Consortium No.: 0031

Smart@Fire final conference

Smart Personal Protective System

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Agenda

1. The PPS short overview
2. Description of individual parts of smart PPS
3. Smart glove
4. Localization
5. Functions of the PPS
6. November testing in France

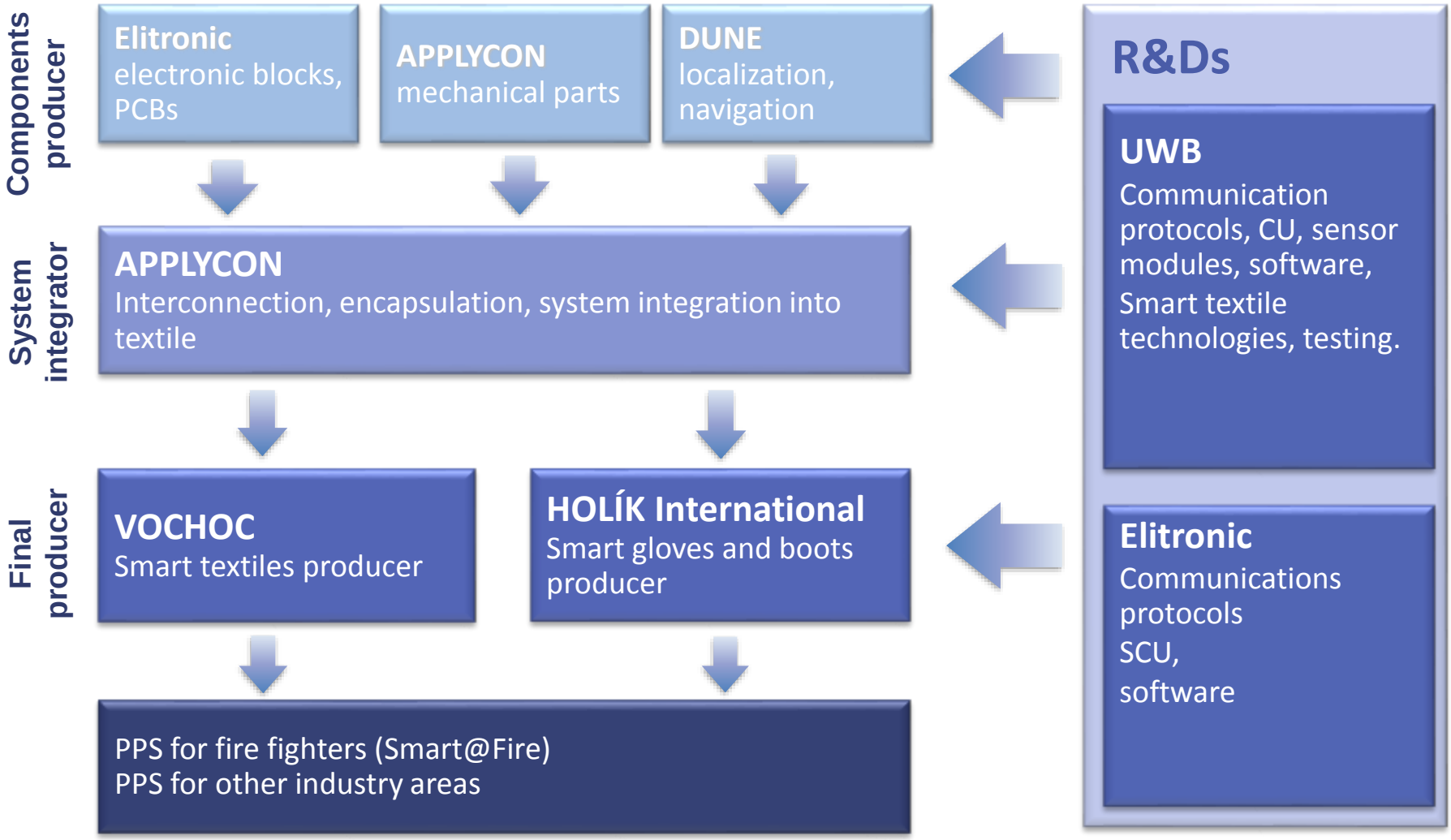
1. The PPS short overview

1.1 The philosophy of PPS

- **The philosophy of the system:**
  - Not double the existing communication system (e.g. radio talkie-walkie).
  - Do not distract a firefighter with many information during interventions.
  - Full information about particular firefighter situation are available to intervention coordinating officer due to the CCU.
  - The PPS can work autonomously in case that the signal between CCU and SCU is lost.

