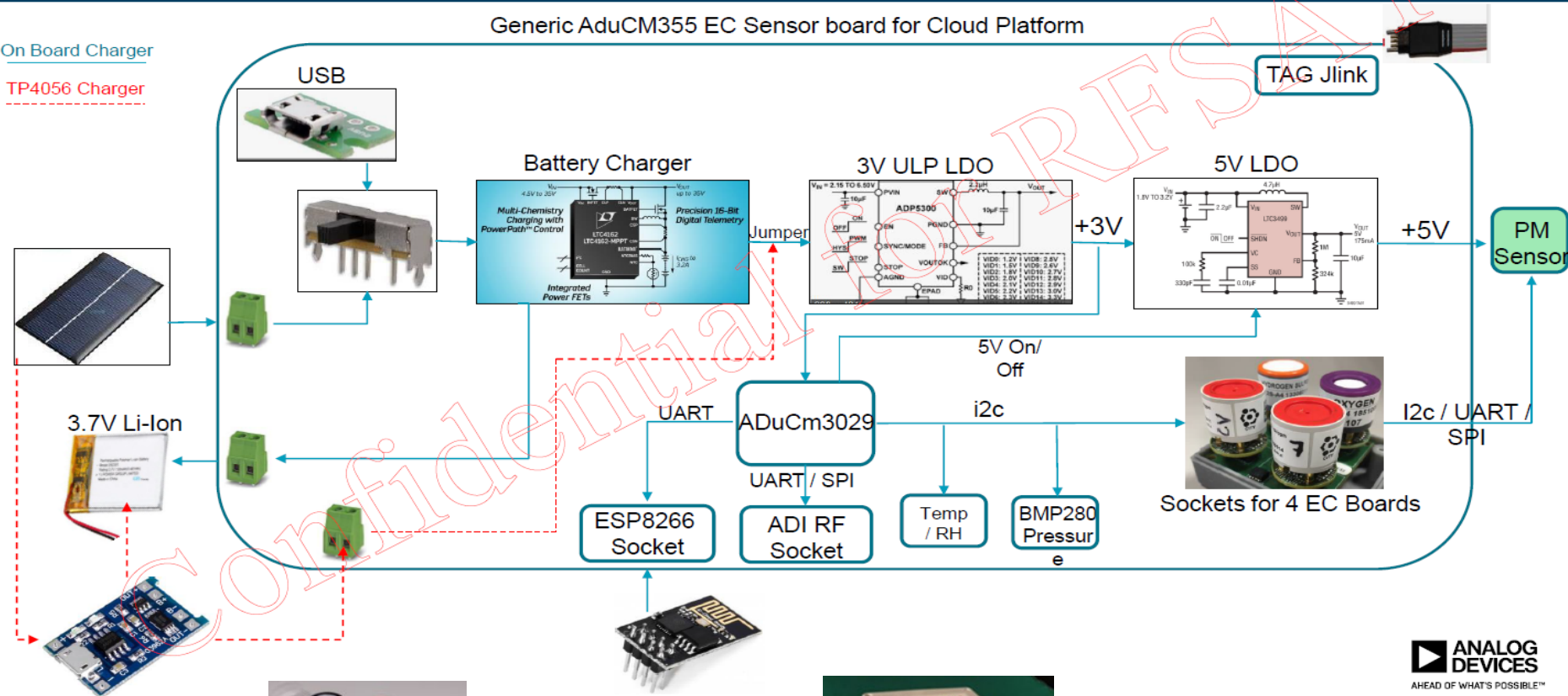
Fast System Solution for Sensor → Cloud applications

Discussing building custom MVP sensor(s) for Camerino

On Board Charger

TP4056 Charger

Generic AduCM355 EC Sensor board for Cloud Platform



AD-MVP Board (electronics + sensors)



