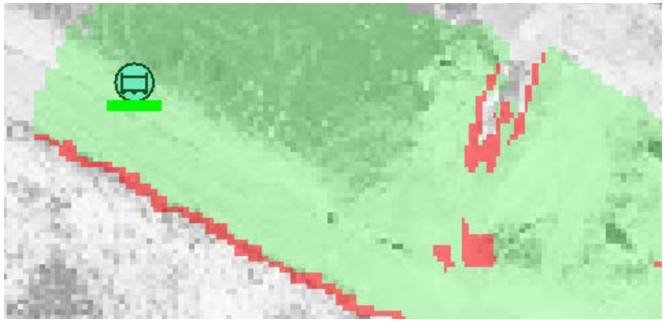
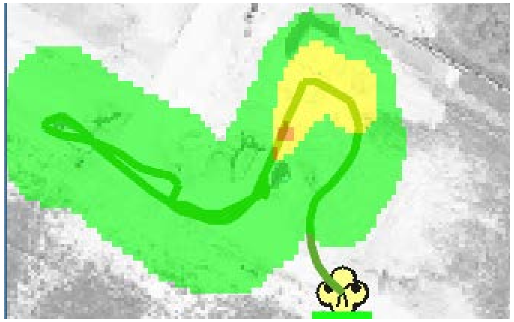
Commanding Heterogeneous Multi-Robot Teams

Thomas Remmersmann – ICCRTS 2014




Motivation

There are many operations in which a multi-robot system (MRS) can be deployed to support the human forces, e.g., for reconnaissance tasks.

Controlling a MRS in operations, however, is a complex and demanding task, especially if the MRS in question has to be controlled by a **single operator** in order to free her fellow soldiers for other tasks and duties.

The operator can be disburdened by giving the robots some **autonomy**.

Motivation

robot autonomy

give orders (task assignments) on a more abstract level;

let the robots handle details themselves.

However, this raises the question as to how those tasks assignments can be defined, formulated and exchanged.

Our approach: express orders (as well as the reports the robots send back to the controller) in **Battle Management Language**.

Battle Management Language

BML has been developed within NATO MSG-048 and NATO MSG-085 (and is discussed by the SISO in order to provide a SISO standard).

BML normally is used to command simulated units in simulation systems in order to improve training, after action analysis, and decision support.

The BML for “C2 system – simulation system”-interaction has been adjusted for our purposes, namely commanding multi robot systems, without changes to the core syntax of the language.

Why Battle Management Language for Robots?

Robots and simulation systems are both systems.

- Both need to “understand” the given commands.

Orders in BML are high-abstraction level orders.

- That’s the way humans give commands.
- They include all the information needed to be executed by humans.
- Long Term Target: Give Robots the same ability.

Additional benefit: connect Robot Systems to existing C2 Systems.

ROS
Robot Operating System

Middleware for R&D projects

Simplifies development

- Defined interfaces
- Interchangeable module
- big, active community

ROS as a middleware

- Simplifies communication
- analyze/monitoring tools
- centrally structured and controlled