- All electronics are encapsulated.
- The SCU and sensor modules are removable.
- Interconnection system is resisted against automatic washing and connecting points are fixed.
- System is based on building blocks therefore it is easy to replace in case of failure or damage.

1. Consortium overview



1. PPS overview - Main features

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Main features increasing safety

- **Fully integrated active illumination**
- **Toxic and combustible gas monitoring**
- **Indoor localization system** (inertial)
- **Remote measurement of hot spots**

1. Overview of PPS generations

- Our consortium has developed smart protective suit since 2014 in close cooperation with firefighter brigades.
- Consortium members use their experiences with smart textiles (dated back to 2005).

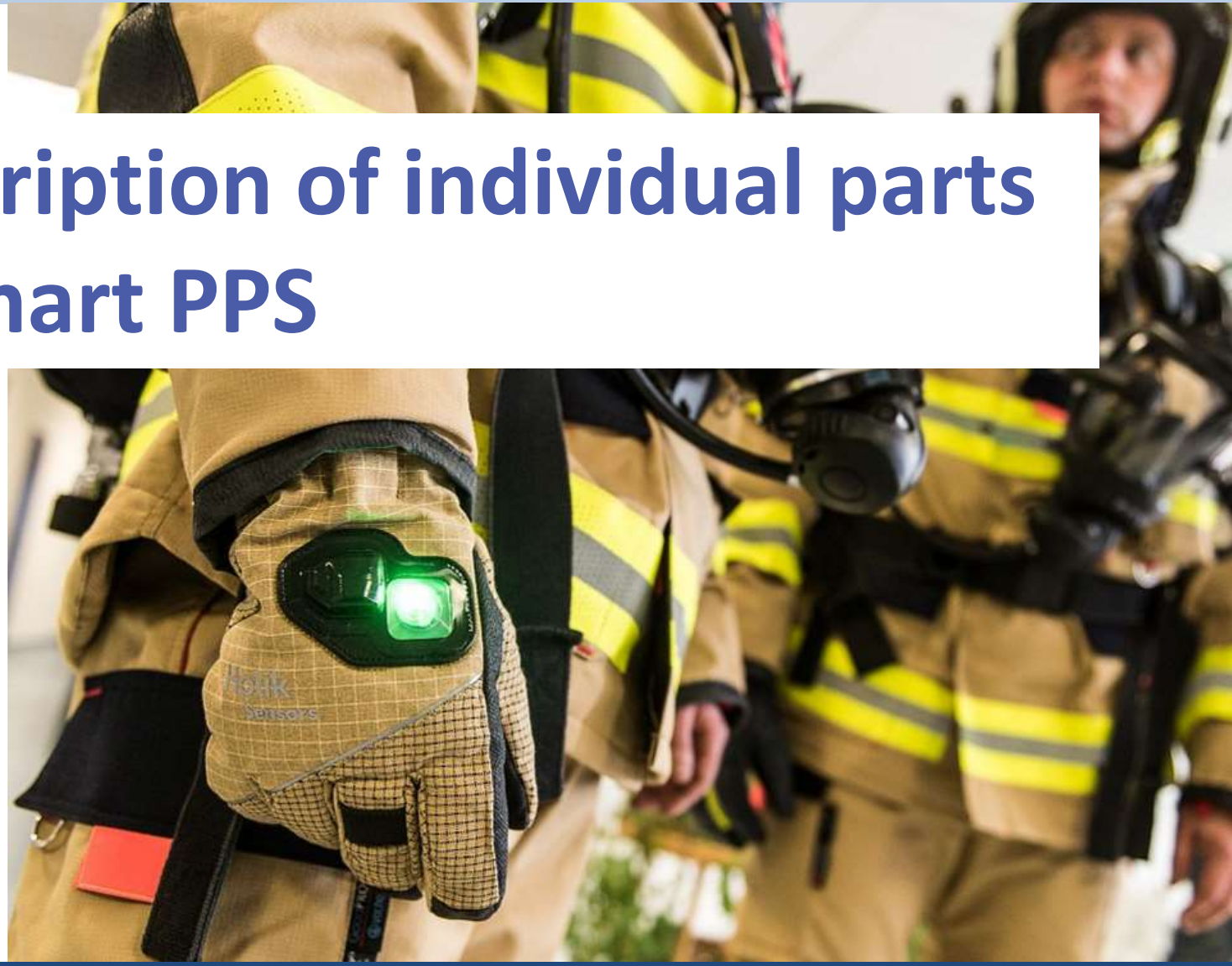
Generations

1. 2. 3.

2014 2015 2016

video

2. Description of individual parts of smart PPS

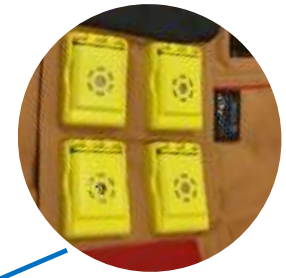


2. The components of the PPS

HR module.

Integrated temperature sensors.

Alarm module.



Sensor modules.

Arriana inertial localization system place on the boot.

Integrated illumination.

Smart glove with integrated thermocouple and IR temperature sensor.

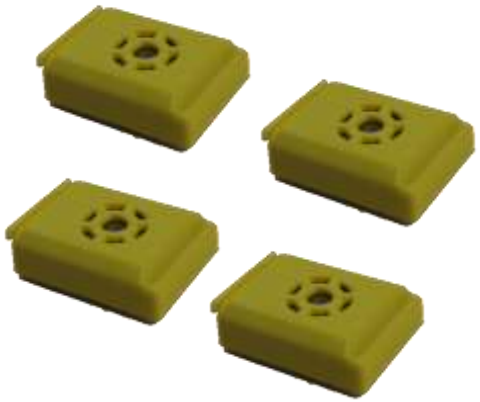
