Static Exhibition
Live Demonstrations
Conference and Seminars

30 September - 2 October 2014, EXPO CENTER Trenčín, Slovakia

Training in Military Robotics and EOD Unmanned Systems

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Outline

1. Motivation and overview of the platforms and systems – TIRAMISU, ICARUS Project & Others

2. Training and multi - level training technologies.

3. Models of trainers – simulators.

4. Requirements for trainers - simulators.

5. Prototypes of an exemplary trainer – simulators.

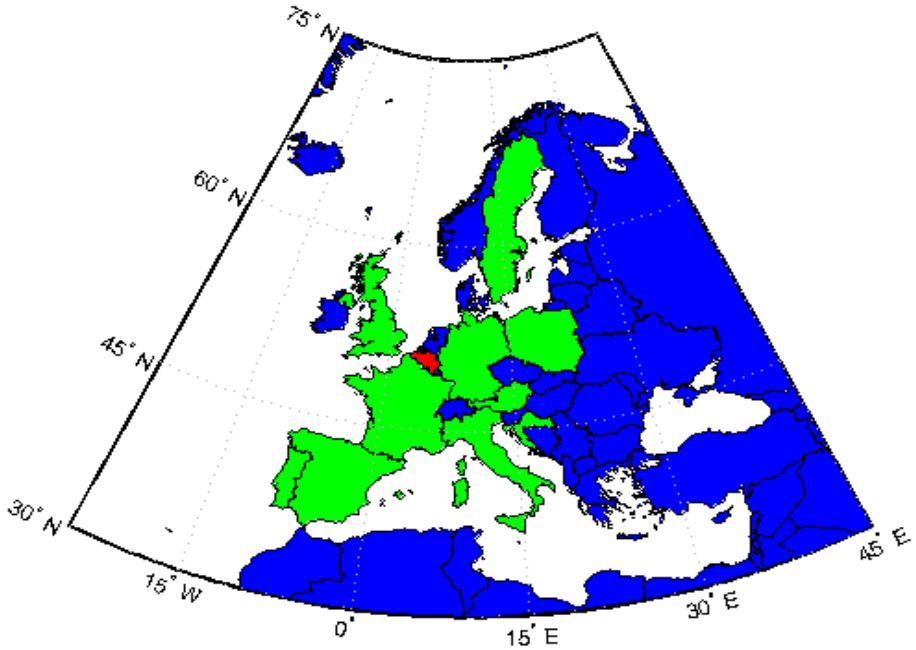
6. Conclusion

7. Video (Dr Janusz Bedkowski)

What is Tiramisu ?

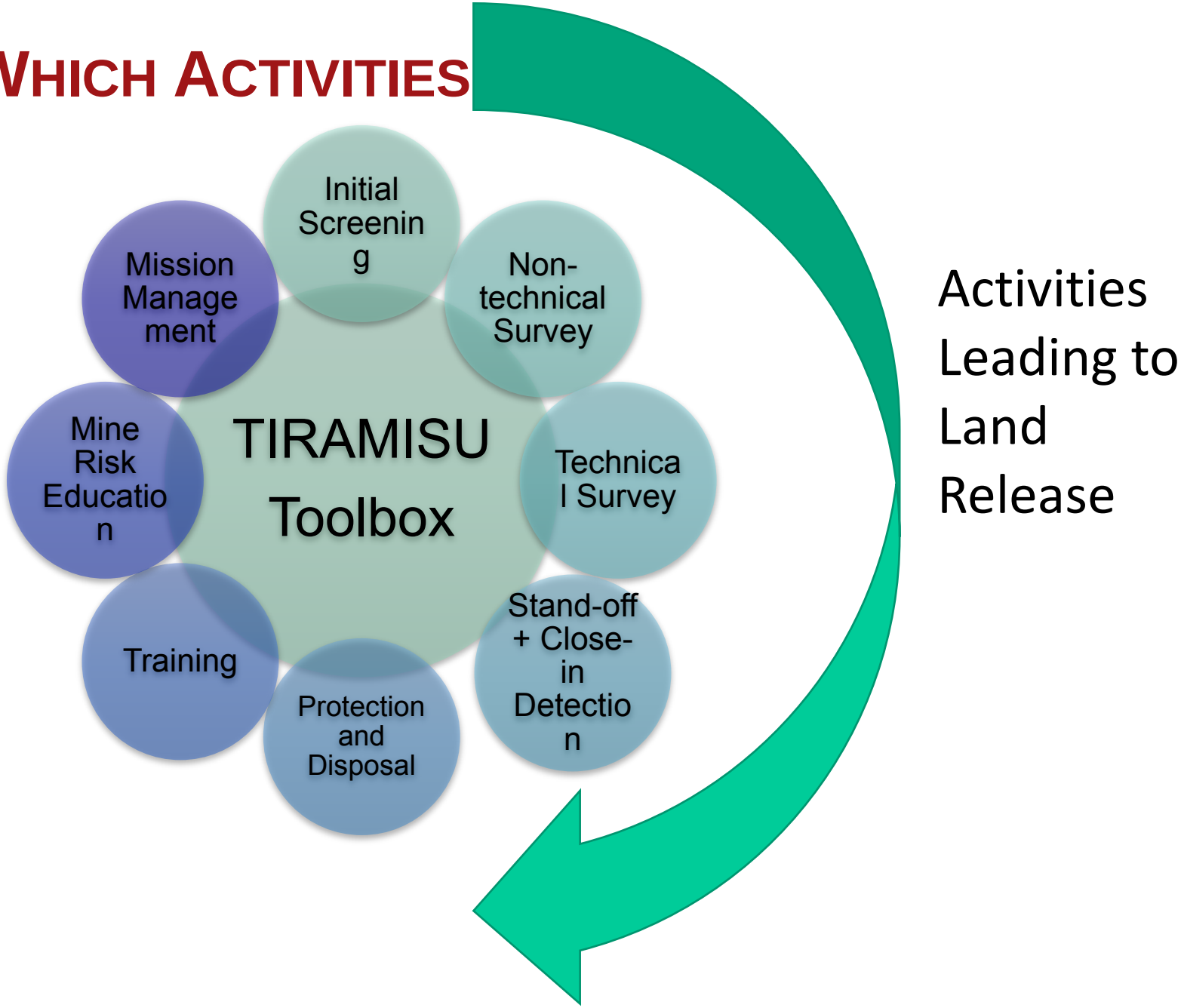
Toolbox Implementation for Removal of Anti-personnel Mines, Sub-munitions and UXO

Funded FP7 program (2012-2015)

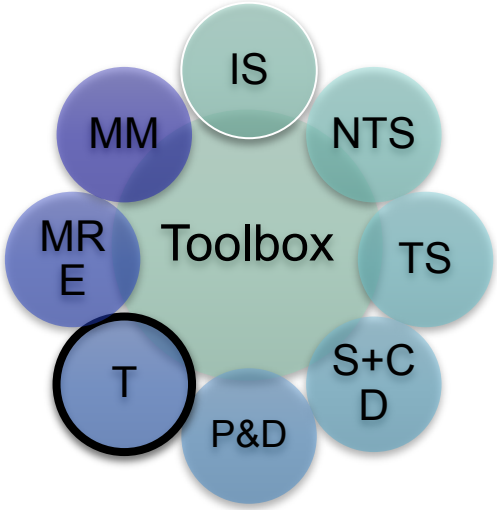


24 Partners – 11 Countries
9 Academies
9 SME
2 RTO
1 NGO
1 IND
1 EU - CROMAC
PAB: 10 experts from GICHD, UN, Field Stakeholders
EUB: 12 MAC

Tools for Which Activities



TRAINING



Objective?

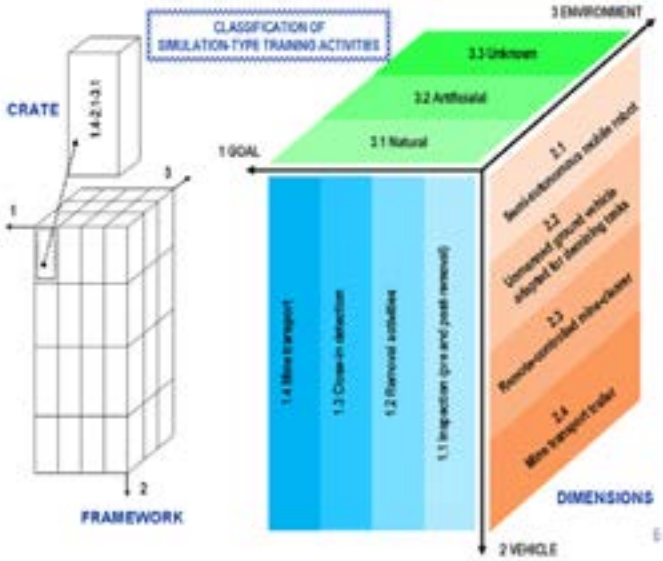
Enhance capacity building

How?