The Multi-Robot System
Platforms

Longcross Chain
- Weight: ~450kg
- 20 km/h
- 200 kg Payload

RUAG „Garm“ Chain
- Weight: ~500kg
- 20 km/h
- 200 kg Payload

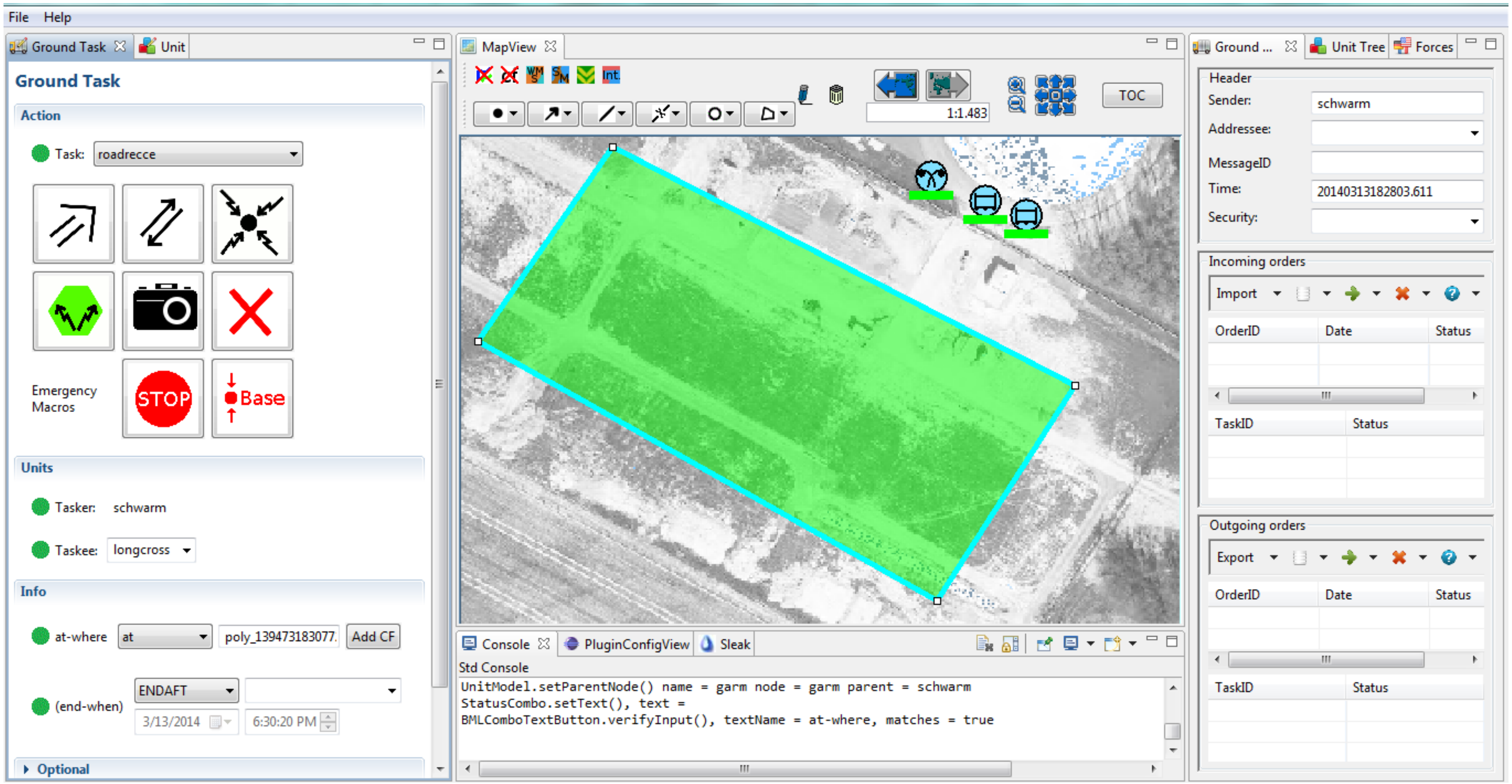
The Multi-Robot System
Payload

Payload „Autonomous Driving“
- 3D Laser Scanner
- Xsens positioning (GPS, compass, acceleration sensors)

Payload „CBRNE“
- Weather station
- CBRNE-Sensors
- Xsens positioning (GPS, compass, acceleration sensors)