Integrated ARCH "Sense-7" sensor node



# Urban Smart Mobility & Dynamic ITS

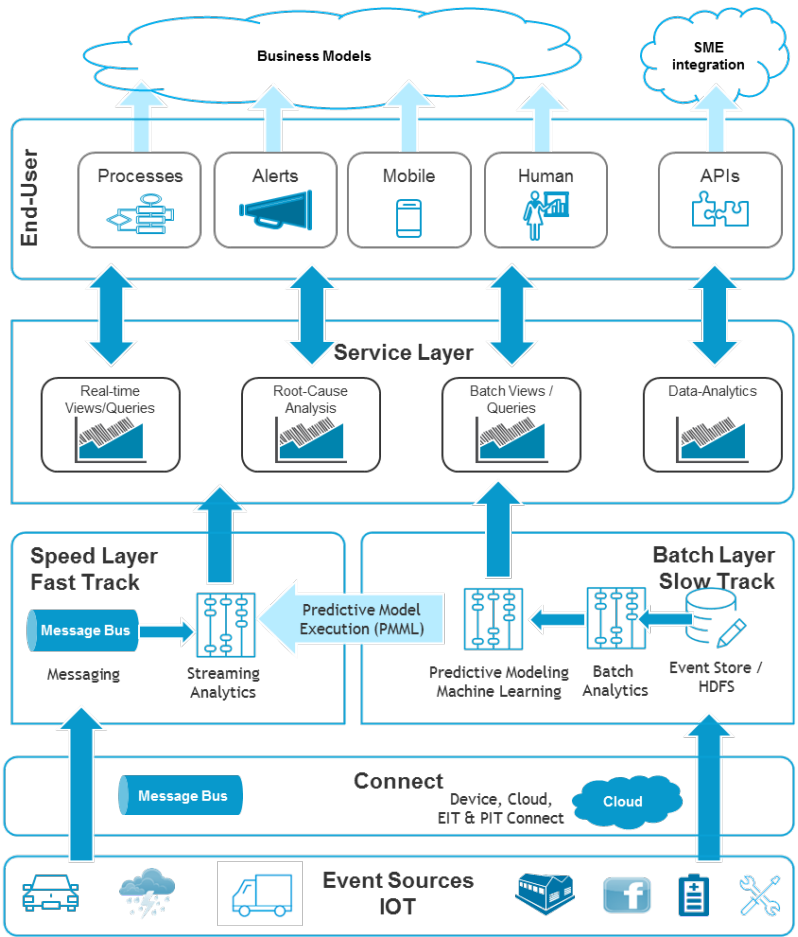
## Predictive Disruption Management in Multimodal Transportation

### Key aspects in disruption management:

- Demand: sensing, modelling and prediction
- Supply: planning, provisioning, adaptation, optimisation
- Interoperability: integrating all models of urban transport
- Traveller mobility management

### Additional functionalities include, but are not limited to:

- cyber-physical monitoring of transport control systems, transport infrastructures and service end-points
- Prevention and recovery from cascading effects from incidents among interconnected critical infrastructures
- Real-time assessment of system resilience for predictive reduction of risks to service availability and continuity





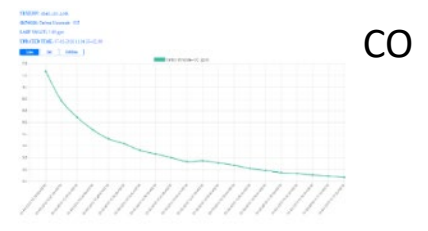


# Air Quality Monitoring Platform and Services

- Stationary sensing of > 6 air quality parameters/node
- Supports autonomous aerial sensing incl. CBRN & SAR
- Offers AR/VR visualisation & ambient U/I controls (FPV)
- Cloud platform + WEB services + mobile applications

## Dashboard

Station: smart_env_node					
Sensor	Value	Time			
Carbon Monoxide - CO	2.66 ppm	07-02-2018 11:14:30+02:00			
Dust sensor (PM1)	3.83 µg/m3	07-02-2018 11:15:16+02:00			
Dust sensor (PM10)	19.21 µg/m3	07-02-2018 11:15:16+02:00			
Dust sensor (PM2_5)	5.00 µg/m3	07-02-2018 11:15:16+02:00			
Humidity	27.5 %RH	07-02-2018 11:15:28+02:00			
Internal temperature	23.51 °C	07-02-2018 11:15:28+02:00			
Sulfur Dioxide - SO2	0.48 ppm	07-02-2018 11:14:30+02:00			
Nitrogen Dioxide - NO2	0.00 ppm	07-02-2018 11:14:42+02:00			
Ozone - O3	0.00 ppm	07-02-2018 11:14:30+02:00			
Pressure	100412.88 Pa	07-02-2018 11:15:28+02:00			