Depiction of needs for and characteristics of training tools

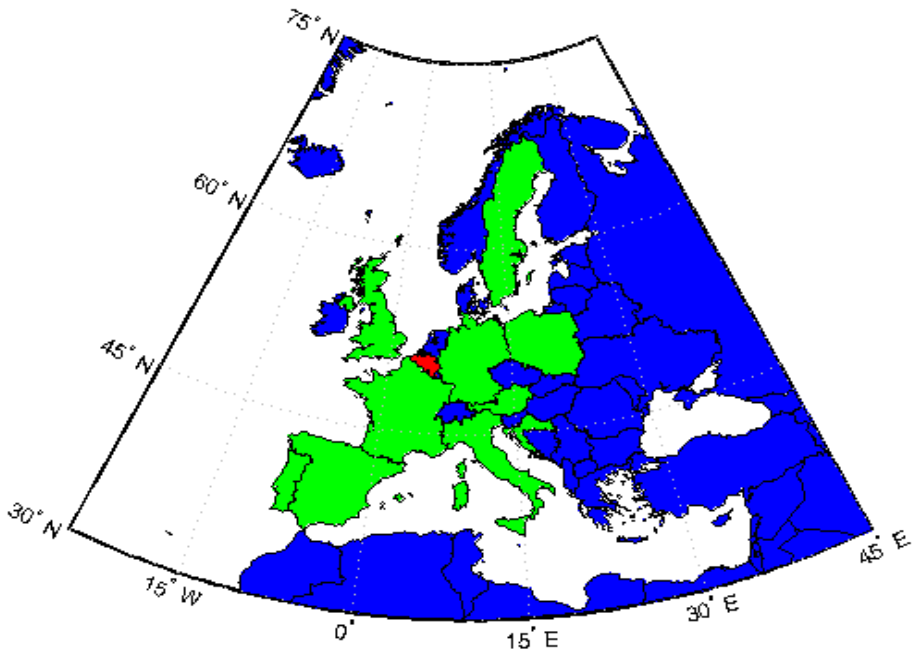
Development of training tools

EUB-defined application of the developed tools
in training of operational and management staff



What is Icarus ?

Integrated Components for Assisted Rescue and Unmanned Search Operations
Providing Unmanned Search and Rescue Tools



Funded FP7 program (2012-2015)

Participants:

24 partners

10 countries

2 end-users:

- B-FAST
- Portuguese Navy

3 large industrials

NATO / NURC

ICARUS - OBJECTIVES

- Development of cooperative Unmanned Aerial System (UAS) tools for unmanned SAR

Used for:

- Mapping of topography and scenario
- Target observation
- People search outdoors and indoors
- Kit delivery
- Communication relay

ICARUS - OBJECTIVES

- Development of cooperative Unmanned Ground Vehicle (UGV) tools for unmanned SAR
  - Development of a large UGV which be used as a mobile base
  - Development of a small UGV which is able to enter in collapsed buildings to search for human victims

ICARUS - OBJECTIVES

- Development of a training and support system of the developed Unmanned Search And Rescue for the Human Search And Rescue teams

  - Development of PC-type trainers-simulators for training operators of SAR robots
  - Development of an e-learning methodology
    ➔ training tool with virtual robots
    ➔ use of semantic information in a human-machine-interface

UGV experiences/Background

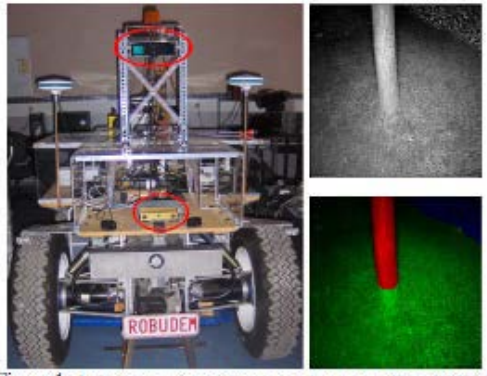


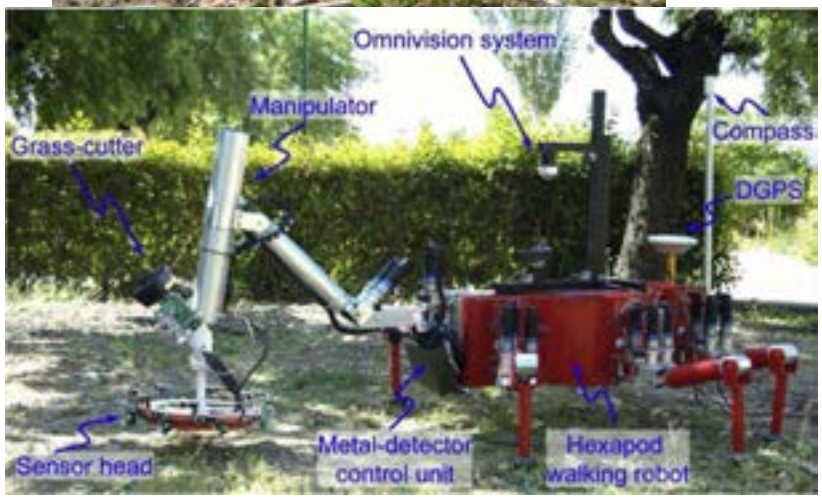
Figure 1: Left: System setup - Outdoor robot with a Time-Of-Flight Camera (on top) and a Stereo Camera (in the middle); Top Right: Amplitude Image; Bottom Right: Traversability Estimation (green: traversable; red: obstacle; blue: suspicious / not enough data)

RMA, ROBUDEM and synergy FP7-ICARUS (Unmanned Search and Rescue Operations)

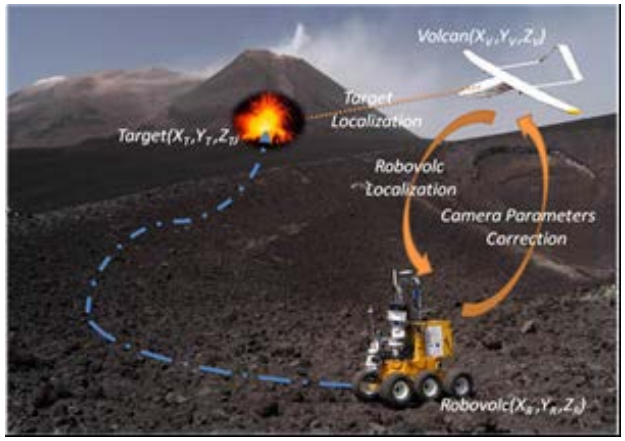
LADERO Project (ISR-UC)
ISR-TTiramisu multi-sensor carrier

LOCOSTRA,
DIMEC/PIERRE/SNAIL-AID

CSIC, DYLEMA
project



UAV experiences/BACKGROUND



UNICT: ROBOVOLC, DIVA Airship

CSIC: FP7 – RHEA Fleet

JMDThèques (ICARUS): Gyropendulum

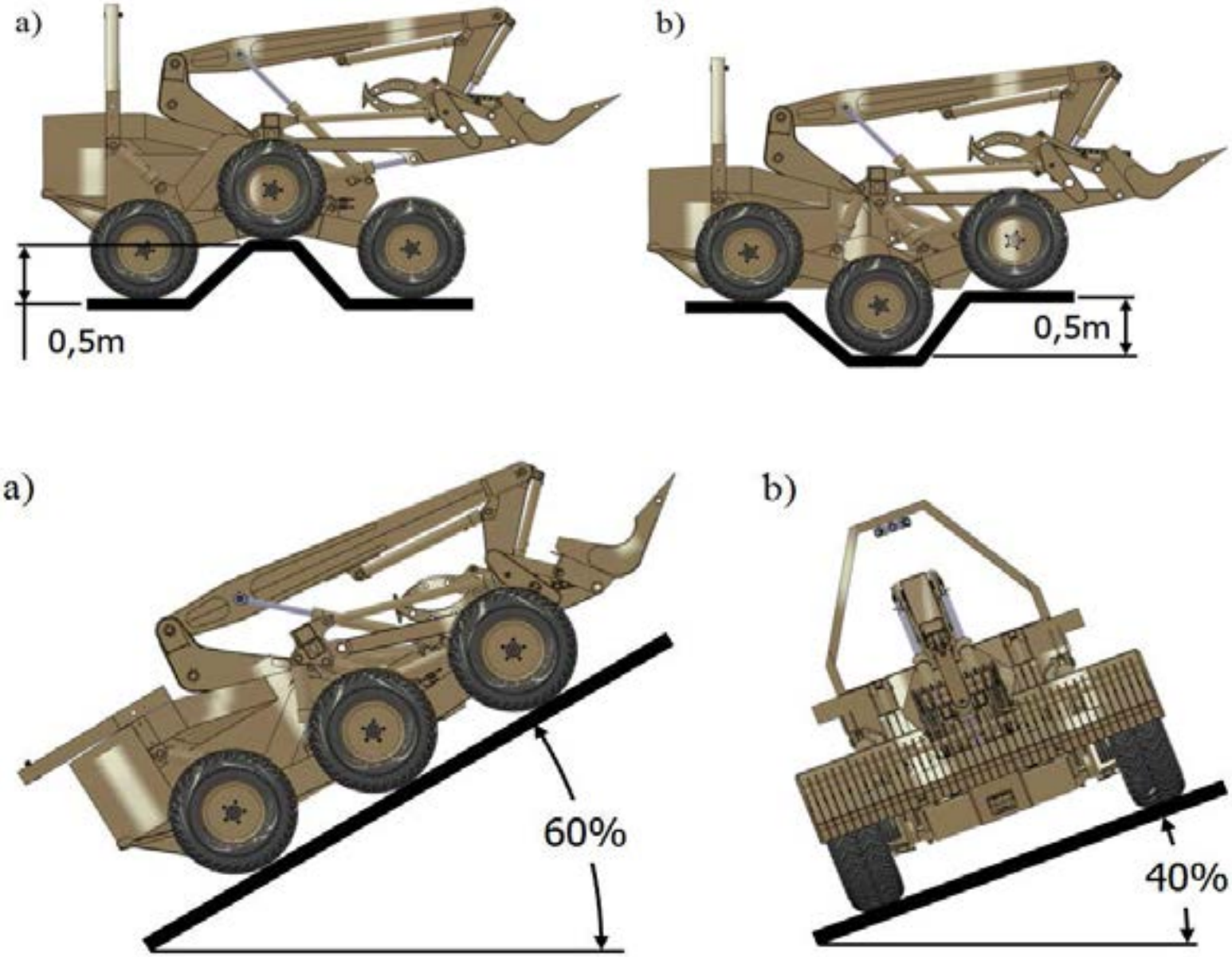
Aerial Processing (CTDT)