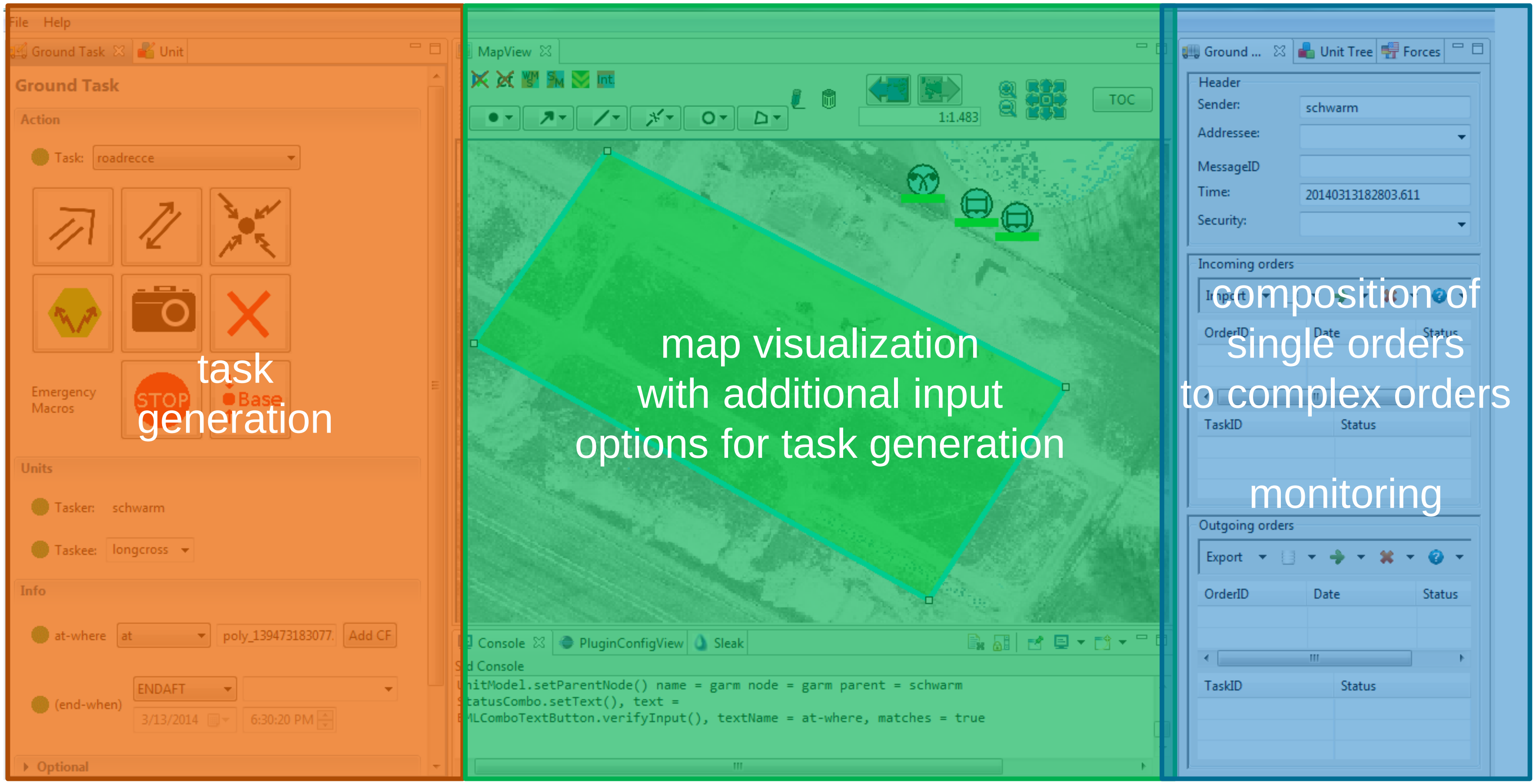
C2LG GUI

The Graphical User Interface



C2LG GUI

The Graphical User Interface

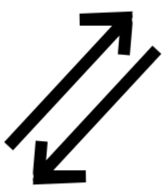


Fraunhofer FKIE

Tasks (1)

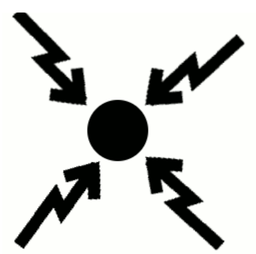
move

Ground vehicle move to position



patrol

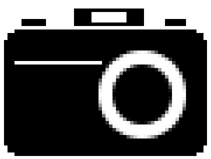
A route is secured by the fleet.



observe

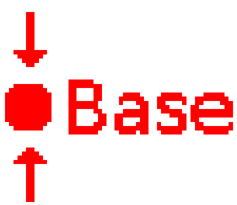
A target object is observed by the MRS.