868 MHz

Suit control unit (SCU).

Commander control unit (CCU).

2. Firefighter suit – outer sensor modules

Mounting of outer gas sensor modules



„CLICK“

2.2 Integrated sensors

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Sensor module	Description	Placement	Measurement range	Communica-tion protocol
Thermocouple module	K-type thermocouple	Suit surface (6 different placements)	-50 to 500 °C	1-wire
Humidity and Temperature sensor module	Sensirion SHT15	Outer	-40 to 120 °C, 20 to 99 % RH	RS-485
Humidity and Temperature sensor module	Sensirion SHT15	Inner	0 to 80 °C, 20 to 99 % RH	RS-485
NO_2 module	Electrochemical sensor	Outer	0 to 10 ppm NO_2	RS-485
Combustible gas module	Pellistor Micropel 75	Outer	0 to 100 % LEL	RS-485
CO module	Electrochemical sensor	Outer	0 to 900 ppm	RS-485
HR module	HR belt	Inner	30 to 240 bpm	Bluetooth

2. Firefighter suit

	Smart firefighter suit set
1	Firefighter suit
2	Sensor modules
3	Acoustic alarm module
4	Suit control unit
5	Tool for sensor module demounting

2. Commander control unit (CCU)

	Functions
Commander Control unit (CCU)	Data processing, indoor/outdoor localization data processing, data visualization, data storage, alarm states signalization, data transfer, wireless communication.

The android application intro screen.