Remotely controlled vehicle Leviathan

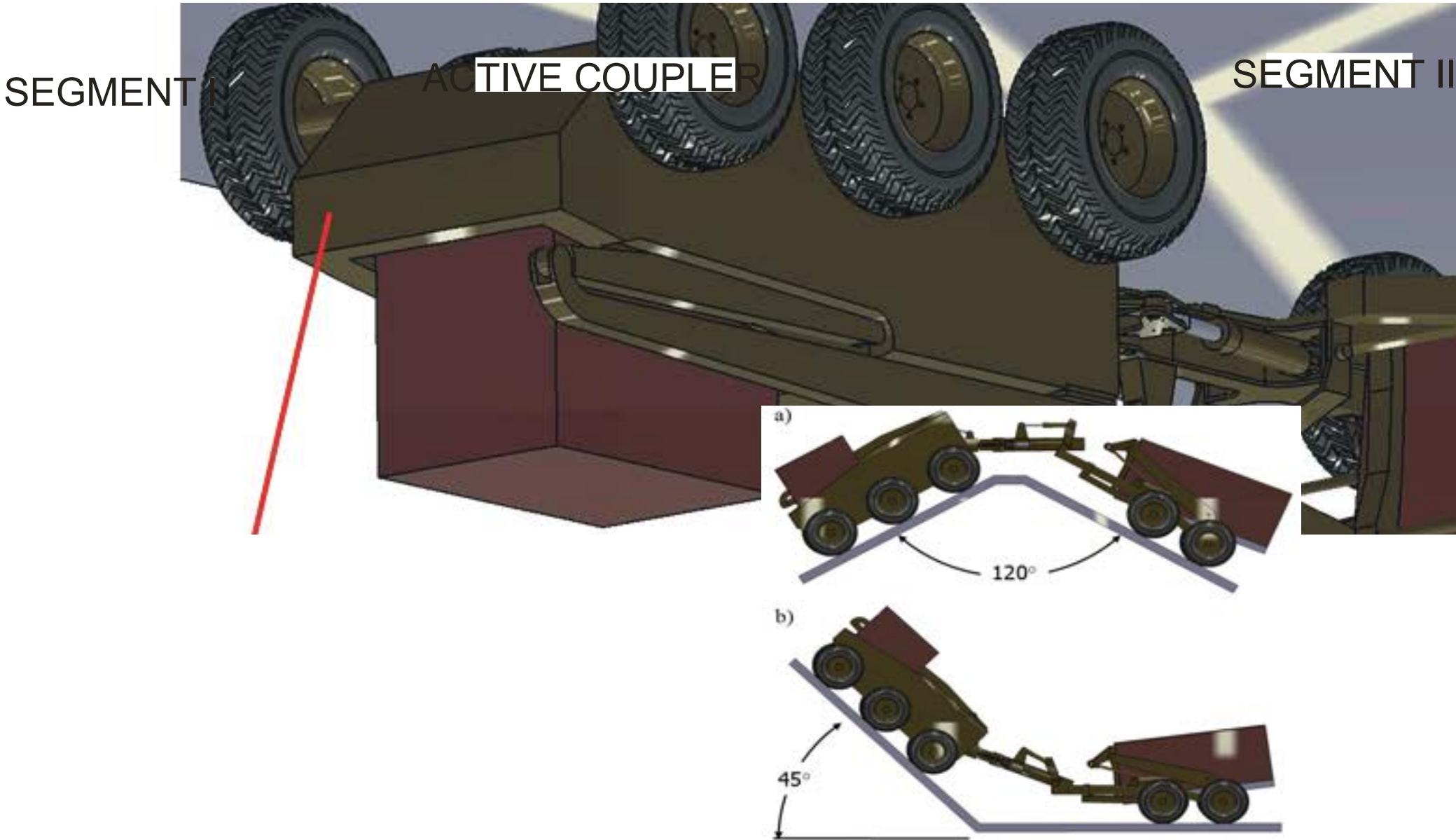
Reconnaissance robot

Tactical support robot

Engineering support robot

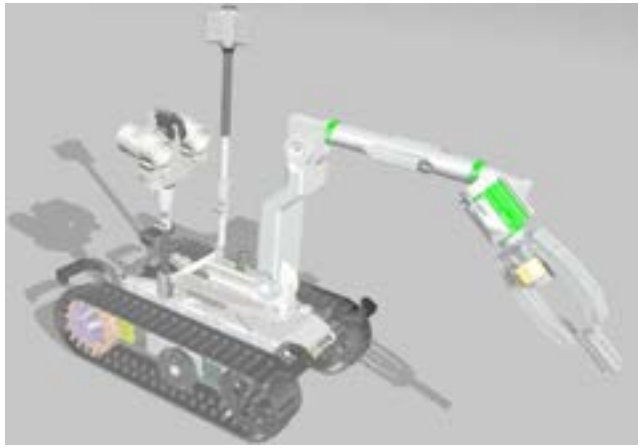

a)
0,5m
b)
0,5m
a)
60%
b)
40%

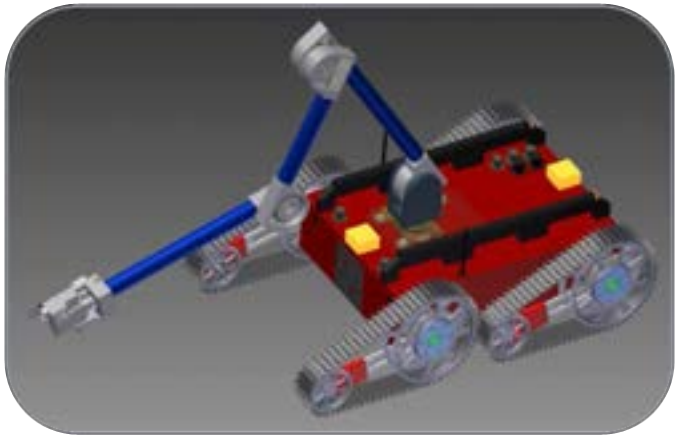
Engineering tactical support platform



The comprehensive set of trailer and demining machine

Pyrotechnic mobile robots

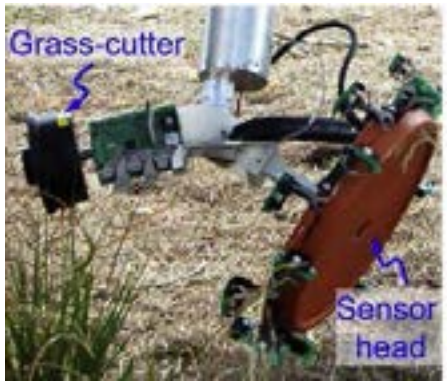




Mobile Platform Equipment (1)

TCP-Box

- WLAN-Mesh-Network
- Positioning Sensor integrated



5DoF Robotic Arm

Mobile Platform Equipment (2)

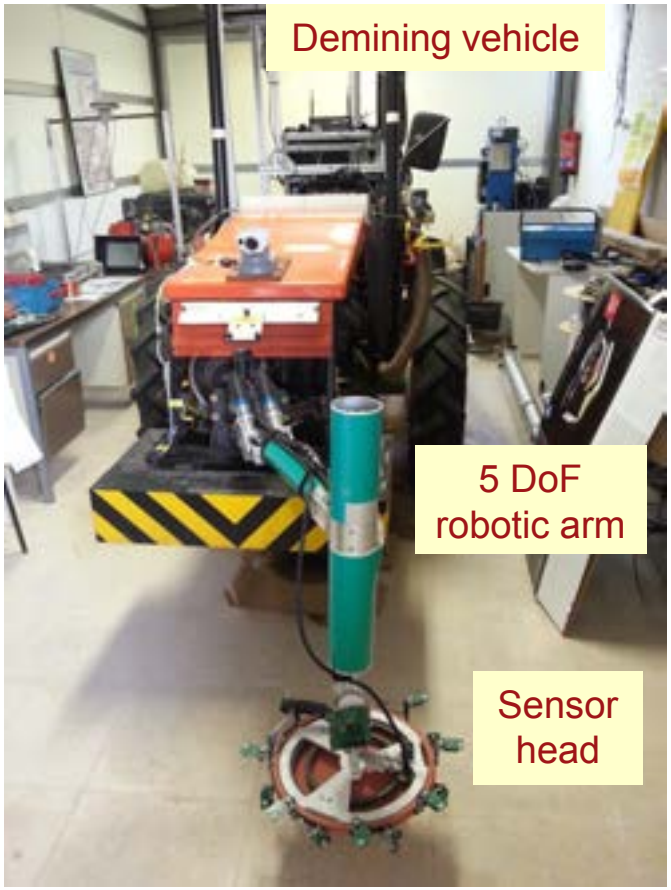
5DoF Robotic Arm

Selection of a 5 DoF robotic arm as candidate for carrying out close-in detection operations in field conditions.

Mechanical adaptation of the selected 5 DoF robotic arm for its integration in one of the proposed remotely controlled inspection platforms.

With the grass-cutter selected as the active tool, the robot “cleans” the area to be scanned.

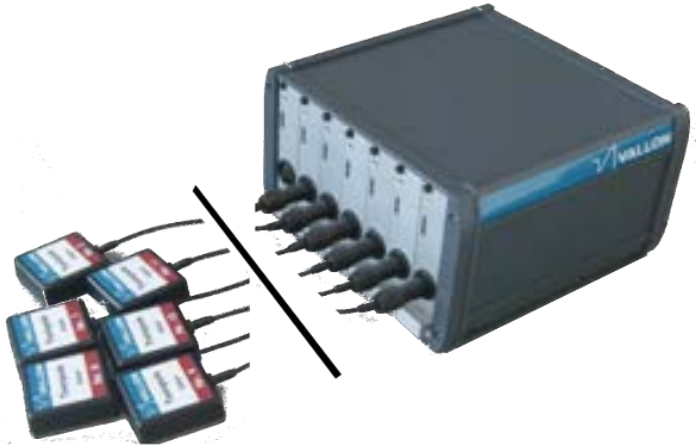
The sensor head contains a metal-detecting set and a network of rangefinders mounted around the mine-detecting set. This network helps the scanning manipulator control the sensor head’s height and orientation.