Tasks (2)

	**reconnaissance**	The MRS is reconnoitering the target area.
	**imagery intelligence gathering**	A picture is taken and reported back.
	**disengage**	Cancel a task.

Emergency Marcos

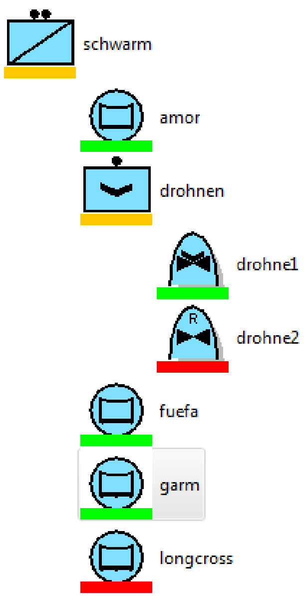
Emergency Stop
Cancel all current tasks.

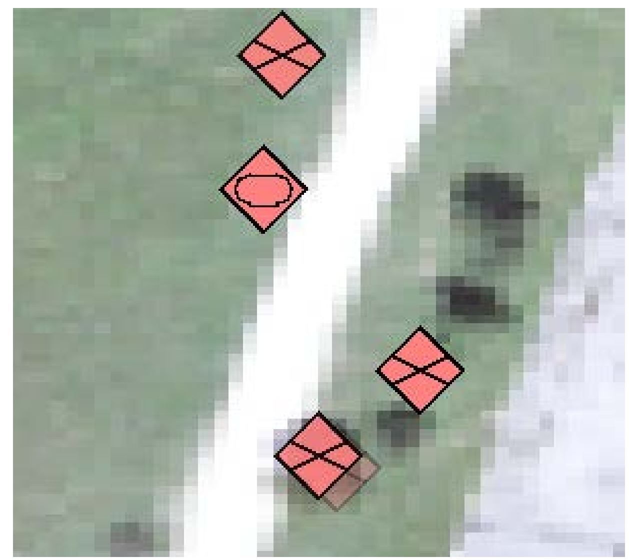


Emergency Return to Base
All robots return to base.