2. Charging stations

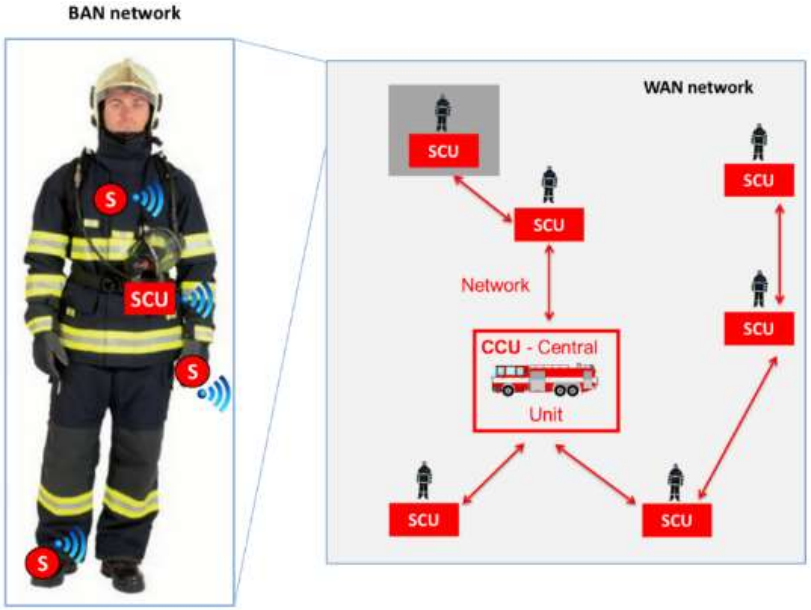
Necessary to charge

- SCU
- CCU
- Smart glove battery
- DLS battery

Charging station for the CCU.

Multi-charging unit for the CCU, DLS and glove batteries.

2. Communication



Wireless communication of the PPS.

Repeater for extension of the communication distance.

- **BAN** network is based on Bluetooth technology version 4 (2,45 GHz).
- **WAN** (868 MHz): the mesh network was developed in order to prolong communication distance.
- Both communication networks are based on point to multipoint architecture.
- To prolong WAN communication distance – use signal repeaters (additional networks notes)

2. The components of the PPS

The CCU for intervention coordinating officer.

Repeaters for WAN.

The set of the PPS for a firefighter.

3. Smart glove

3. Smart glove

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Sensor module	Description	Placement	Measurement range	Communication protocol
Thermocouple module	K-type thermocouple	Glove surface – middle finger	-50 to 500 °C	SPI/Bluetooth
Infrared thermometer	Melexis MLX90614	Glove surface - backhand	-70 to 380 °C remote hot spots measurement	SPI/Bluetooth

- The IR temperature sensor and laser pointer is directly integrated into a protective glove
  - ⇨ for comfortably remote detection of hotspots.
- Thermocouple also integrated in the glove.
- All data sent through Bluetooth to the CCU.
- An evaluation circuit integrated in the glove.
- Rechargeable battery is detachable.
- The glove can work also autonomously.

Smart glove with integrated IR sensor and thermocouple.