Example graphs

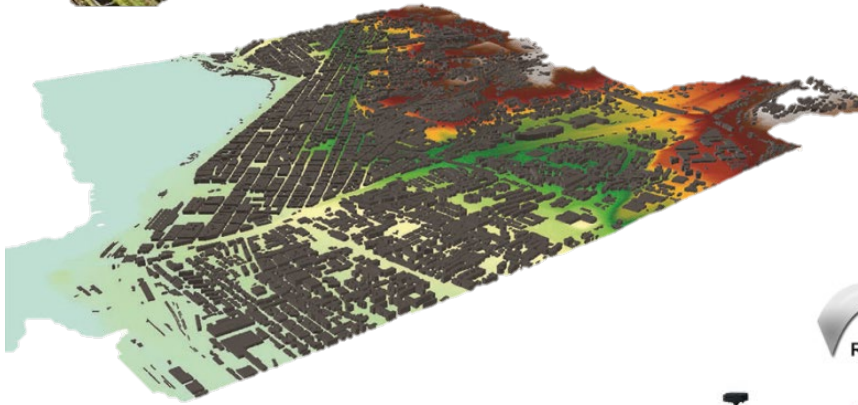


# 3D DEM from satellite and UAV

DJI Inspire 1 + X3 camera (HD) altitude 30 meters on regular grid  
8-core 2.8GHz Intel i7 32GB + dual NVidia GeForce GTX 1080 (CUDA)



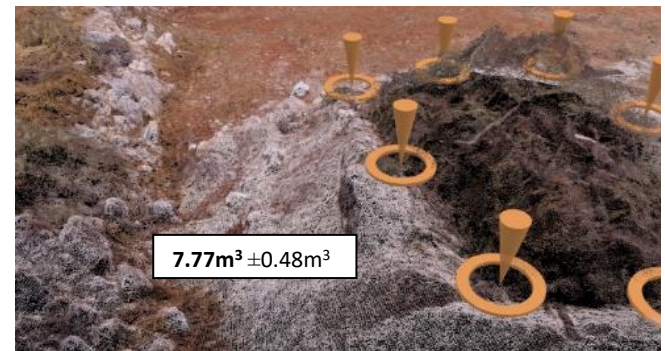
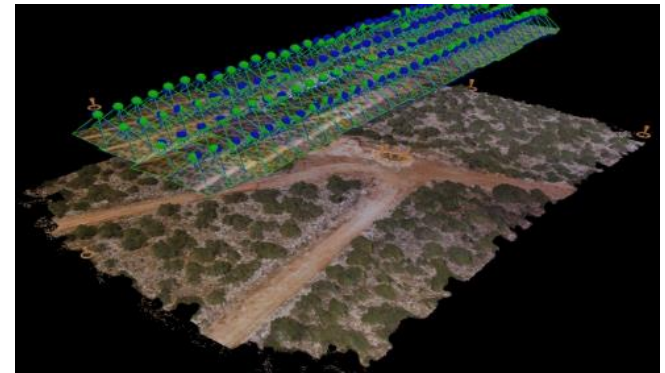
Area 100 x 30 meters



Resolution: 1-2m  
Pay Data (e.g., WV3-4, Pleiades)



DJI Mavic Pro with near-IR spectrometer



7.77m<sup>3</sup> ± 0.48m<sup>3</sup>

Resolution: 2cm





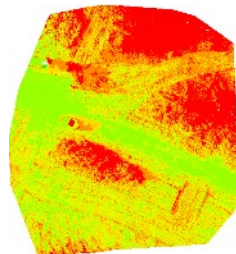
# Multispectral 3D Imaging from Aerial Drones

Combining models from multi-spectral images using multispectral Parrot Sequoia camera

- 3D geometry from multispectral scans with Parrot Sequoia camera
- Supported frequency ranges (synchronised):
  - 16 MPIX RGB visual
  - 1.2MPIX Green (550 BP 40)
  - 1.2MPIX Red (660 BP 40)
  - 1.2MPIX Red Edge (735 BP 10)
  - 1.2MPIX Near infrared (790 BP 40)

Sequoia is supported by RFSAT's SWSCAN API (HTTP access)

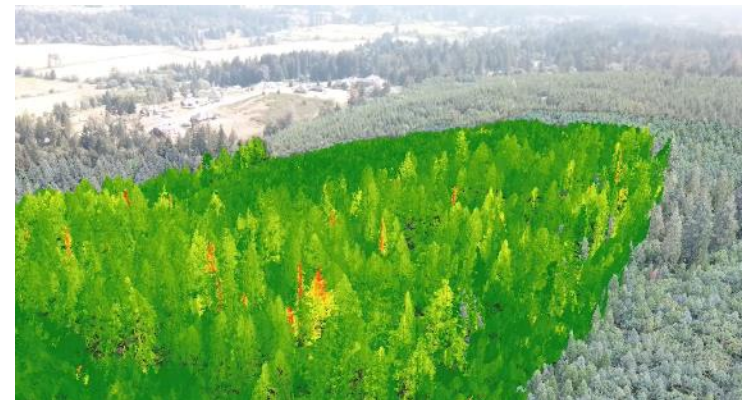
**Example:**  
Vegetation health



DJI Mavic Pro +  
Parrot Sequoia camera

## **Example:**

Normalized Difference Vegetation Index (NDVI)  
Indicator for vegetation health and biomass.  
$$NDVI = \frac{\{NIR - Red\}}{\{NIR + Red\}}$$