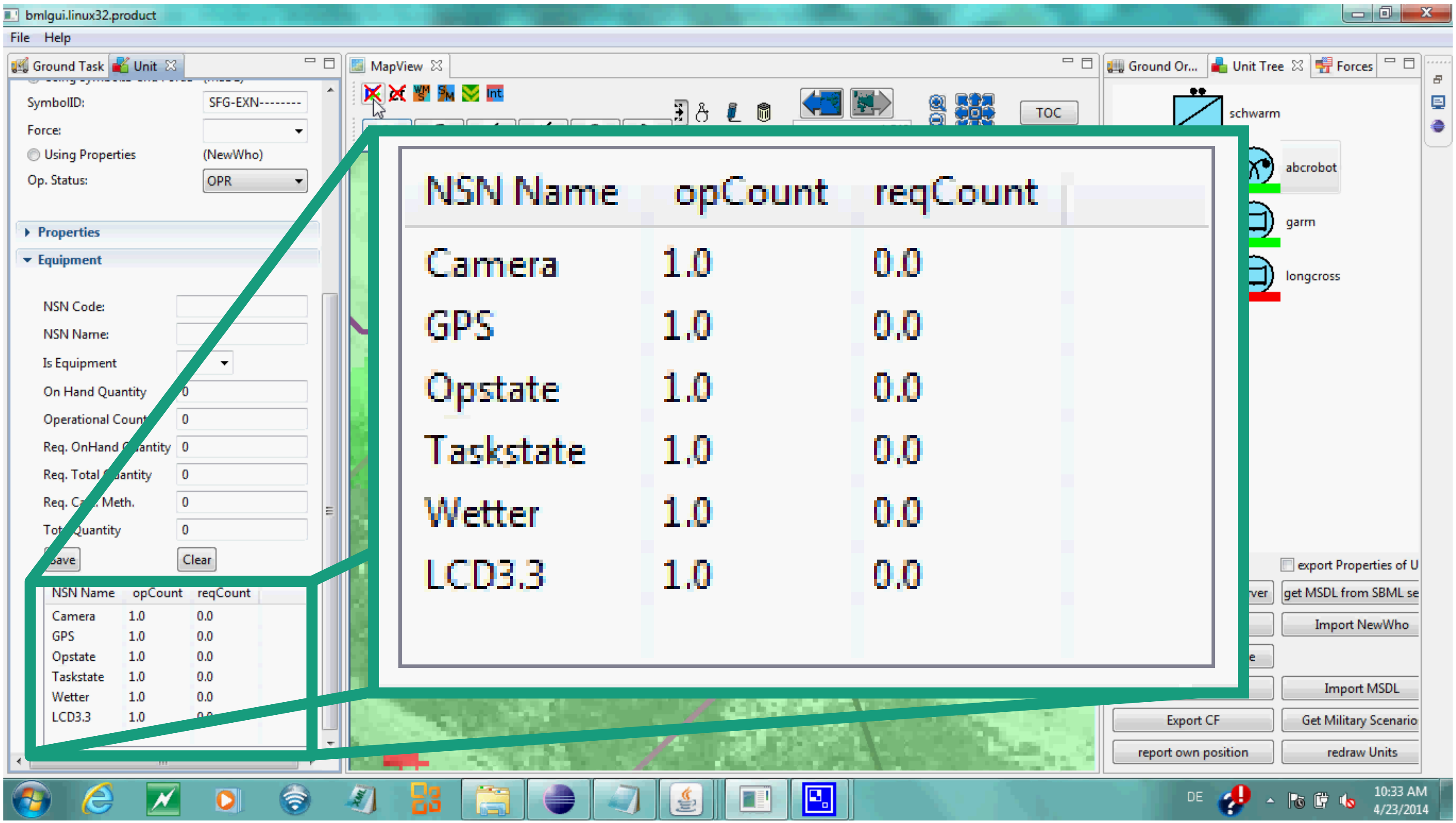
Reports in BML

- Reports are also expressed on “high-level”.
- Aggregate data to produce high-level information.
  - Examples: Robot status, Red-Force Tracking