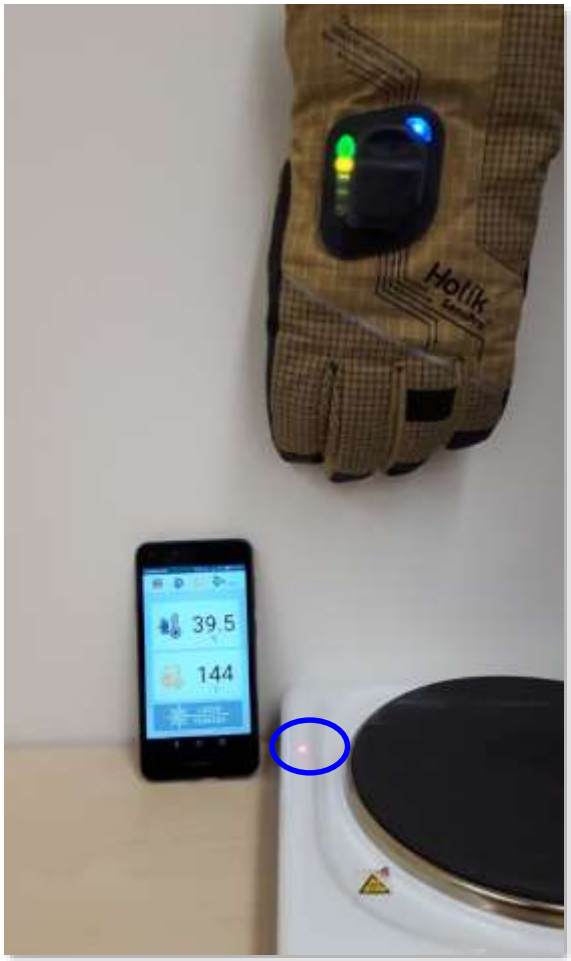
3. Smart glove

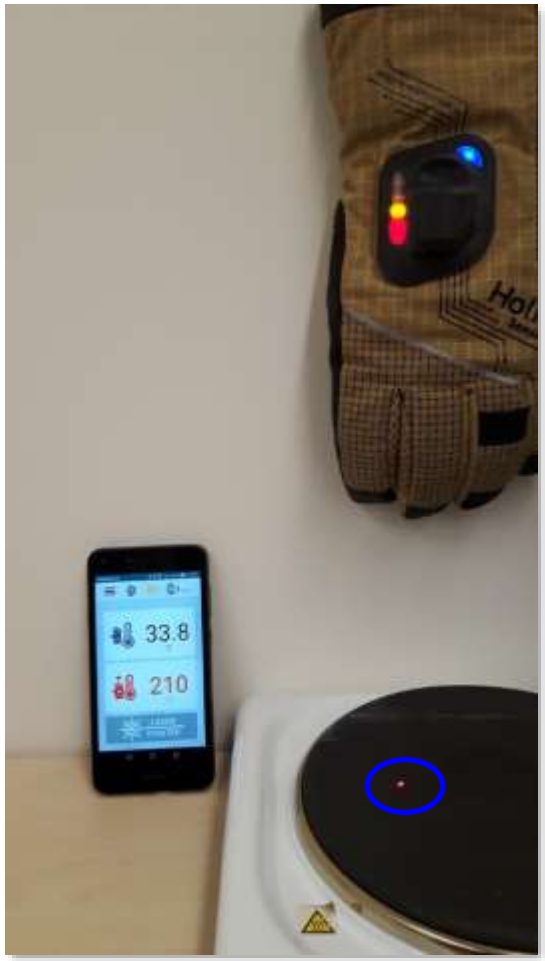
- Temperature visualization – LED bar graph (traffic light).
- User settings of thresholds by mobile phone application.
- Possible to find gradient of temperature.

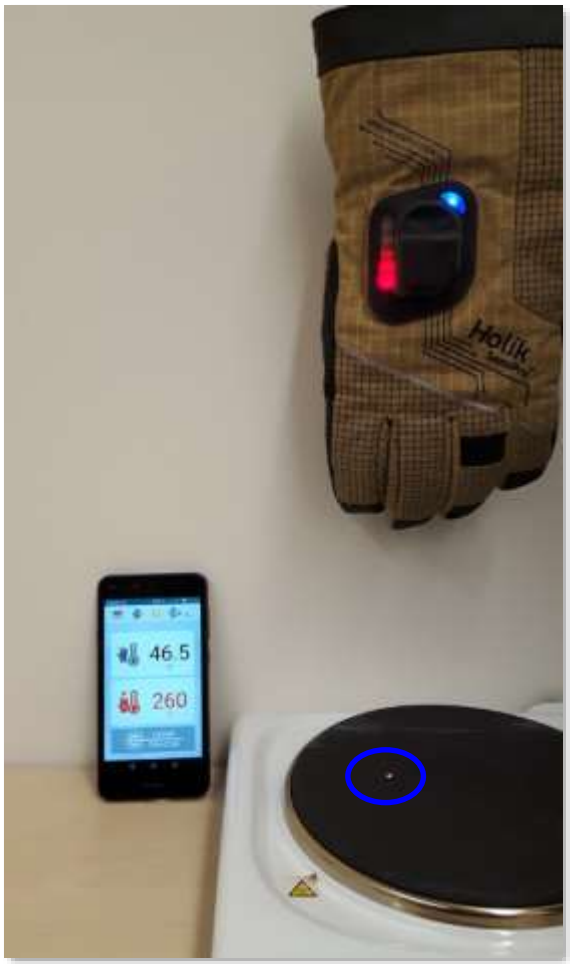
Bar graph	Temperature range	
	Thermocouple	InfraRed sensor
green	<100°C	<100°C
green orange	from 100°C to 125°C	from 100°C to 150°C
orange orange	from 125°C to 150°C	from 150°C to 200°C
orange red	from 150°C to 175°C	from 200°C to 250°C
red red	from 175°C to 200°C	from 250°C to 300°C
red flashing	>200°C	>300°C