# Autonomous Unmanned Vehicle(s)

RFSAT offers autonomous platform(s) for:

- control swarms of autonomously operating UAS / UAV
- be equipped with micro sensors (environmental)
- embed imaging for 3D cultural heritage modelling
- We are now legally (2 pilot licenses) able to operate drones in EU-MCs



Intel Aero + RealSense 435i (discontinued)



DJI Inspire 1/2 + FLIR (thermal imaging) and pollution/climate sensing



Power Dolphin UUV (Underwater Drone)



UgCS-based Ground Control



DJI Mini (250g) Supported by default



DJI Mavic Pro with sensing pollution, NIR spectrometer, etc



DJI Mavic Pro with embedded Parrot Sequoia camera (multispectral)



DJI Robomaster (customisations)

# Autonomous UAS Operations

## Overview

- Autonomous UAS systems protecting areas/structures against rogue drones violating restricted air spaces
- Early detection of intended intrusion, tracking and localisation of the drone operator
- Effective against common commercial civilian micro drones
- Implements both passive and active countermeasures

## Passive Countermeasures

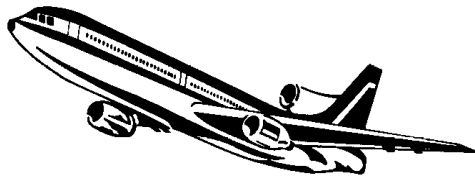
- Detection of wireless remote control signals and/or visual recognition (autonomous UAVs)
- Short-range and/or directional jamming of the communication link to the operator
- Short-range and/or directional jamming and substituting synthetic GNSS signals

## Active Countermeasures

- Seizing control of the rogue drone by hacking into control system
- Physical interception / taking down

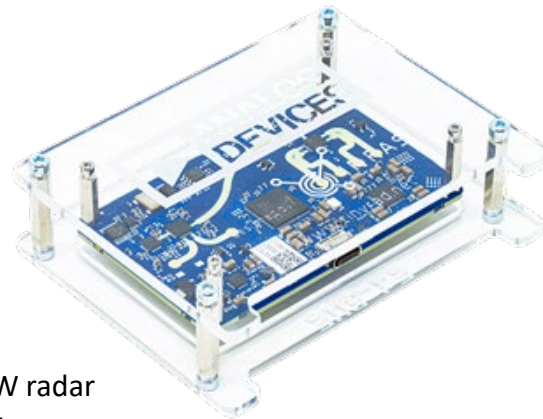
## Ongoing developments

- Coordinated operation of swarm of interception UAVs (remote and autonomous)
- Autonomous mission execution to counter jamming
- Autonomous drop of relief materials at incident sites
- Swarm operation of autonomously collaborating UAS
- 3D scanning and analysis of damages to areas, objects and infrastructures



# Synthetic Aperture Radar (SAR) for 3D city footprint

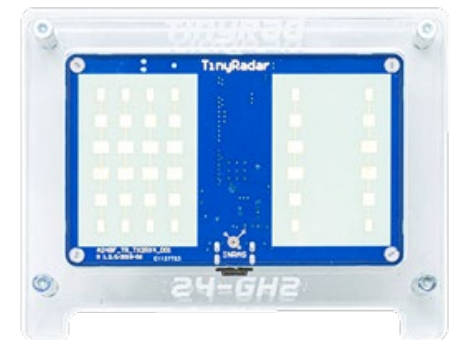
Size: 85x55 mm  
Weight: < 100g



RFSAT currently develops a SAR sensor for wide area surveillance and spatial modelling based on [Tiny RAD from Analog Devices \(ADI\)](#)

