Concept & Rules

- ELROB 2020 -

11th European Land Robot Trials

www.elrob.org

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1 Introduction

The ELROB is an annual robotics competition. Its purpose is to demonstrate and compare the capabilities of unmanned systems in realistic scenarios and terrains. All tasks and scenarios are developed in close collaboration with experienced users from possible application domains.

The ELROB explicitly addresses the field of robotics in Europe. The trial is held annually at changing locations throughout Europe.

1.1 Potential Participants

The ELROB is open to:

- Users
  These are (future) professional users of robots.

- Industry
  These are designers and manufacturers of integrated ground robots or accessories for these robotic systems.

- Research facilities
  These are universities and other research institutes focusing on (partial) solutions relevant to the considered domains.

See section 3 on how to apply for participation.

1.2 Scenarios and Tasks

The ELROB defines a variety of scenarios instead of only one single mission. These scenarios include, for example, security missions, convoying and reconnaissance by day and night. All scenarios are developed in collaboration with users from possible application domains. For a description of current tasks as well as scenarios of former events visit the ELROB website.

The different scenarios are chosen to test specific aspects of robot deployment. Some challenges are common to all tasks; others are specific to certain tasks. Most of the scenarios have a focus on driving distances of up to several kilometres. A continuous broadband radio communication between a control station and the unmanned vehicle cannot be expected. Furthermore, it may be difficult to have continuous GPS reception.

The organizers strongly encourage autonomous solutions.

Each participant can subscribe to one or more scenarios. In advance to the event the organizers will define and publish the scenarios (for details see section 5.2.1) and provide sensor data sets recorded on the actual trial area (see section 5.4). This allows the participants to adequately prepare for the environmental and technical conditions.

1.3 Course of Action during a Trial

All teams that successfully completed the application procedure (see section 3) and whose vehicle meets the necessary requirements (see section 4) will receive time slot(s) in each registered scenario. A general schedule for the event can be found on the ELROB website; a detailed schedule for each scenario will be published on site at least one day in advance.

In the setup phase, the vehicle will be put into operation and prepared for the start on the actual track. One team member, the "operator", is allowed to control the vehicle from a dedicated control station.

A second team member, the "technical assistant", accompanies the vehicle on the track. This technical assistant, however, is not allowed to control the vehicle. The run will be supervised by the organizers. Participants might be allowed to repeat the run on request.

Detailed regulations regarding the actual trials can be found in section 5.2.

1.4   Rules

Please read all information available on the ELROB website carefully – especially this document!

The exact organization and conditions of the trial will be governed by a set of rules and descriptions published on the ELROB website. Rules (including this document) and scenarios are subject to change. Please check the ELROB website for updates regularly!

In case of any questions, remarks and problems regarding the rules, participants are advised to contact the organizers immediately. Violations of the organizers' rules or instructions will result in an exclusion from the event.

2   Eligibility

2.1   Team Membership

Each organization (from the research, industry or user domain) which is going to take part in the ELROB has to establish a team. This team represents its organization and effectively participates in the trial.

A team is comprised of the individuals identified to the organizers on the team roster. Only these individuals are team members. Each team must designate a single individual to serve as the team leader. The team leader must be at least 21 years of age and must hold European citizenship. Proof of European citizenship for the team leader must be provided with the application as described in the application instructions (see section 3.1). The organizers' representatives will verify these documents.

The team leader will serve as the primary point of contact with the organizers. The team leader must sign the application, must provide a Letter of Intent (LOI) including the Liability Statement, and must be present at the team leader meeting. An individual may be the leader of only one team, but team members may serve on multiple teams.

Team leadership may be transferred from the team leader to another eligible individual. However, there may be only one team leader at any time. Transfer of team leadership occurs when the organizers receive a new LOI. The form must be signed by the former team leader and the new team leader. The new team leader must also submit a proof of citizenship.

Although the number of individuals listed on the team roster is not expressly limited, the organizers will impose a limit on the number of team members allowed into the designated areas at the ELROB event. The organizers will communicate the limit to the team leaders upon notification of selection.