The 2nd generation of the smart glove with integrated LED bar graph.

3. Smart glove







Remote measurement by the smart glove.

4. Localization

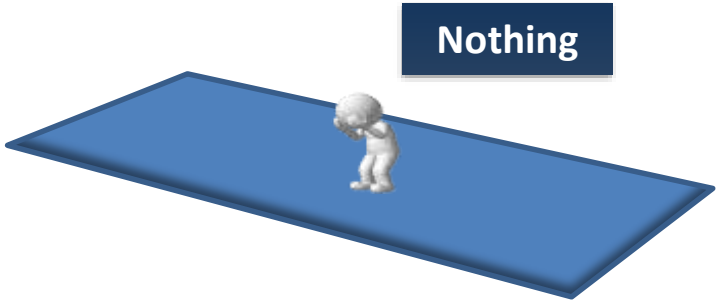
4. Localization

- The DLS unit is a navigation unit based on a inertial sensor.
- It is not a measuring system but it is an estimator.
- It calculate the actual position based on an estimation of physical sensor data.

Arianna Estimator vs Measuring System

• Cheap. • Light. • Small. • Disposable. • No training. • No other infrastructure • Ready to be used. • No dedicated behaviour.	• Expensive. • Heavy. • Big. • Not disposable. • Training. • Infrastructure. • Not ready to be used. • Dedicated behaviour.

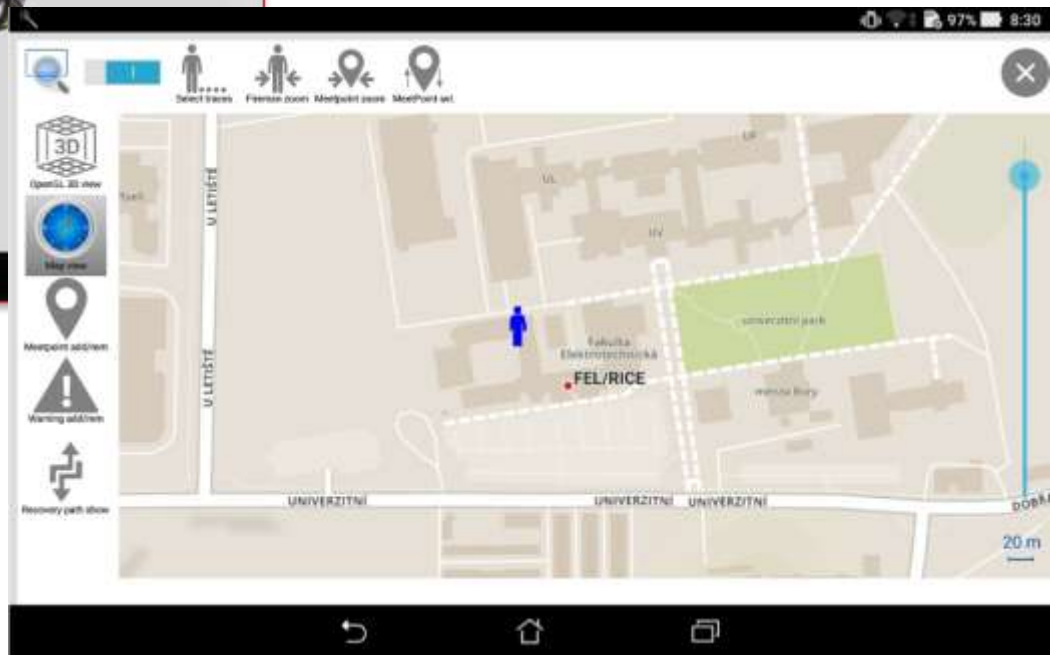
The worst scenario: no other information.