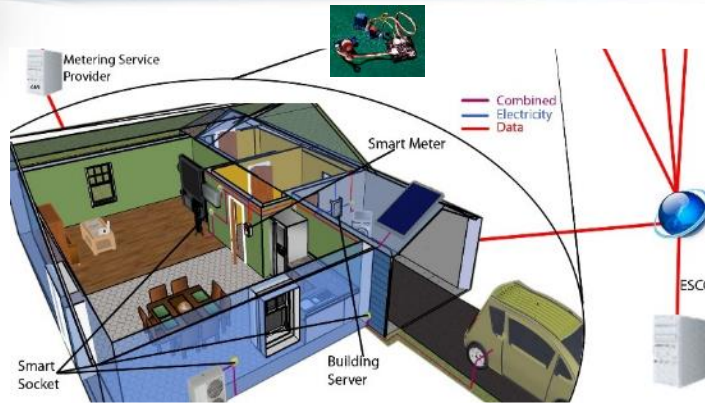
Suitable for deployment on micro-UAV/UAS

- 24 GHz to 24.25 GHz MIMO FMCW radar
- Flexible FMCW measurement timing
- Suitable for target detection and tracking
- Range resolution of 60 cm, range = 100 m (for RCS = 1 m<sup>2</sup>)
- 3 dB beam width = 75° in azimuth and 15° in elevation, azimuth resolution using MIMO angle estimation = 20°
- 1 PCB, 85 mm × 55 mm
- 2 front side transmit antennas
- 4 front side receive antennas
- Reverse side ADF5901 24 GHz transmit monolithic microwave integrated circuit (MMIC)
- Reverse side ADF5904 24 GHz receive MMIC
- Reverse side ADF4159 13 GHz phase-locked loop (PLL)
- Reverse side ADAR7251 16-bit, 4-channel ADC
- Reverse side ADSP-BF706 Blackfin DSP
- Accompanying software controls all functions from a PC
- Externally powered via the USB connection





# Cyber-Physical Protection of Smart Energy Grids



Sensor	Value	Time	ΔC	ΔA
sg Motion Detector	0	01-01-1970 04:05:23+02:00	ΔC	ΔA
sg Motion Detector Counter	10	01-01-1970 04:27:48+02:00	ΔC	ΔA
On/Off state	OFF	01-01-1970 01:00:04+02:00	ΔC	ΔA



**Proprietary Solution**  
(ongoing R&D)

*Focus on Residential Energy infrastructures*  
*Self-installable non-invasive enhancements*  
*Embedded compatibility with Smart Grids*  
*Active cyber-physical protection built-in*

- Residential infrastructure:** Smart Meter, Energy Management System, smart/dummy appliances, sensing & control nodes
- Embedded components:** Replacement of existing plugs/sockets with “smart” enablers, installation of the EMS
- Cyber-physical protection:** Artificial Intelligence based analysis of energy consumption, appliances use versus user activities  
Detection of inconsistencies between data acquired from sensors / appliances and physical events  
Detection of diversions from pre-programmed by user and/or self-sensed usage profiles  
Network isolation of residential energy devices from Internet (EMS the only one linked to Internet)
- Smart-Grid interoperability:** Secure accounting of consumption data, cost policies and billing  
Reverse-verification of data submitted to the Grid, reducing risk of fake data submission to the Grid  
Prevention of reverse-engineering of usage profiles (data obfuscation), e.g. user inside/outside



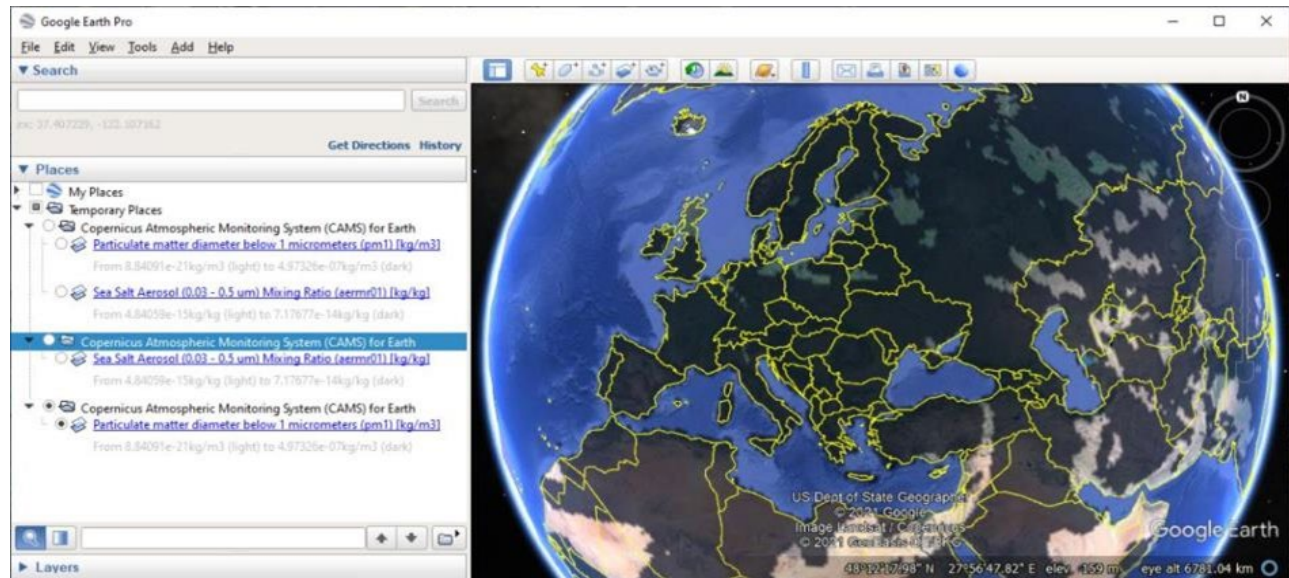
# SatNav/SatCom/EO (Copernicus) AgriBIT project