For details on the application procedure and the necessary documents (Letter of Intent, Liability Statement, team roster etc.) look at section 3 below.

2.2   Non-European Participation and Sponsorship

Non-European team members are eligible; however, the team leader must hold European citizenship. Non-European corporations and non-governmental organizations may participate as team sponsors. Teams receiving funding or any form of support from non-European governments or non-European governmental organizations are not eligible to participate.

2.3   Team Funding and Support

The cost of developing, fielding and insuring entered vehicles is the sole responsibility of the individual teams. The organizers will not provide funding for the purpose of ELROB entry or participation. However, depending on the available budget there might be the possibility of getting a compensation for students' travel costs, see section 7.1.

3 Application Procedure

3.1 Basic Requirements

World Wide Web access, e-mail access and basic word processing are necessary to complete and submit the application and to communicate with the organizers of the ELROB.

The application consists of four parts:

Part 1:   Team Application including Letter of Intent (LOI) & Liability Statement.

Part 2:   Team Information, selection of scenario, and Vehicle, Radio and Exhibition Specification Sheet

Part 3:   Team Roster, Scenario Application Paper (SAP)

Part 4:   Payment of 500 EUR non-refundable registration fee

Instructions for obtaining the above-mentioned ELROB application materials and for proper submission can be found on the ELROB website.

Note that modified LOIs will NOT be accepted!

A team that has submitted application parts 1 and 2 before the deadline and has received acknowledgement from the organizers becomes an ELROB entrant. However, to remain an entrant and to successfully finish the application procedure, part 3 and part 4 have to be completed before the deadlines as well. All deadlines will be published on the ELROB website.

Materials received after the respective deadlines cannot be considered and will be discarded by the organizers.

3.2 Submission Procedures

Application documents must be submitted using the transmittal instructions on the forms. The receipt of application documents will be acknowledged by the organizers.

Application materials remitted using any kind of delivery service should be addressed to:

Frank E. Schneider
Fraunhoferstr. 20
53343 Wachtberg
Germany
Tel.: +49 228 9435 481
Fax: +49 228 9435 16 481
E-mail: elrob@fkie.fraunhofer.de
URL: www.elrob.org

The time of receipt for each package will be logged in the organizers' mailroom. The time of receipt for each electronic document will be logged by the organizers' e-mail system.

3.3 Qualification Process

A scientific qualification process is obligatory for all ELROB entrants. For each scenario in which a team is going to participate a Scenario Application Paper (SAP) has to be prepared. Therein the participants have to describe how their team will tackle the challenges of the selected trial scenario.

The participants should explain how their system will cope with problems typically arising in the selected task.

A scientific advisory board will then perform an evaluation of the SAP. Currently, this board is identical with the Chief Judge Team (see section 5.1). To gain as much scientific progress as possible, all Scenario Application Papers and their evaluation will be published on the ELROB website.

This qualification process must be completed by all teams that wish to take part in the ELROB.

3.4 Publication of Materials

For each team the following documents will be published on the ELROB website:

- the Team Information, to enable contact from potential sponsors, other teams and media,

- the Scenario Application Papers (SAP) and the corresponding evaluation results for each selected scenario (see section 3.3), and

- all measures collected for evaluation purposes; see section 6.

Additionally, any information related to the participants' awards (see section 7) will be published on the ELROB website.

See the ELROB website on what information is exactly contained in these published materials.

3.5 Registration Fee

Each team that successfully completed the application procedure will have to pay a non-refundable registration fee of 500 EUR. This fee, together with additional donations for the ELROB from sponsors and companies, builds the budget for selective travel support. The resulting budget will be completely redistributed among the participants according to the rules described in section 7.

4 Vehicle Requirements

4.1 Mode of Operation

During the application procedure, each team has to specify the mode of operation for their vehicle. The mode of operation can be chosen from three categories: full autonomy, supervised autonomy and tele-operation. The categorization will be verified and, if necessary, corrected by the ELROB authorities (e.g. the "Chief Judge Team", see section 5.1).