To an estimation is associated intrinsically an error.

4. Localization

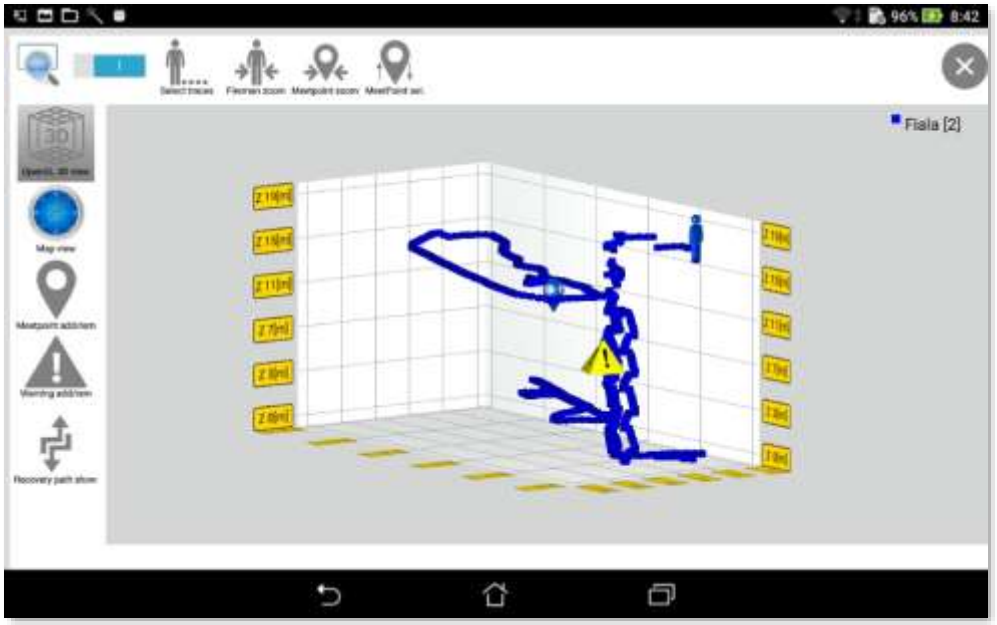
2-D trajectory vizualization.



Open street map with current position of a firefighter.

4. Localization - inertial

Placement of warning and meet points in 2-D view.