Mobile Platform Equipment (3)

FSR Husky remotely controlled/autonomous mine detection platform

Mobile Platform Equipment (4)



Test setup for detector, 6 x (upper)

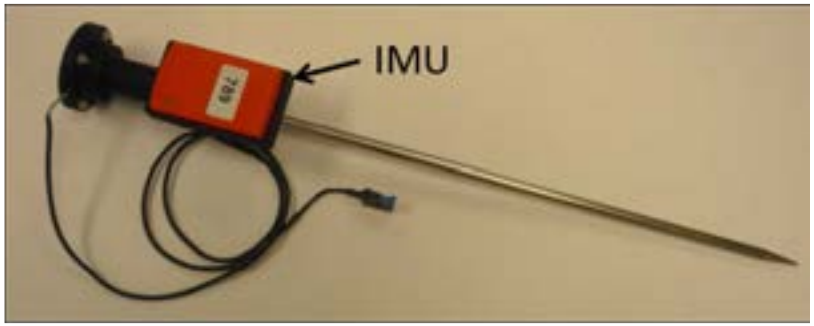
Integrated system (right) with Wifi Connection (3 antennas)

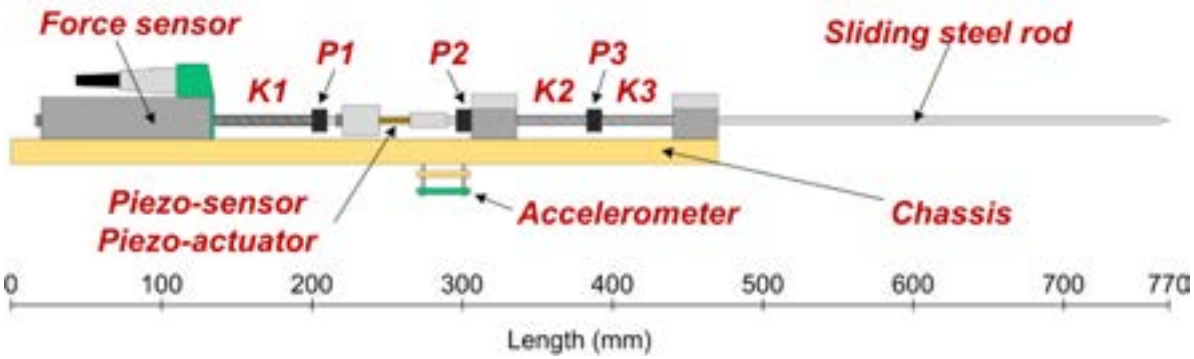
Accesspoint inside tEODOr

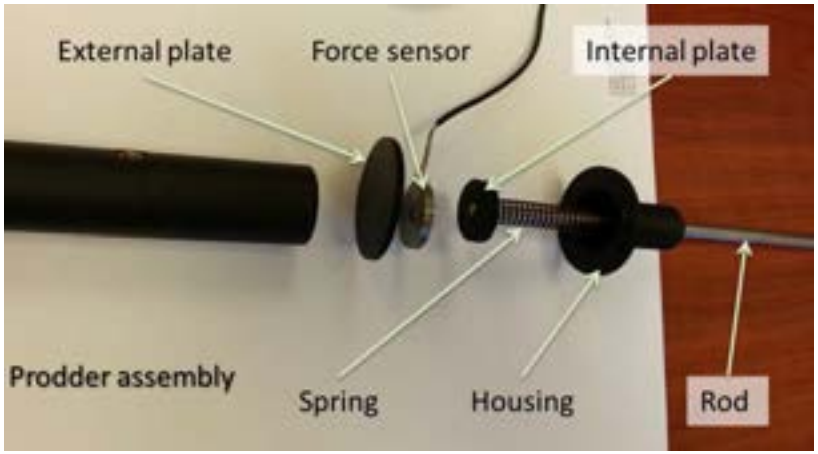
Mobile Platform Equipment (5)

Intelligent Prodder

A pair of piezoelectric transducers, used as actuator and sensor, a linear potentiometer sensor with three springs (K1,K2,K3), and an accelerometer. Instrumentation of a prodder provided by VALLON with force sensors and a inertial measurement unit.







Motivation (1)

- Multi-robots teams, as well as groups made up of robots and humans can be a subject of supervision and command by system operators.
- Thus, there is a need to develop adequate methods and means of training. Trainer - simulators, taking advantages of computer games technology and e-learning, are the obvious solution.
- e-training - understood as an extension of e-learning: e-learning consists in computer-network-based obtaining of knowledge, e-training has in view obtaining of operation skills.

Motivation (2)

- Mines and others EOD, first of all in the form of improvised explosive devices (IEDs), become now the threats.
- There is a need for simulators of different tele-operated robots or platforms.
- Flexible software platform (framework) for designing e-Training for different surveillance and inspection robots and different environments.

Tele-operated robots
- manoeuvring problems

1. Amount of degrees of freedom.
2. Big number of control buttons and joysticks.
3. Little knowledge of the scene.
4. Unpredicted problems (lack of the communication range, failure of the part of the robot).
5. Separation of the robot from the operator.

Training tasks and training program generation (1)

Training tasks have a form of games played by a trainee in a virtual world composed of the virtual robot with real or virtual control console, and of virtual environment.

A typical task, both for earth-surface and underwater or flying mobile robot in a surveillance system, consists in inspection of a terrain/water body, detecting an explosive device and detonating it or moving to determined place (for example to a proper container).

Training tasks and training program generation (2)

For every task, the following elements should be specified:

environment;

robot’s initial position and orientation;

a mission to fulfill;

events treated as faults;

expected reaction of the system to trainee’s actions.

Training tasks and training program generation (3)

- In the executable program created on the base of the above specifications, connections among tasks are of dynamic nature:

  the choice of a next task (or a decision to finish the training) depends on the evaluation of the level of skills achieved by the trainee.

- After the end of game, a report including description of events that happened during the game, with their timing, is created. The complete training is composed of interrelated tasks-games, and can be depicted in the form of a graph, which vertices represent tasks, and edges – paths between tasks.

Training tasks and training program generation (4)

Training's graph includes information which task should be executed first, which next, and which last; moreover the information about conditions that have to be met for passing through a path – to a new vertex-task, or to an old one for a game repetition.

The program can be used not only for training programs generation but also for generation of certification tests, in which a number of tasks is limited, and tasks inadequately executed are not repeated.

Simulators - motivation

1. Training of the candidates in order to decrease/eliminate difficulties with steering of the robot.
2. Developing particular skills (for example: precision, planning, reflex, orientation).
3. Handling with input devices.
4. Lower costs of the training of the operators.
5. Commercial software.
6. Multimedia for show.

Framework - motivation

1. Simulators

- Limited number of robots, scenarios, environments

- Defined ranking methods for training.

2. Building new simulator from „scratch” – huge programming work.

3. Lower costs of the production of the simulators.

Vision of the system

Multi-level training:

1. Different skills developing.
2. Profiling into groups of advance.
3. Cheaper than one-level (cost of computer hardware).

Multi-level training

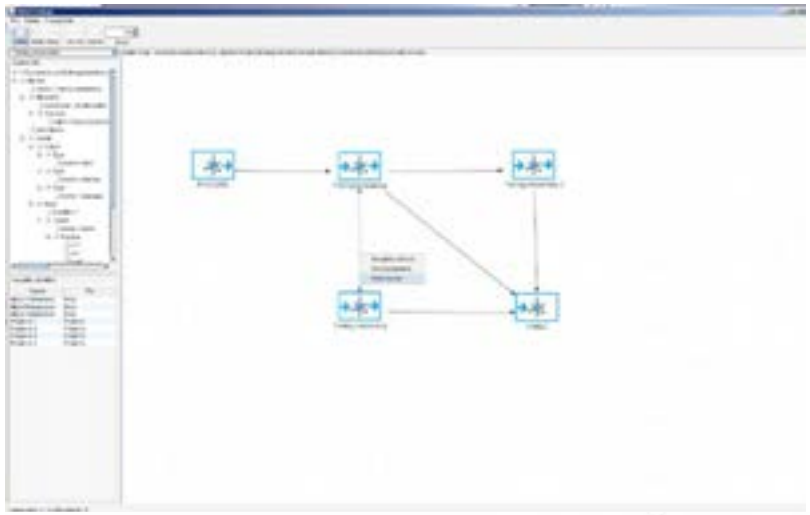
Trainers of the Level 1 – built with use of typical PCs. VR technology is applied. Robot, its environment and control console are simulated