4.1.1 Fully Autonomous Vehicle Operation

In fully autonomous operation, the operator is not allowed to interact in any way with the vehicle after it has left the starting area and entered the trial route. Direct control as well as passive monitoring via an operator device is prohibited. Interaction is only allowed to provide the vehicle with necessary input data (see section 5.3.6) before the vehicle leaves the starting area and to receive result data from the vehicle (see section 5.3.7) after the trial has finished.

If the vehicle or operator console signals an incident it cannot cope with autonomously, the operator (or, on the operator's request, the "technical assistant"; see section 5.2) may interact with the system. Note, however, that any interaction between the technical assistant and the vehicle will have a negative influence on the resulting evaluation (see section 6).

In autonomous operation, vehicles and control station must be completely unmanned.

4.1.2 Supervised Autonomous Vehicle Operation

In supervised autonomous operation, a vehicle operates autonomously, but at the same time retains continuous human oversight ("man-in-the-loop"). Direct control is only allowed to provide the vehicle with necessary input data (see section 5.3.6) before the vehicle leaves the start chute and to receive result data from the vehicle (see section 5.3.7) after the trial has finished.

During the trial the operator is allowed to execute perception tasks and to monitor the system. At any time the operator (or, on the operator's request, the "technical assistant"; see section 5.2) may actively control the system. Note, however, that any interaction between the technical assistant and the vehicle will have a negative influence on the resulting evaluation (see section 6).

In supervised autonomous operation, vehicles should be unmanned. After prior agreement with the organizers, each vehicle can be manned with a safety driver (accompanied by a member of the Chief Judge Team). Operator and safety driver may be the same person. In any case, only one operator is allowed.

4.1.3 Tele-operated Vehicle Operation

For tele-operated vehicles the operator is allowed to control the vehicle at any time during the trial. On the operator's request, the "technical assistant" (see section 5.2) may interact with the vehicle. Note, however, that any interaction between the technical assistant and the vehicle will have a negative influence on the resulting evaluation (see section 6).

In tele-operation, vehicles must be completely unmanned.

4.2 Vehicle Limitations for UGVs

A team's entry to the trial must be at least one ground vehicle that is propelled and steered principally by traction with the ground. The type of ground contact devices (e.g. tires, treads and legs) is not restricted. The vehicle must not damage the environment or any infrastructure at the ELROB location.

Vehicle operation must conform to any regulations or restrictions imposed by the applicable land-use authority.

Vehicles weighing more than 75 kg must be equipped with a recovery facility. The vehicle must be able to travel on asphalt pavement without damaging the pavement surface.

The participants should be aware of the fact that huge and/or heavy vehicles will face difficulties in some scenarios. The same holds for small/light vehicles in long-distance scenarios.

4.3   Vehicle Limitations for UAVs

The UAV must weigh less than 5 kg or have special and valid flight permission according to the law of the host country. Obtaining the permission falls into to the sole responsibility of the team.

The team must have appropriate and valid aircraft liability insurance for the UAV and the operator. Obtaining the aircraft liability insurance falls into to the sole responsibility of the team.

The maximum cruising altitude is 30 m over ground.

Tethered systems that are designed to extend more than 10 m above the surface must be painted to enhance their visibility. Entrants are advised that the European Aviation Safety Agency (http://www.easa.eu.int) regulates the operation of moored (tethered) balloons. Entrants are advised that the route may be adjacent to utility and power structures and high-voltage power lines.

All teams must obey the aviation rules and laws of the host country. After the final location for the trials is announced, there might be additional local regulations that must be adhered to.

4.4   Classified Data and Devices

No classified data or devices may be used by a team in preparation for or during the ELROB.

4.5   Vehicle Safety

The organizers do not guarantee the safety of any vehicle entered in the ELROB, notwithstanding any rule or the organizers' acceptance of any application document, vehicle specification sheet, video demonstration or any inspection or demonstration required for participating in the ELROB.