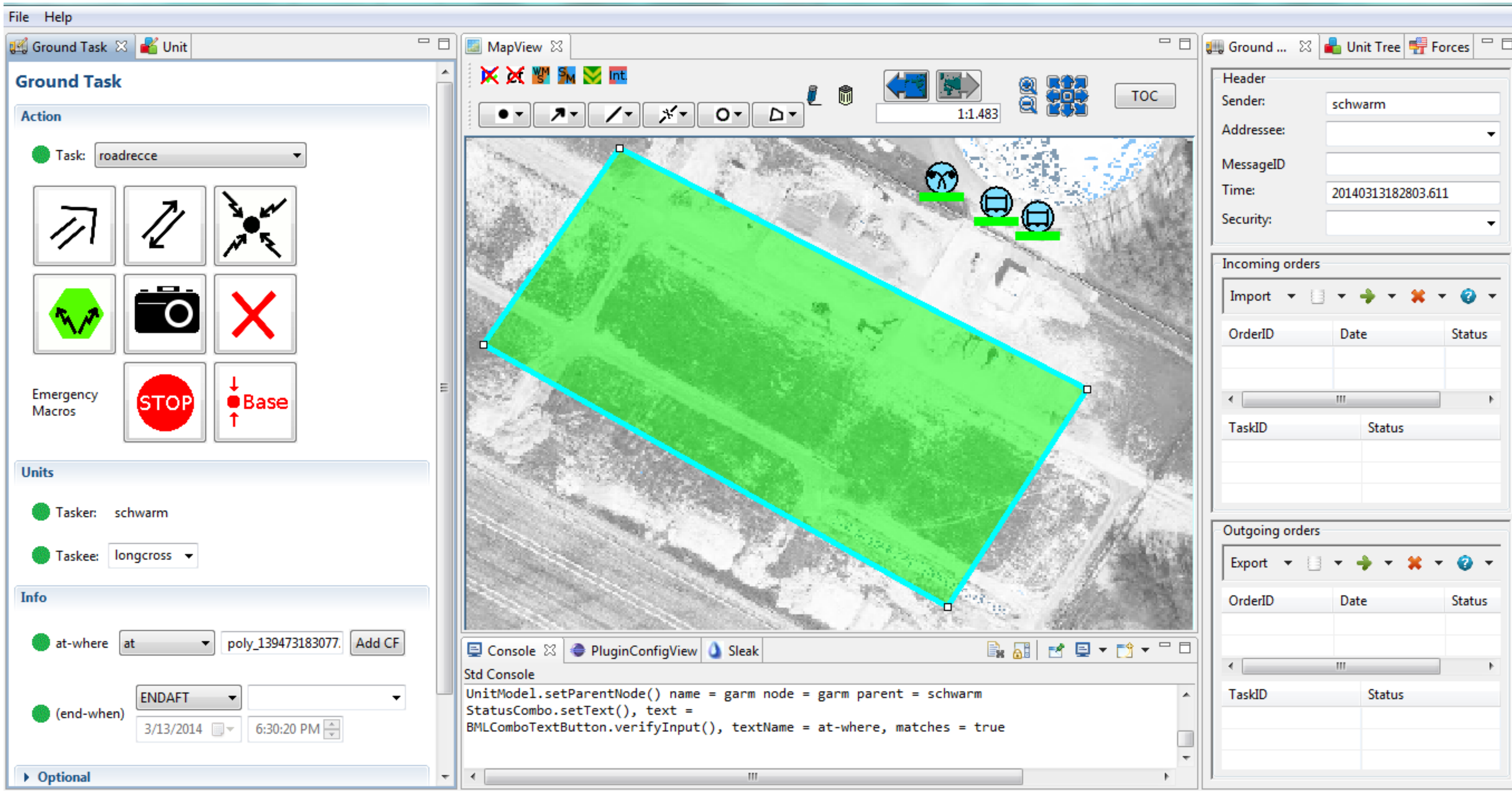


Reports
Capabilities



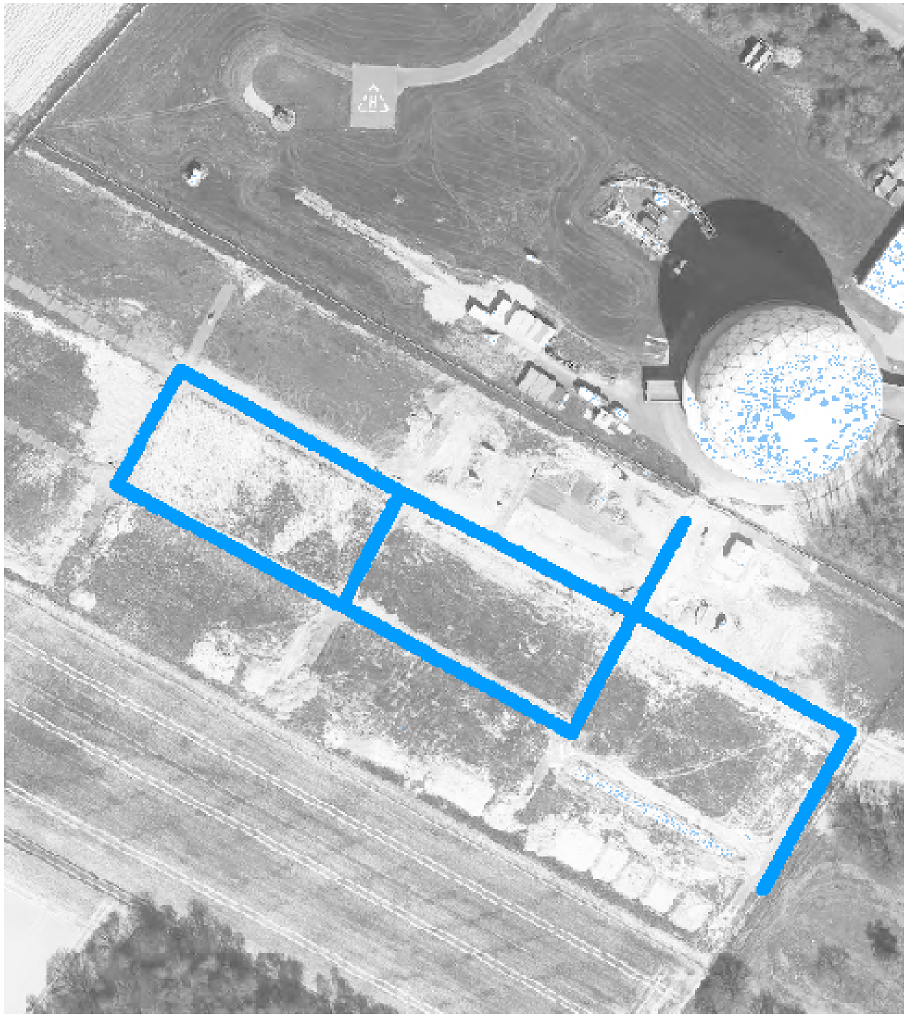
Fraunhofer FKIE

Planning
Enter High Level Task

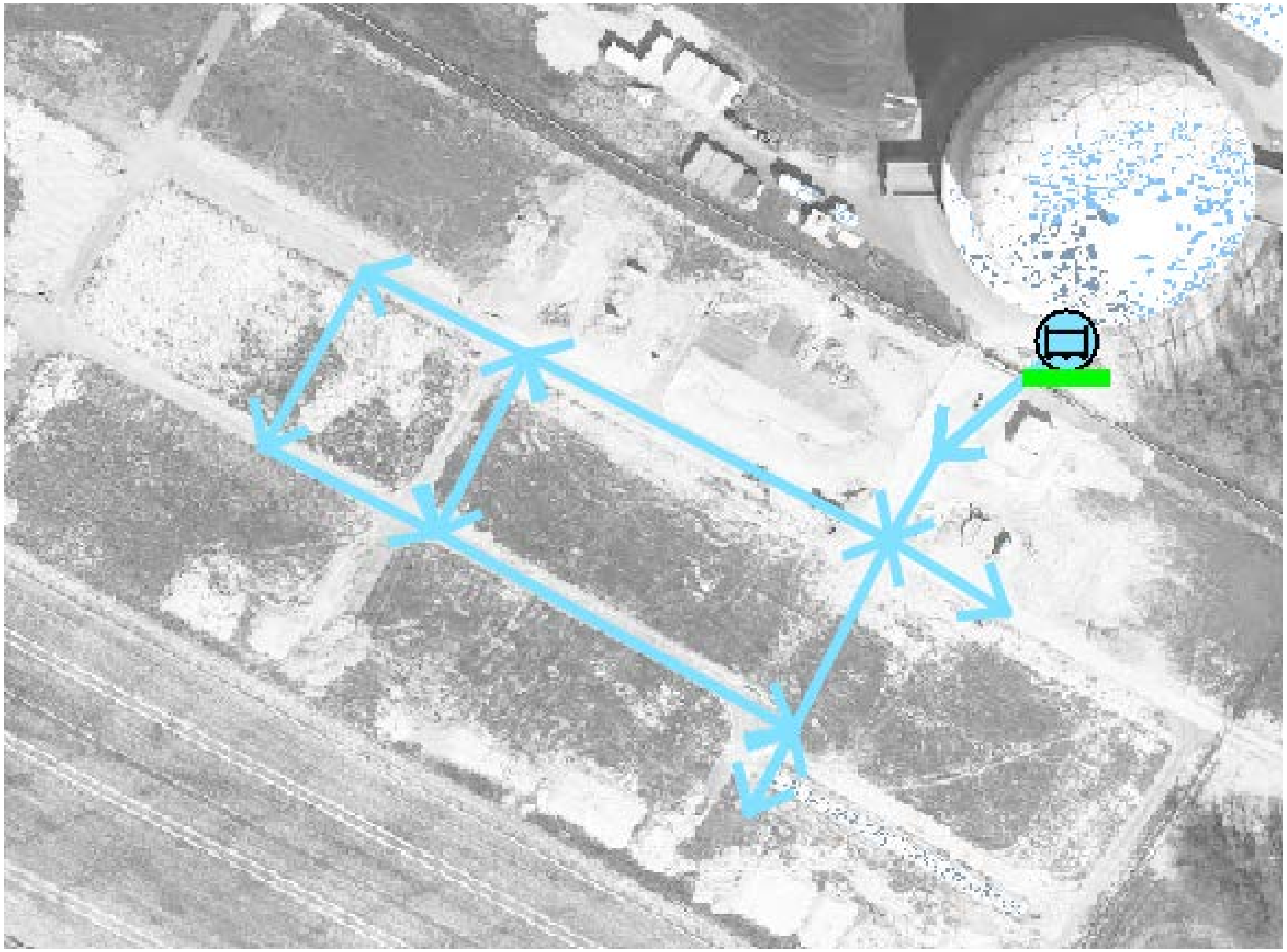


Planning
Automatic Process

- relies on descriptions how to get from high level tasks to low level (executable) tasks
- planning system can use known information like