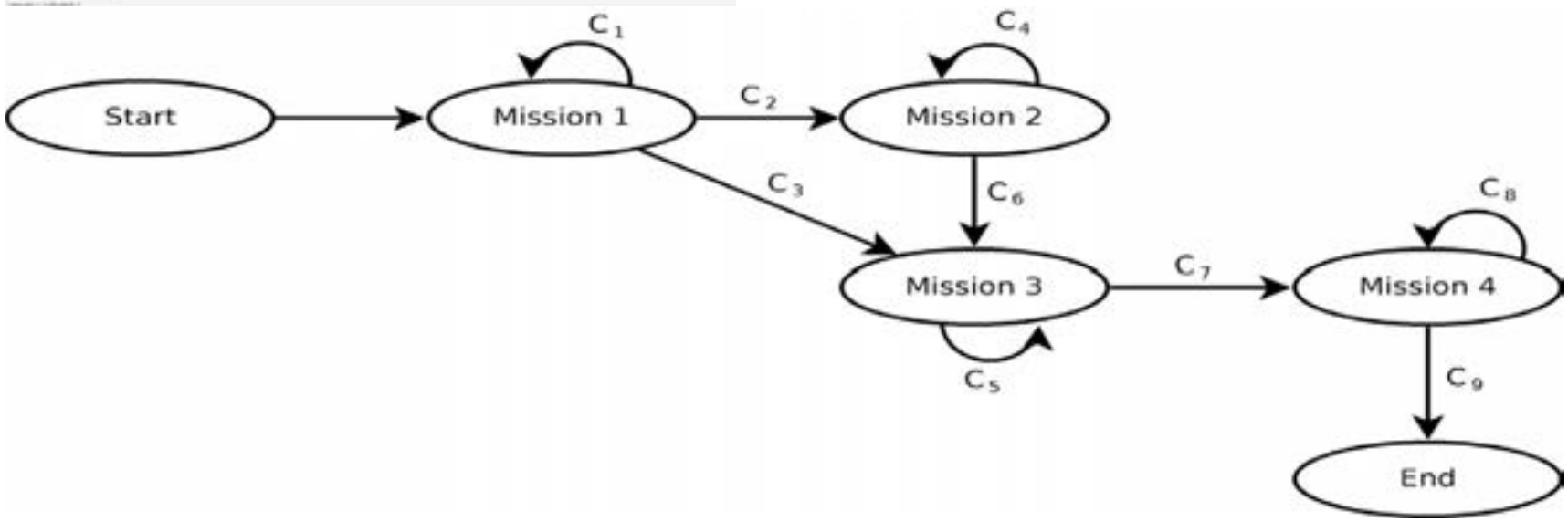
Trainers of the Level 2 – built with use of PCs with real robot control consoles connected. VR technology is applied. Robot and its environment are simulated.

Trainers of the Level 3 – trainers of the Level 1 or 2 with application of AR technology - real robot in the real environment with simulated elements added. A trainee uses special helmet.

Trainer – simulator of the level 2

e -Training - implementation





Tiramisu training system

The system allows for use in TIRAMISU project for training of multiple UGV operators during one training scenario. Maximum number of user is 10. The core of the system are VORTEX physics engine, for robust simulation, and OSG (Open Scene Graph) for rendering purpose. The system allows for online, robust simulation of the robots and environment. System architecture allows for scalability: new user can be attached dynamically. The robots can interact with each other, including colliding and realistic gripping simulation.

System features

Dynamic environment modeling

Dynamic robot customization

High fidelity rigid body simulation

Interactions: collisions, high accuracy joint, models friction, gripping etc.

Event based mission execution

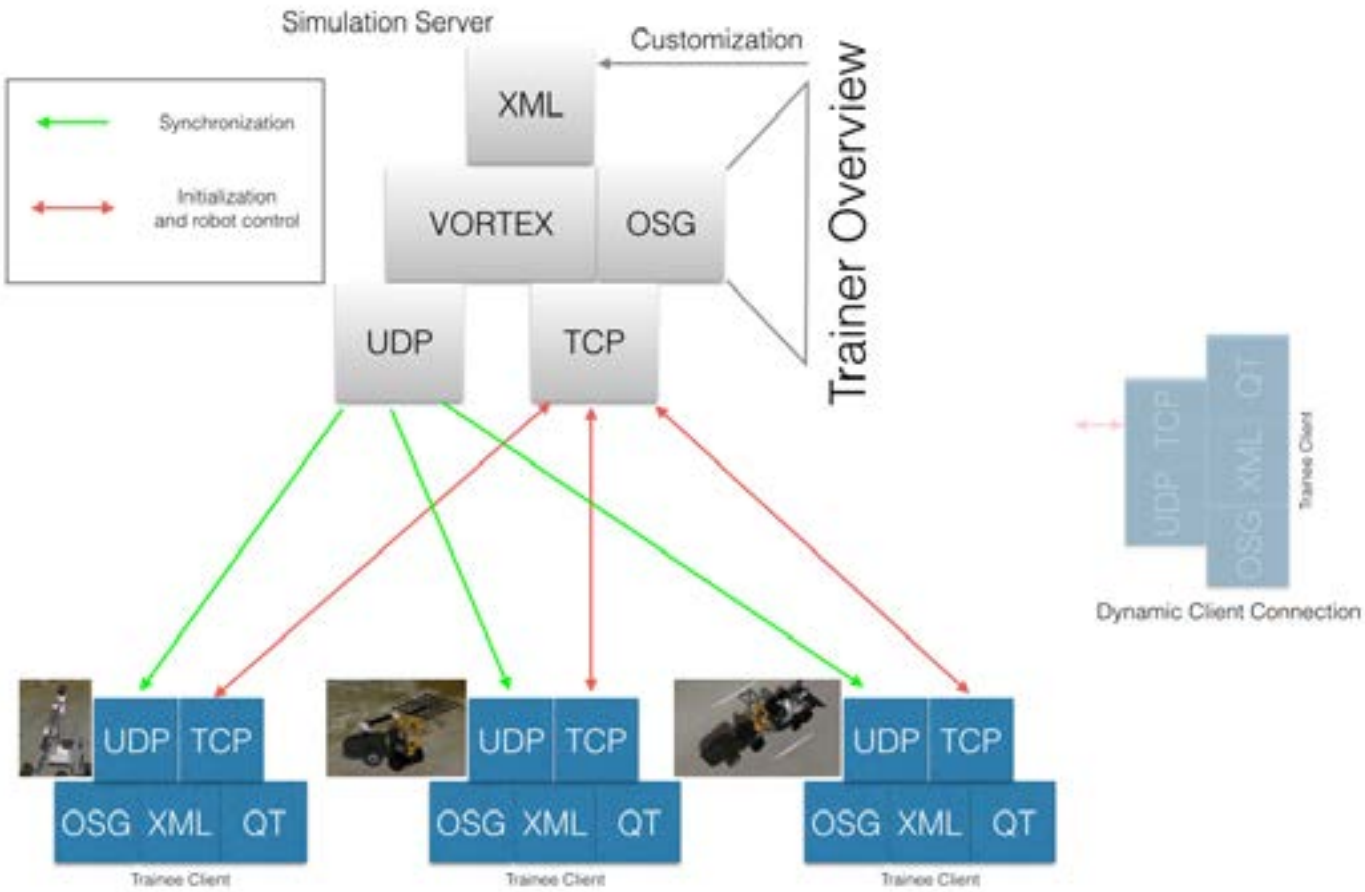
System overview

The training system allows for multi robot simulation and interaction. It was designed to work on multiple computers, with a powerful central one as server.

Physics layer: **VORTEX** engine

Visualization layer: **OSG** (Open Scene Graph)

Simulation system architecture



Simulation server

The main server is responsible for performing all physic simulation and distributing it among the trainee clients. The server is also directly connected with trainer tools, which allow for modifying the environment, adding robot models and customizing them. The trainer is also responsible for adding events that define the mission scenario. All information are defined in XML files.

Trainee client

The client allows the trainee to control the robot. This module only has the OSG visualization layer. All environment changes are send form the server. The trainee ahs access to robot controls and simulated robot sensor feed (cameras).

Communication

The system communicates via TCP and UDP packages

TCP:

- New client initialization: dynamic client connection
- Robot commands and control

UDP:

- Synchronization of the environment between server and clients: broadcast
- Only changes in the environment are send

Robot models (1)

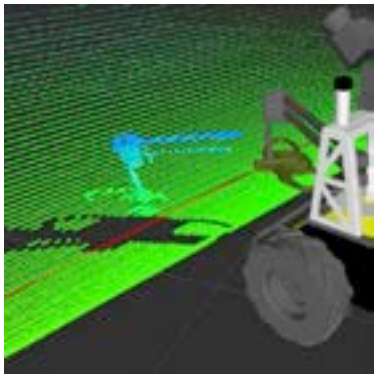
iRobot – PackBot

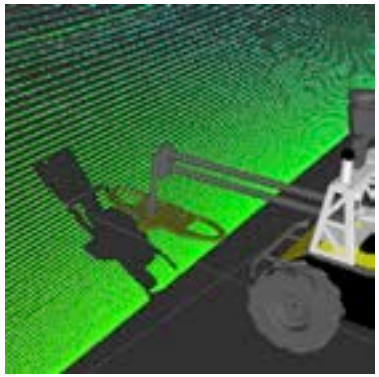
LOCOSTRA with different configurations: trailer, UXO detector