4.5.1   Health & Safety Standards

All trial teams and vehicles must comply with all applicable safety regulations (see http://europe.osha.eu.int/ for details).

After the final location of the trials is announced, there might be additional local regulations that must be followed. All teams must obey the health & safety rules and laws of the host country.

4.5.2   Environmental Impact

Any aspect of vehicle activity or operation that has an unacceptable impact on the environment is prohibited. These activities include destructive vehicle behaviour, the use of abnormally hazardous substances or materials, and generally reckless operation. Potentially hazardous equipment or activities must be identified to the organizers for review in the vehicle specification sheet and at the site visit.

4.5.3   Wireless Emergency Stop and E-stop mode

It is the sole responsibility of the team to properly install a wireless emergency stop (E-stop) system in its vehicle. The E-stop system must be fully functional for the participant to be eligible to participate in the ELROB.

In case of emergency (i.e. imminent danger for individuals and/or the vehicle) the E-stop system must be activated instantaneously.

Triggering the E-stop mode brings the motion of the vehicle to an immediate stop, with brakes applied to hold the vehicle even if it is on a slope. The E-stop mode should be latched so that its state cannot be changed unintentionally after initiation. Electrical connections to the E-stop must be ruggedized to ensure functionality even after exposure to adverse (damp or dusty) environmental conditions and a high vibration environment.

The vehicle should be ready to promptly resume motion as soon as the E-stop mode has ended. The E-stop mode may be entered numerous times during a trial, and each E-stop event may last up to several minutes.

In the special case of a vehicle with a safety driver, entering the E-stop mode requires the driver to stop the vehicle immediately and completely. If applicable, additionally the handbrake must be put on and the gearbox/automatic transmission must be put into the neutral position.

4.5.4   Vehicle mounted Emergency Stop Unit

Each vehicle must be additionally equipped with an externally actuated emergency stop capability. Activating the emergency stop must promptly bring the vehicle into the E-stop mode, leading to an immediate and complete stop. At least one actuator and its labelling must be easily visible and accessible from anywhere around the vehicle. The manual emergency stop must be easy to identify and to activate, even if the vehicle is moving at a walking pace. The operation instructions for emergency stop actuators must be clearly labelled in English. The instructions must not be interfered with by any other labelling or advertising.

4.5.5   Warning Devices

Each vehicle shall display one or more flashing amber warning lights, the combination of which results in a visibility of 360 degrees azimuthally around the vehicle. The warning light(s) shall continuously operate whenever the vehicle is switched on. The vehicle may not commence movement until the warning light(s) have been in operation for 5 seconds.

The warning light(s) shall comply with standards for warning lights and shall not produce light that can be confused with those of public safety vehicles such as law enforcement, fire or ambulance.

4.6   Towing Requirements

Each vehicle over 75 kg must be designed to facilitate removal from the route should the vehicle be disabled. These vehicles should have towing points front and rear, or if the vehicles design precludes towing, the vehicles should have hoist points. Wheeled or tracked vehicles must have a free-wheel mechanism that enables the wheels or tracks to spin freely in order to allow towing.

4.7   RF and Other Communication Equipment

After the final location for the trials is announced, there will be additional national and local regulations for RF and other communication that must be adhered to.

Please note that the participants have to take care of the frequency regulations themselves. The frequencies reported by the teams will be published on the ELROB website. There will be no frequency management by the organizers!

The overall height of the control station antenna must not exceed 2.5 m. The overall height of the vehicle antenna must not exceed 2.5 m.

To be precise: No antenna of any RF or other communication equipment used by the team shall exceed the overall height of 2.5 m.

4.8 Position Determination

Vehicles may be equipped to receive and process electronic position determination signals (such as GPS, GLONASS, Galileo, WAAS, EGNOS etc.) that are openly available to all teams. Position determination signals that are not available for free (e.g. OmniStar, SAPOS etc.) are prohibited. Any costs associated with any subscription service are borne by the team.

GPS signals might not be available throughout the route at all times. Be aware that GPS alone will not provide adequate navigation information to the vehicle. Additionally, visual navigation may be disturbed. There may be dust, smoke and other visual obscurants on the route, and visual-spectrum-only sensing may not be adequate under these conditions.