Within H2020-ARCH and H2020-AgriBIT **RFSAT** develops Earth Observation services built on data from Copernicus CAMS (air quality), C3S (climate) and MARS (historical) repositories incl. distribution and long-term forecasting.

In H2020-AgriBIT **RFSAT** develops also a multi-constellation custom board-level GNSS receiver incorporating a range of augmentation and correction options to achieve accuracies better than 5 millimetres, with at least 95% reliability and availability and competitively priced to end users as compared to currently available commercial products with same performance.



GNSS Receiver rev. 2 (board-level)



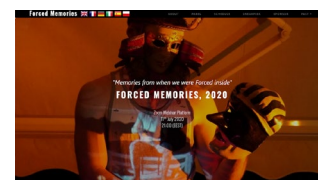
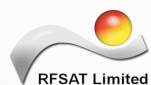
Example global-scale time-lapsed map overlay from CAMS data in Google Earth

# Arts Projects by "Arts & Technology" department

## Virtual Performance Forced Memories "Memories from when we were Forced inside"

Venue/Date/Time: [Zoom Webinar](#) Platform, 11<sup>th</sup> July 2020 at 21:00 (EEST)

Synopsis: contemporary «memory recorder» of a global human; a lonely, locked down universal individual. These memories, created by a team of artists, are merged and interconnected, come to life and die on an electronic platform, in an intangible place to seek communication and create a contact with their untouchable global world, before the arrival of their oblivion.



## Live Performance The Last Human

Venue/Date/Time: [Art Gallery Vryssaki](#) (Athens, Greece), 7-10<sup>th</sup> February 2015 @ 19pm (EEST)

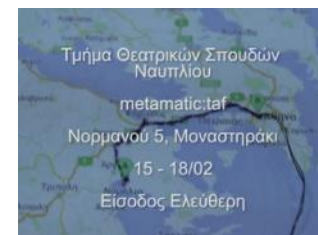
Synopsis: Projects inspired by theatrical plays "The Tempest" by William Shakespeare and "Happy Days" by Samuel Beckett. The loneliness, isolation and wilderness operate allegorically, bringing forward important and timeless social issues that concern some of us and some of us they do not. The "Ultimate" group consists of young artists, third-year and fourth-year students of the Faculty of Fine Arts at the Department of Theatre Studies, of the University of Peloponnese. They reach to you, wishing to share your thoughts, worries and concerns.



## Live Performance "Tempest" by William Shakespeare

Venue/Date/Time: [METAMATIC-TAF](#) (Athens, Greece), 15-18<sup>th</sup> February 2014 @ 12:00-21:00pm

Synopsis: Performance Art project by the Prospero group inspired by William Shakespeare's "Tempest". A group of young artists presents its inventive interpretations by creating a storm full of unexpected experiences adjusted in an unexpected world. The exhibition comprises costumes, installations, short films, video art and performances.

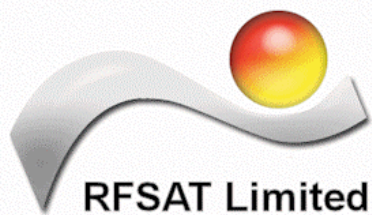




*Thank you for Your attention*



Thank  
You



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