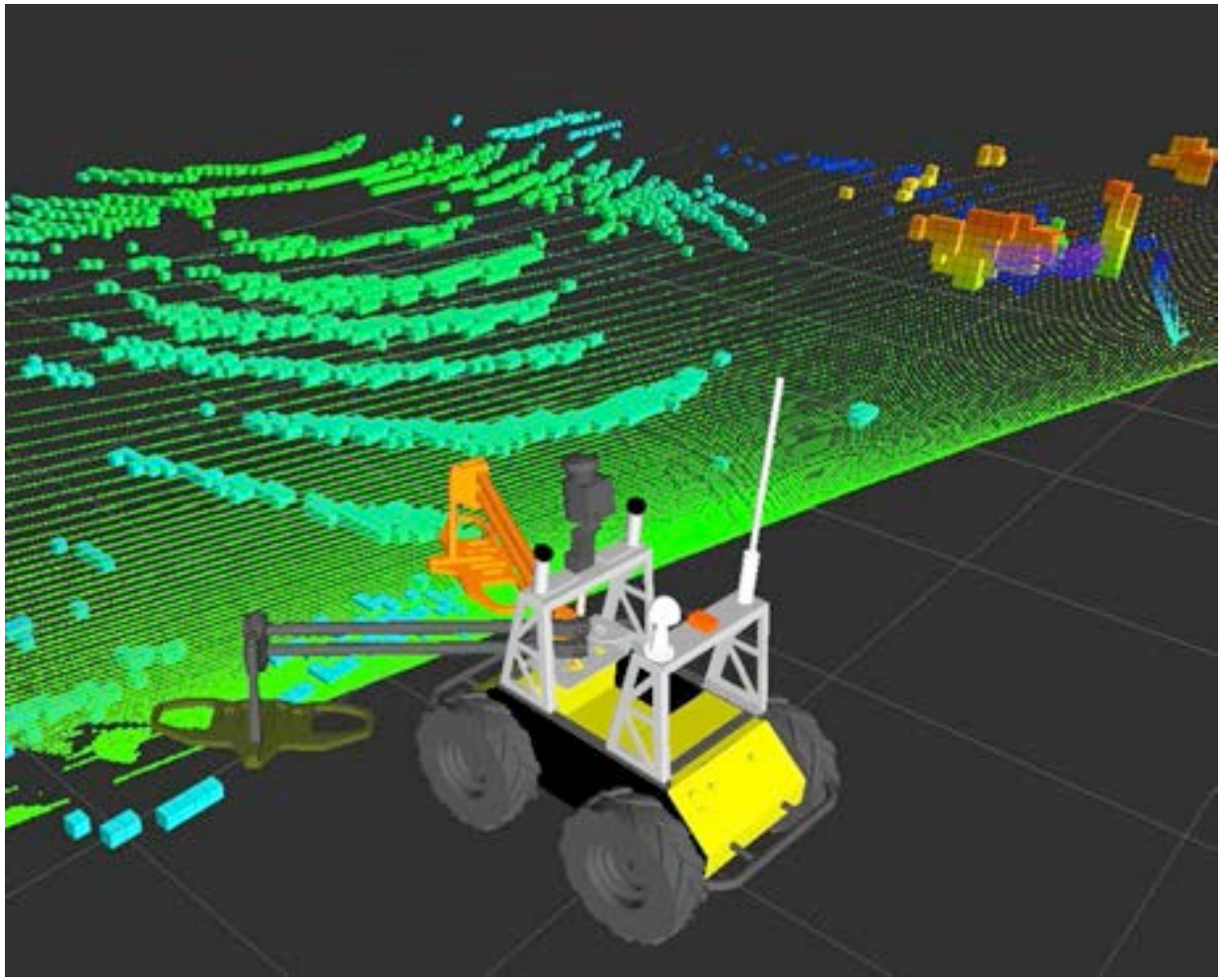
Robot models (2)

FSR Husky Arm

- 3D perception using the LRF.
- Self-filtering of the 2DoF arm.
- Arm path planning and obstacle avoidance.







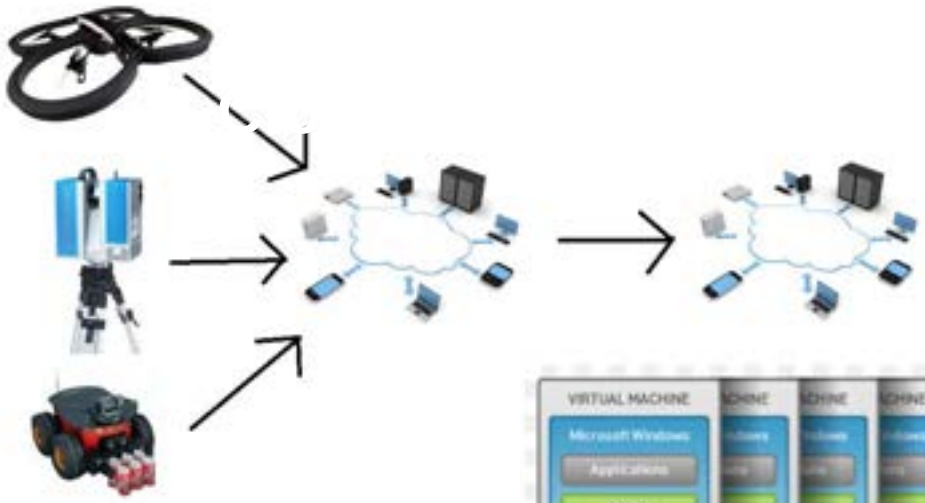
Scenario – UXO removal (1)

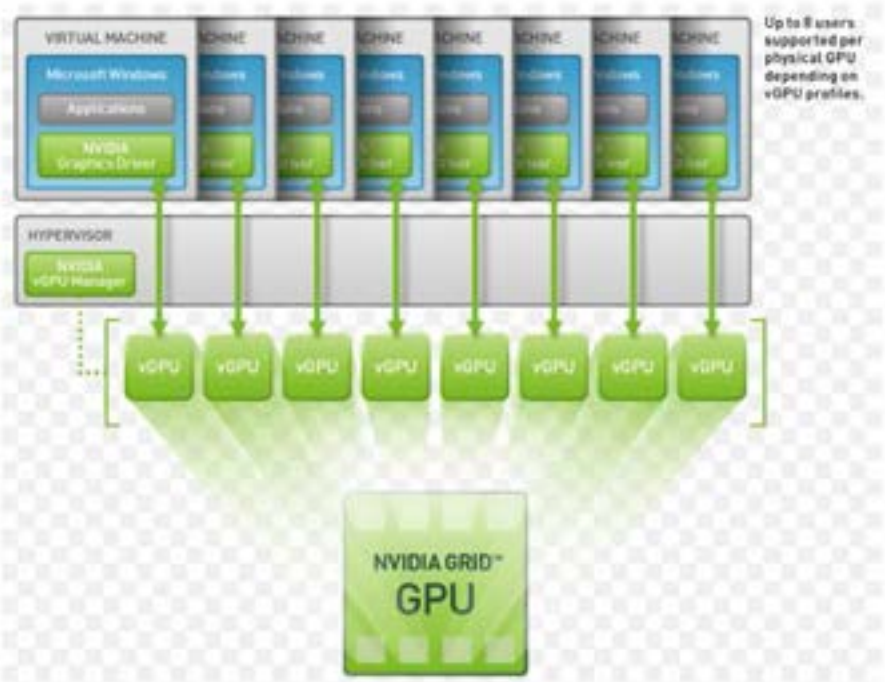
1. Detection of UXO.
2. Robot transportation.
3. UXO securing.
4. UXO removal.

Scenario – UXO removal (2)

Icarus
training and suport systems

Architecture of Training and Support System in the Cloud

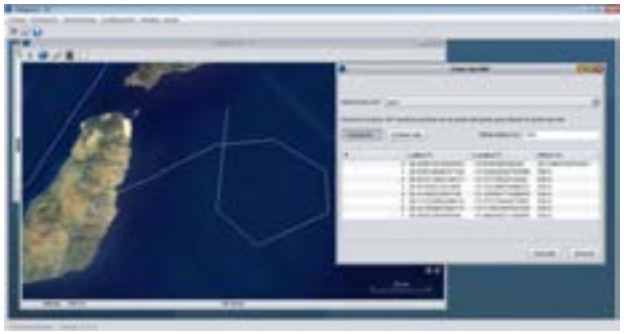


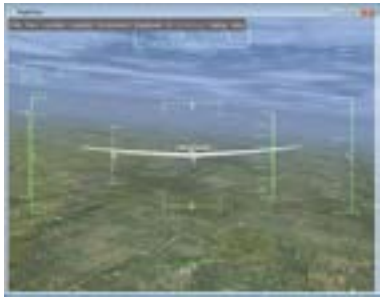


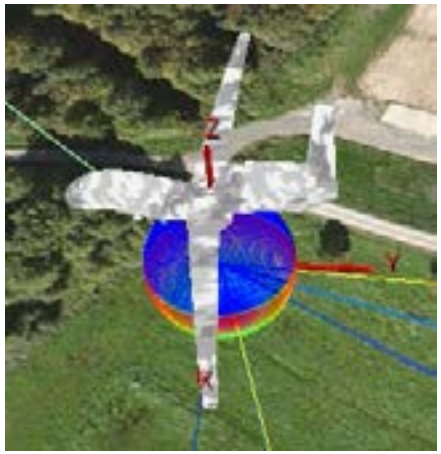
Multi robot simulator in the cloud available via NVIDIA GRID

UAV FLIGHT AND LINK SIMULATION

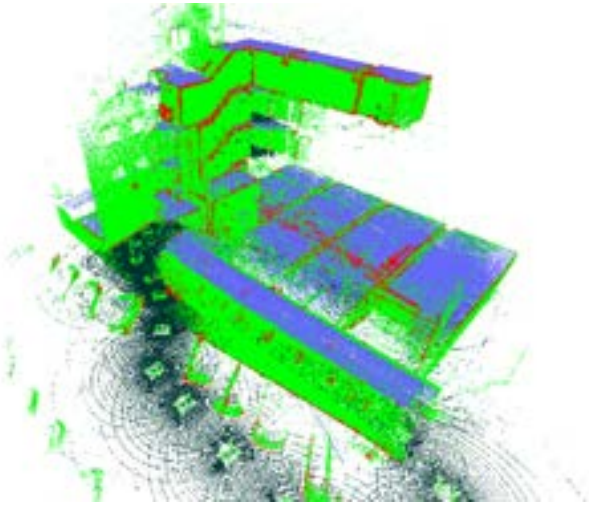
- Design of flight plans in Digital Globe
- Generation of detailed track data using autopilot and FlightGear
- UAV flight execution on Digital Globe with platform 3D model
  - recorded track
  - real-time autopilot
  - Real-time manual operation
- Calculation of MSS+WLAN+PMR link status using platform, antenna and sat geometries
- Mapping from ICARUS UAVs TM/TC to FLightGear TM/TC in progress