4.9 Pre-Trial Testing

Testing of trial vehicles or components is the sole responsibility of each team. The use of public lands for this purpose is at the team's own risk and must be in accordance with the applicable laws.

5   Regulations

Pushing the development of revolutionary technologies is a key objective of the ELROB. Entrants are invited to communicate directly with the organizers regarding any rule that restricts their ability to demonstrate technical achievement and innovative solutions to intelligent ground vehicle behaviour.

5.1   The Chief Judge Team

The Chief Judge Team is a group of officials designated by the organizers as such. The Chief Judge Team is the final authority on all matters referred to in the rules and on all matters affecting the operation of the ELROB.

The Chief Judge Team has the authority to modify the rules at any time. Reasons for modifications include, but are not limited to, the accommodation of promising but unexpected technical approaches that would have been prohibited by the rules and the exclusion of approaches that seek to participate without demonstrating the desired technical achievement in vehicle behaviour that is the purpose of the event. The organizers will announce any modifications to the rules with an e-mail to all entrants and a corresponding statement on the ELROB website.

The Chief Judge Team may revise the schedule of the trials and provide interpretation of the rules at any time and in any manner that is required. The Chief Judge Team's decisions regarding the rules are based on a number of factors, such as safety, legal compliance, fairness, trial goals, environmental protection and efficient operations.

Decisions of the Chief Judge Team are final.

5.2   Procedures at ELROB

5.2.1   Route Definition

Per scenario, three route definitions will become available over time. See the ELROB website for further details and examples from former events. These definitions are:

1. a preliminary general description of the scenario and the route,   (via ELROB website, together with the general announcement of the ELROB)

2. a detailed description of the scenario and the route,   (via ELROB website, about 3 months before the event)

3. map and waypoints of the route.   (on site, with the start of a trial)

Inspection of the trial area by any entrants is not allowed or possible.

Note that, instead of physically inspecting the trial area in advance, there is the possibility of receiving recorded sensor data in form of standardized Common Shared Data Sets (CSDS) for each scenario. These data can be used to train and improve various parts of a robot's software architecture. See section 5.4 for further details.

5.2.2   Starting Area/Departure Procedure

Each team has to name a "technical assistant" and an "operator"; these two people build the troop.

Trial vehicles start in sequential order at specified time intervals. The start order is announced on the ELROB website. The whole run will be supervised by the ELROB officials.

During the departure procedure, the vehicle will be put into operation and prepared for the start on the actual track. All required material has to be moved promptly by the troop from the unload location to the start chute. The start chute is a part of the starting area directly before the departure line. A team must place its vehicle in the start chute prior to enabling it for operation. Note that there will be no support at this location (no table, no chair, no electricity etc.).

Each vehicle must be enabled for operation within 5 minutes after entering the start chute. Vehicles must be prepared to wait in the start chute for up to 30 minutes. At the designated starting time the vehicle must be waiting in the start chute, readily prepared for operation. As soon as the departure signal is given by an ELROB official, the vehicle must depart from the start chute.

The technical assistant is responsible for operating the wireless emergency stop system (E-stop); see section 4.5.3. Thus, he will leave the starting area (and the control station) and will accompany the vehicle as soon as the start signal has been given.

5.2.3 Vehicle Control

There is only one control station allowed; this control station is part of the starting area (see section 5.2.2). It is not possible to see the entire trial area from this control station. The operator must not leave the control station during the trial.

Only the operator is allowed to control the vehicle. The exact kind of permitted interaction depends on the chosen mode of operation, as defined in section 4.1.

The technical assistant accompanies the vehicle during the trial and operates the E-stop. At any time in the preparation phase and during the trial an ELROB official may prompt the technical assistant to put the vehicle in E-stop mode due to safety or operational reasons. As soon as the official agrees, the vehicle may be resumed from E-stop mode.

In case of emergency (i.e. imminent danger for individuals and/or the vehicle) the technical assistant must self-reliantly activate the E-stop.