  - previously measured data from MRS like occupancy grids
  - known road network
- planning creates low level tasks, assigns them to respective robots and sorts them, chronologically.



Planning
Show Plan to User via BML



Reports
Sensor Date Interpolation

Visualization of measurements from CBRNE robot

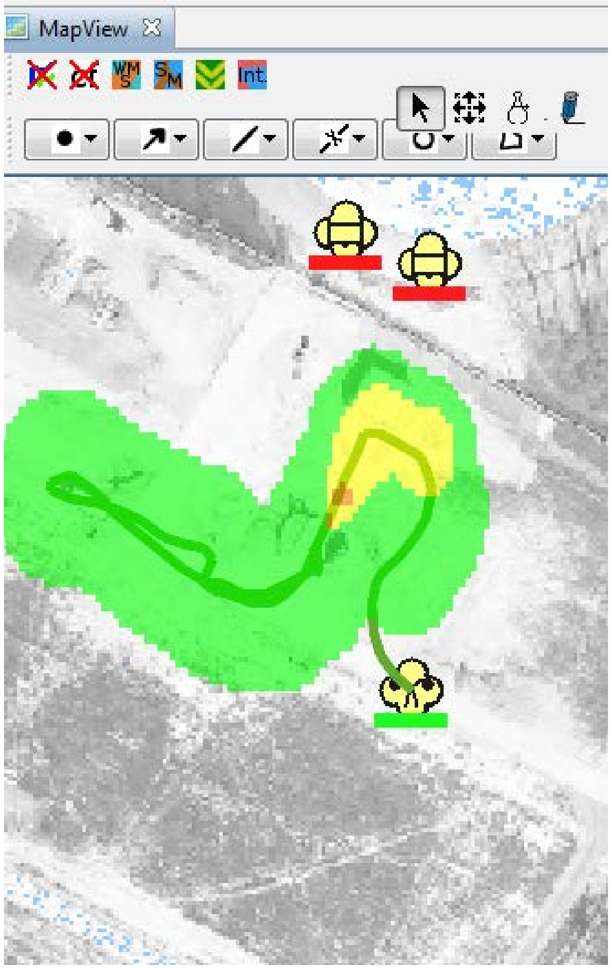
green: harmless

yellow: alarming

orange: hazardous to health

new BML report “Measurement”

Phenomenon
Reporter Identification
Sensor Identification
Measured Value
AtWhere
When
Certainty
Label



Fraunhofer FKIE

Report
Pictures

Pictures are sent via the

Sensor Data Return Channel

- on demand
- automatically

Demonstration – STARO 2014 CBRNE RECCE