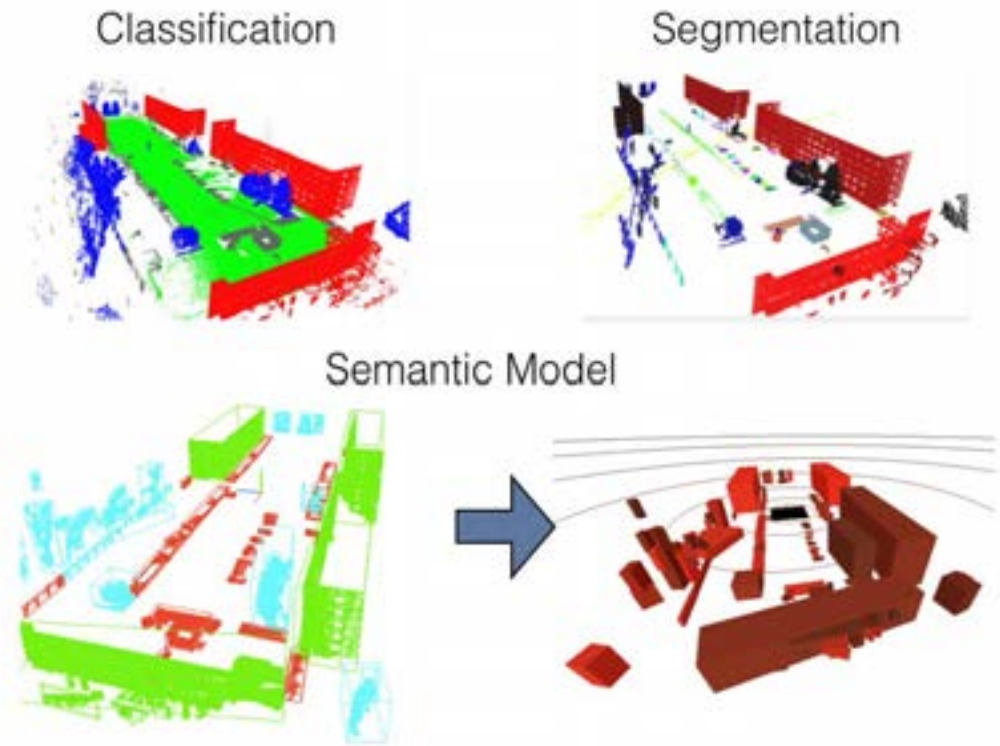






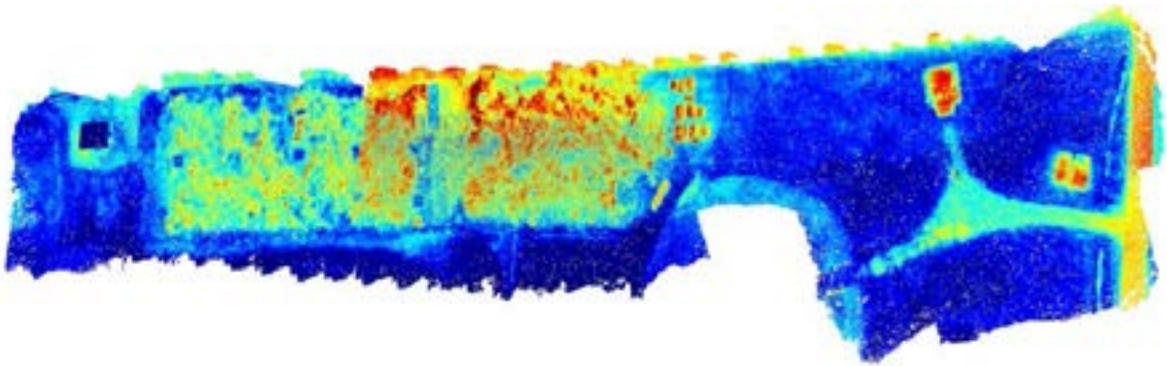
SEMANTIC MAPPING

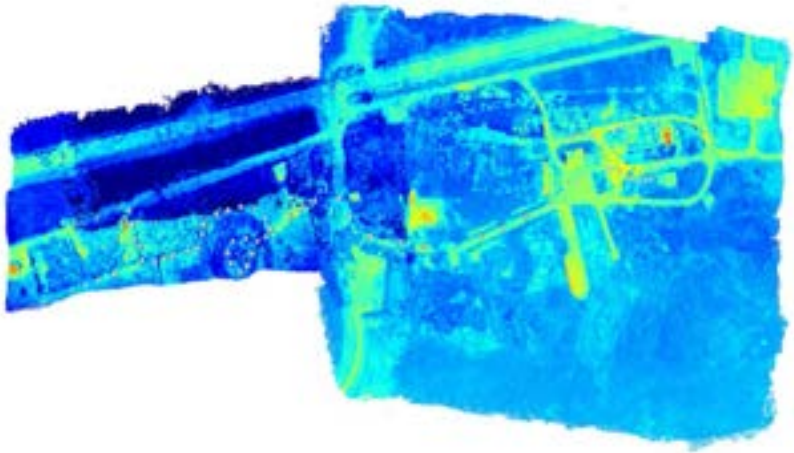


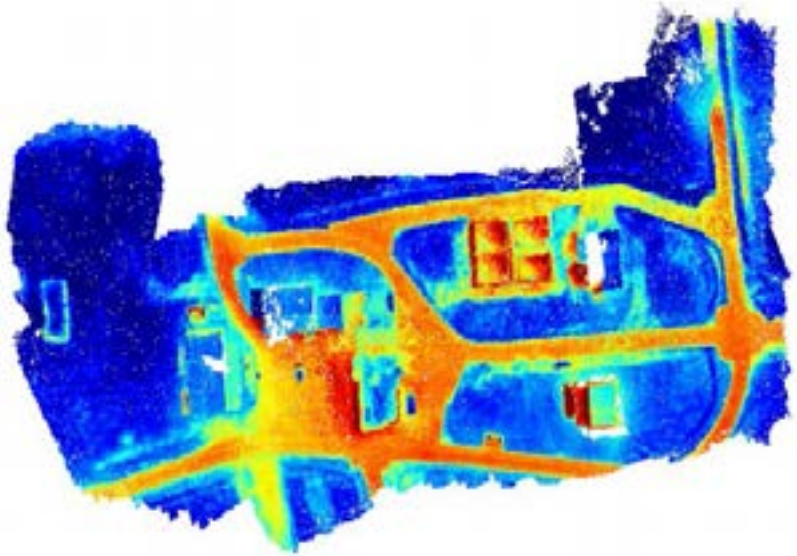


Colour data from UAVs

Thermal data (thermal layer)