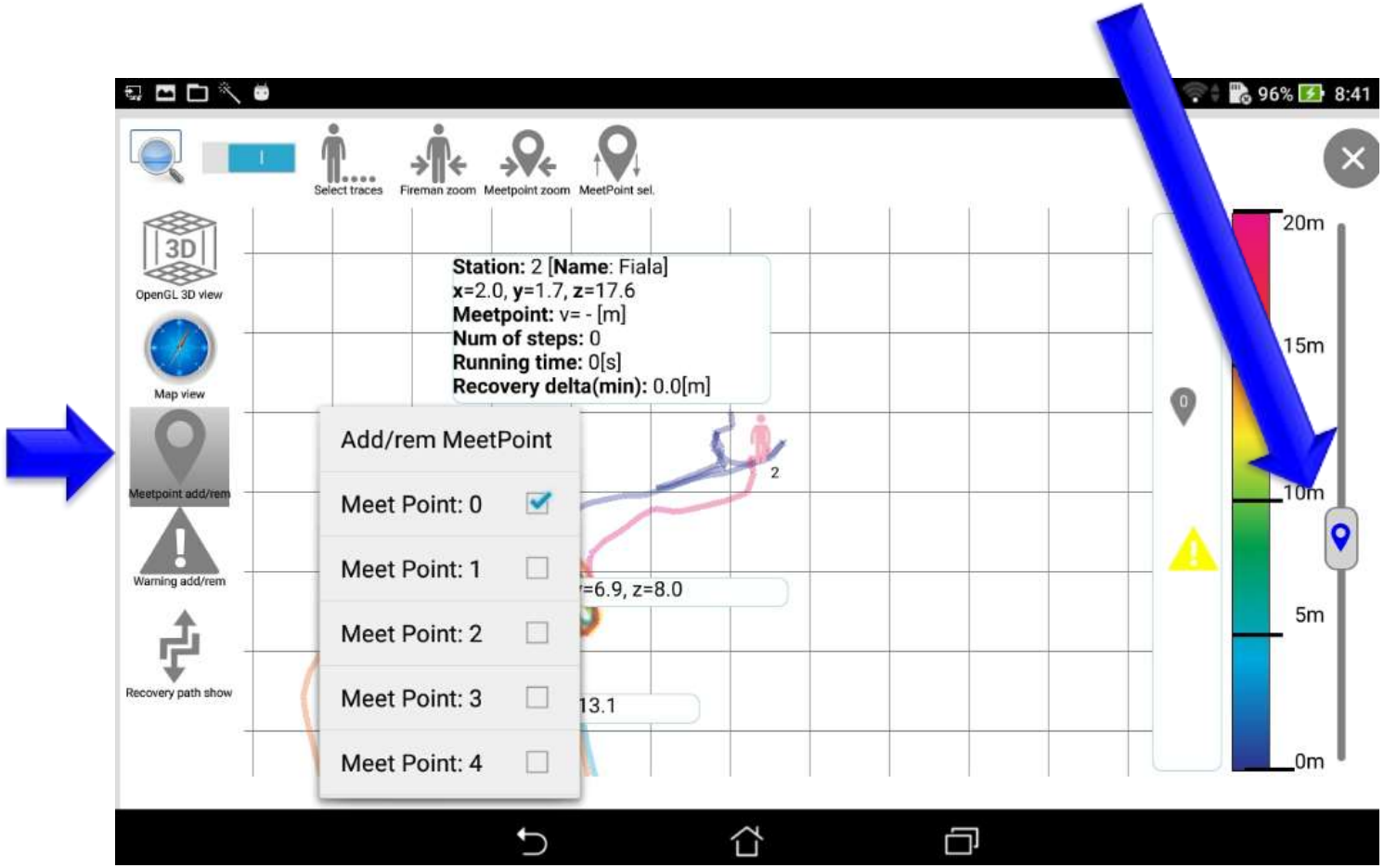
Placement of warning and meet points in 3-D view.

4. Localization - inertial

Add/remove meet points

1. Placement and move in the x,y-coordinates

2. Setting of z-coordinate (altitude)



5. Functions of the PPS

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No.	Required challenge	Features of our PPS
1.	System architecture and communication	E-textile harness (wire interconnection system)
		WAN and BAN wireless communication
		Signal processing and data evaluation (SCU)
		Independent historical data logging including black box function
		Unique identification of suit
		Acoustic alarm
		Optical alarm by integrated LED diods
		Autonomy system – function without dashboard
2.	Environmental and physiological monitoring	Inner and outer temperature measurement
		Inner and outer humidity measurement
		Combustible and toxic gases measurement (CH_4, CO, NO_2)
		Heart rate monitoring
		Firefighter motion detection
3.	IR thermal hotspot detection	IR sensor integrated into glove
		Hot spot detection (firefighter)
		Hot spot detection and measuring data evolution

5. Functions of the PPS

No.	Required challenge	Features of our PPS
4.	Localisation	GPS localisation system
		Inertial localisation system - HW
		Inertial localisation system - SW
		Relative map
		Recovery path function
		Meet point function
5.	Data visualisation	Intuitive dashboard – CCU with touch screen integrated in rugged case
		Threshold visualisation and setting – traffic light approach
		Monitoring up to 12 firefighters – possibility group them
		Historical data logging (including graphical visualisation and measuring data evolution)
		Automatically generated alerts
		Manually generated alerts from commander
		Wireless communication (WAN, WI-FI, BT)
6.	Active illumination	Omnidirectional LED illumination
		Alarm mode
		Automatic activation

6. November testing in France

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Thank you for your attention

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