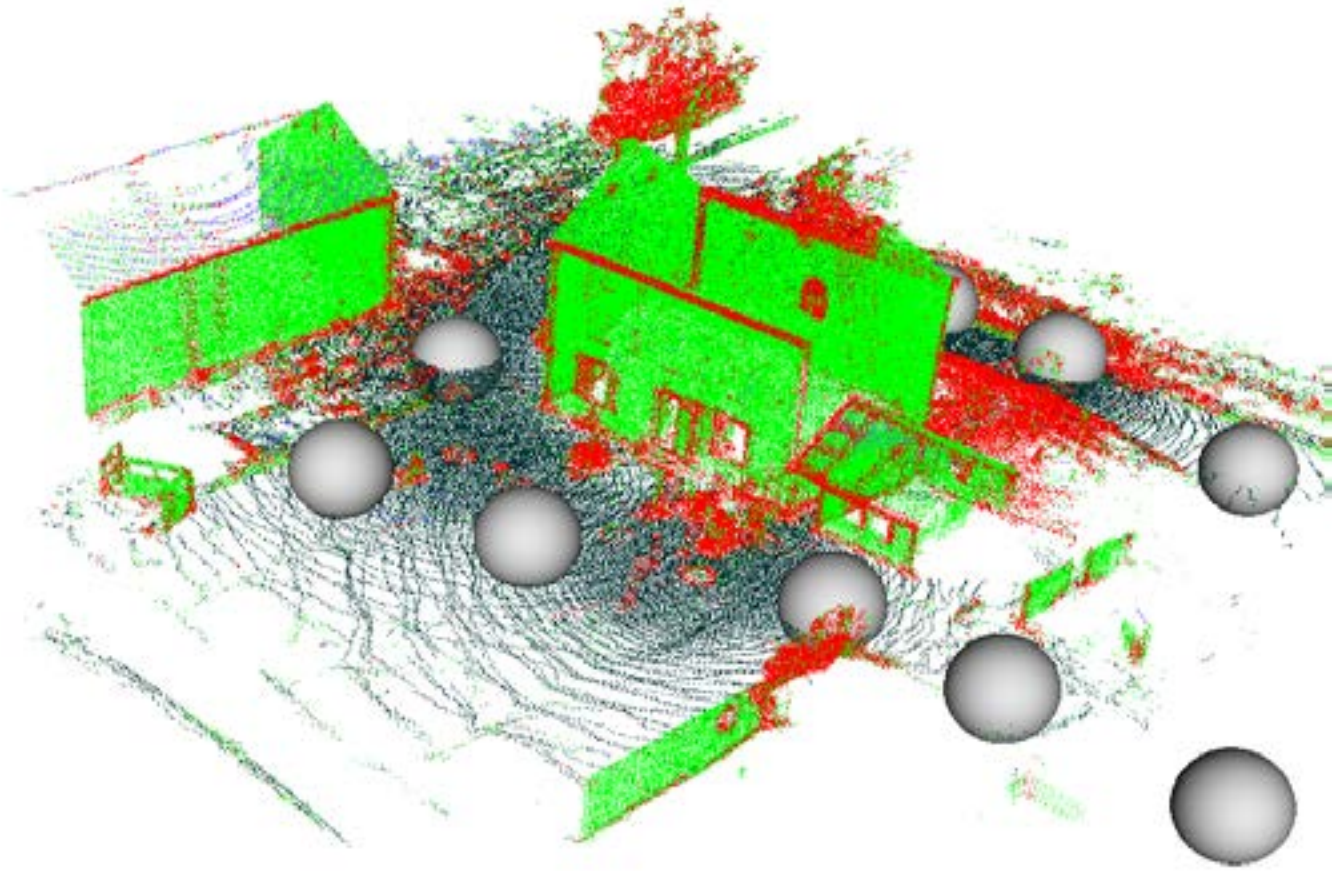






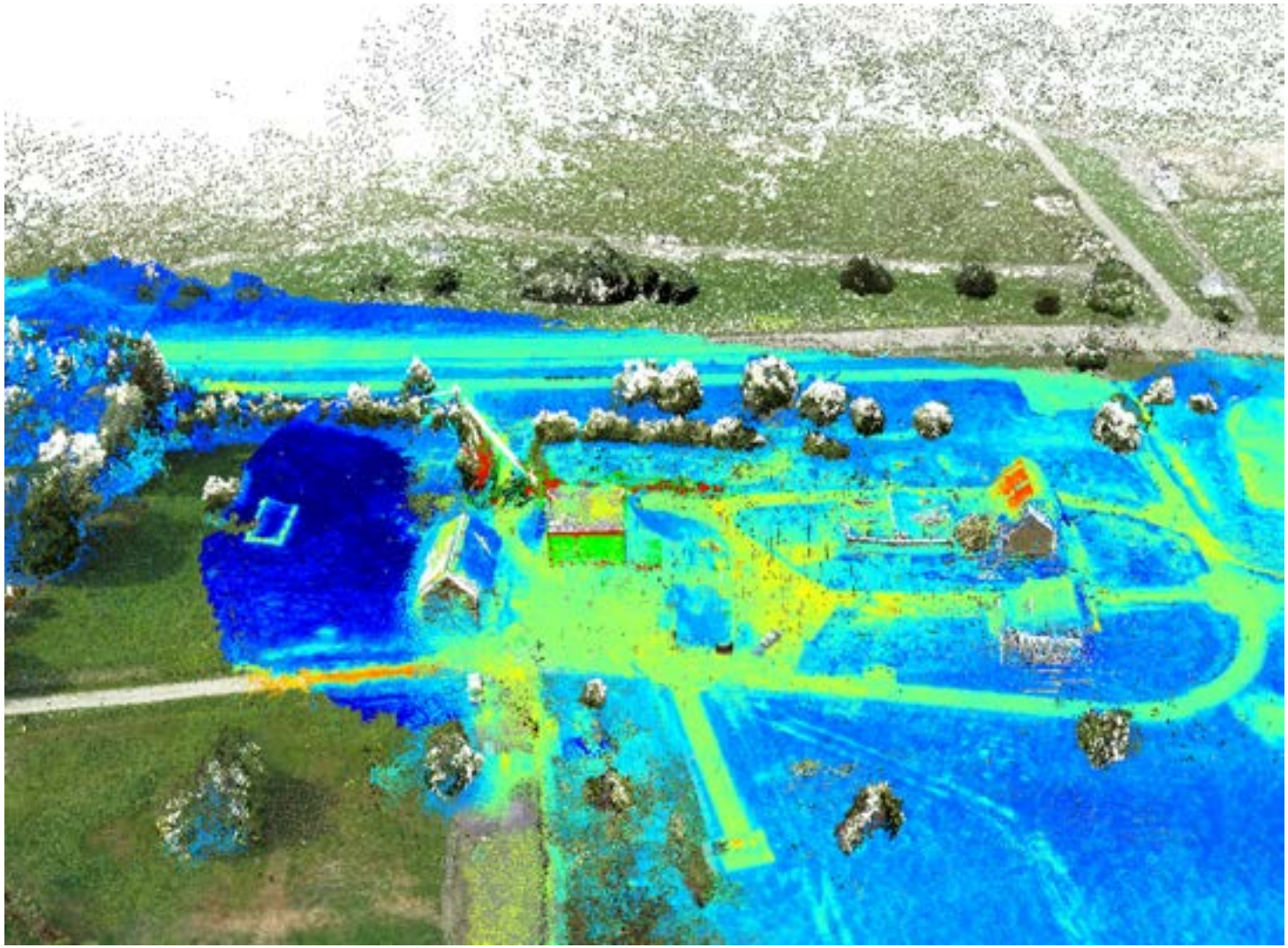
Data from geodetic Z+F scanner

Semantic layer

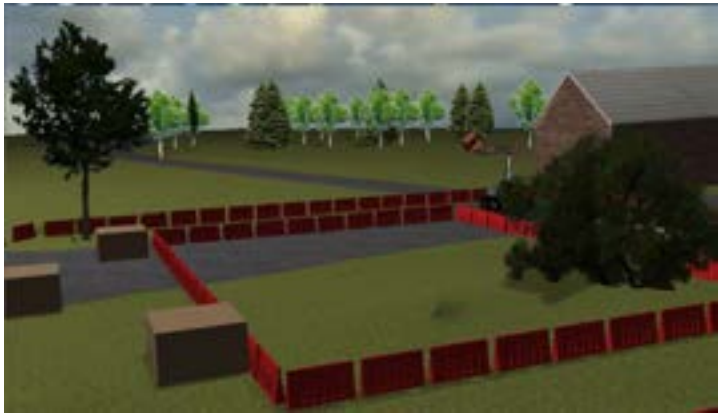


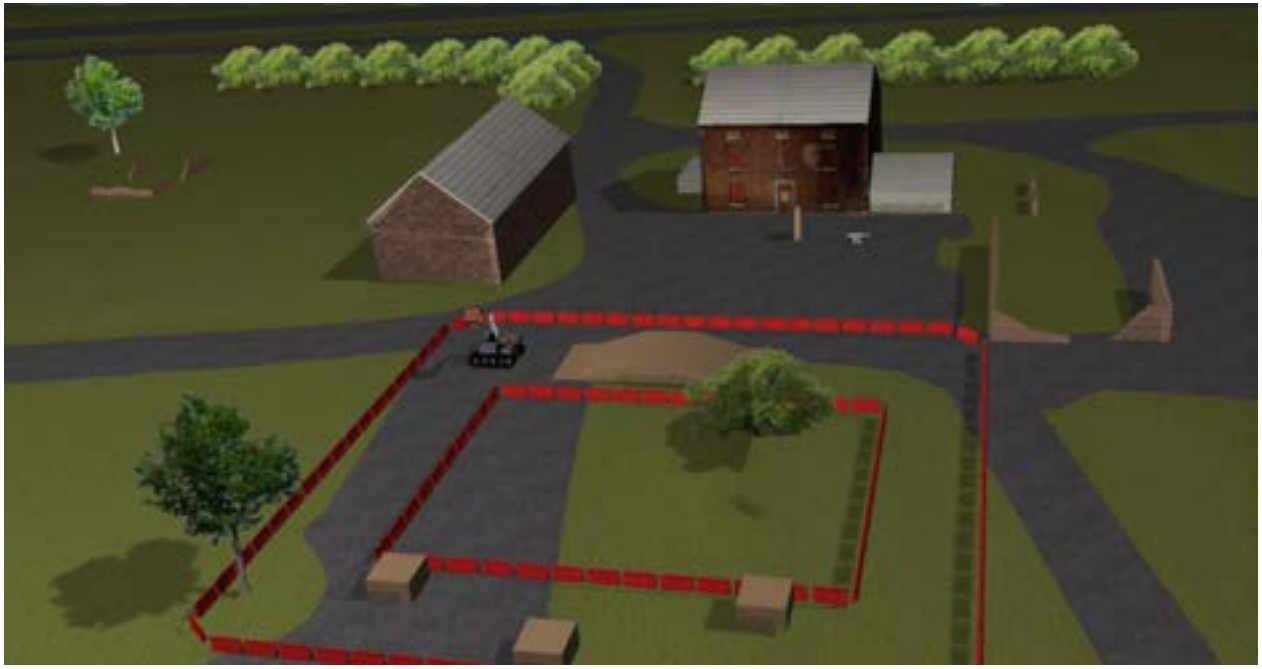
Street view from robot camera

Data fusion



Scenarios for UGV remotely control training





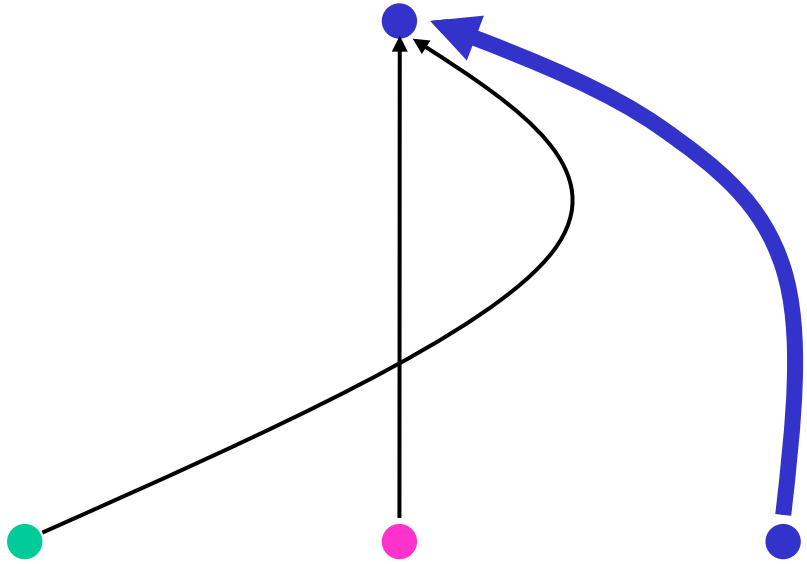
Scenario for UAV remotely control training

Augmented Reality scenario for LUGV remotely control training

Conclusion

- The complete training is composed of interrelated tasks - games, and can be depicted in the form of a graph, which vertices represent tasks, and edges – paths between tasks.
- A concept of systems with built-in training possibilities, is presented. Procedures of generation of virtual robot, virtual console, virtual environment, training tasks, and training program, finding their applications in trainers - simulators of the system are shown. Augmented reality techniques can be applied.

E-TRAINING



COMPUTER GAME **E-LERNING** **COMPUTER SIMULATORS**