Only due to an explicit request of the operator, the technical assistant may interact with the vehicle. Without the operator's request, the technical assistant may interact with the vehicle only in case of emergency (i.e. imminent danger for individuals and/or the vehicle) and only after activation of the E-stop.

In the special case of a vehicle with a safety driver, the driver may interact with the vehicle only in case of emergency (i.e. imminent danger for individuals and/or the vehicle).If so he must put the vehicle immediately into E-stop mode (see 4.5.3).

Any other unauthorised interaction between the technical assistant/safety driver and the vehicle will lead to the abortion of the trial.

Note, moreover, that any interaction between the technical assistant and the vehicle, including any activation of the E-stop, will have a negative influence on the resulting evaluation (section 6).

In the following situations the actual trial can be aborted by the ELROB officials. However, depending on free timeslots, the team may apply for another attempt.

- If a maximum number of E-stop activations per trial is reached.
- If a vehicle that is not in E-stop mode does not progress for longer than 5 minutes.
- If dangerous or destructive behaviour of a vehicle is imminent (and an ELROB official places the vehicle in E-stop mode)

The organizers will take measures to stop a vehicle that does not respond promptly to an E-stop command, even if these measures may result in damage to the vehicle.

5.2.4   Regulations for the Trial Route

While a vehicle is on the route, ELROB officials might follow it.

During the trial there will be no communication between the operator and other individuals, especially other team members, with the only exception of communication with ELROB officials.

The technical assistant may be contacted by the operator, but only indirectly via the ELROB officials. There will be no direct communication between operator and technical assistant during the trial.

Apart from the technical assistant, no team member will physically intervene in any aspect of vehicle operation or physically participate in vehicle tracking from the time the vehicle clears the start chute until it is returned to the team. A vehicle is returned to the team after the trial is aborted or after it crosses the arrival line. During the trial refuelling of vehicles is not permitted.

Apart from designated viewing areas, teams may not operate any vehicles or position any team members on or near the route at any time during the ELROB event.

If the ELROB officials determine that letting a vehicle proceed on the trial route would hinder subsequent ELROB operations, the trial can be aborted. The team may apply for another attempt.

5.2.5   Obstacles on the Trial Route

The route will include mobile obstacles and on-the-fly modifications. For example, a dead-end can appear where the previous participant had a free road.

The vehicle must avoid collisions with any obstacles, moving or static, on the route. The organizers will place obstacles along the route to test obstacle avoidance capabilities. Incidental or non-damaging contact with obstacles may not result in trial abortion.

5.2.6   Abortion of Trials

A vehicle must not continue on the route if the trial was aborted. The organizers will coordinate the recovery the vehicle together with the team. Teams may enter the trial area only if directed by the ELROB officials.

If a participant has to abort the trial because of technical difficulties, the Chief Judge Team may allow repeating the trial, depending on available start slots.

5.3   Data Requirements

All data requirements have to be met. Submitted data which do not comply with the formats specified in the following section will not be handled/accepted.

5.3.1   Data Transfer/Exchange

All electronic data transfer/exchange in ELROB activities will be done via WebDAV.

For any electronic data exchange a computer has to be connected to a standard IPv4 based Ethernet using a CAT6 twisted pair 8P8c/RJ45 cable. The cable will connect the computer via a switch to a special ELROB server. There will be no other devices on this dedicated network.

Either an arbitrary static IP address in the range of 10.10.10.[11-111] may be selected, or an IP address can be obtained via DHCP from the ELROB server with the range 10.10.10.[112-254].

Access to the mission data on the dedicated ELROB server is realized using WebDAV (HTTP V1.1 based). The access requires a login and a password which will be received from the organizers beforehand. The general format of mission input data is described in section 5.3.6.

When a mission is finished, the results have to be put on the same ELROB server, again using WebDAV with the same login and password. The general format of mission output data is described in section 5.3.7.

The following schematic drawing illustrates the principle of electronic data exchange for the actual ELROB trials:
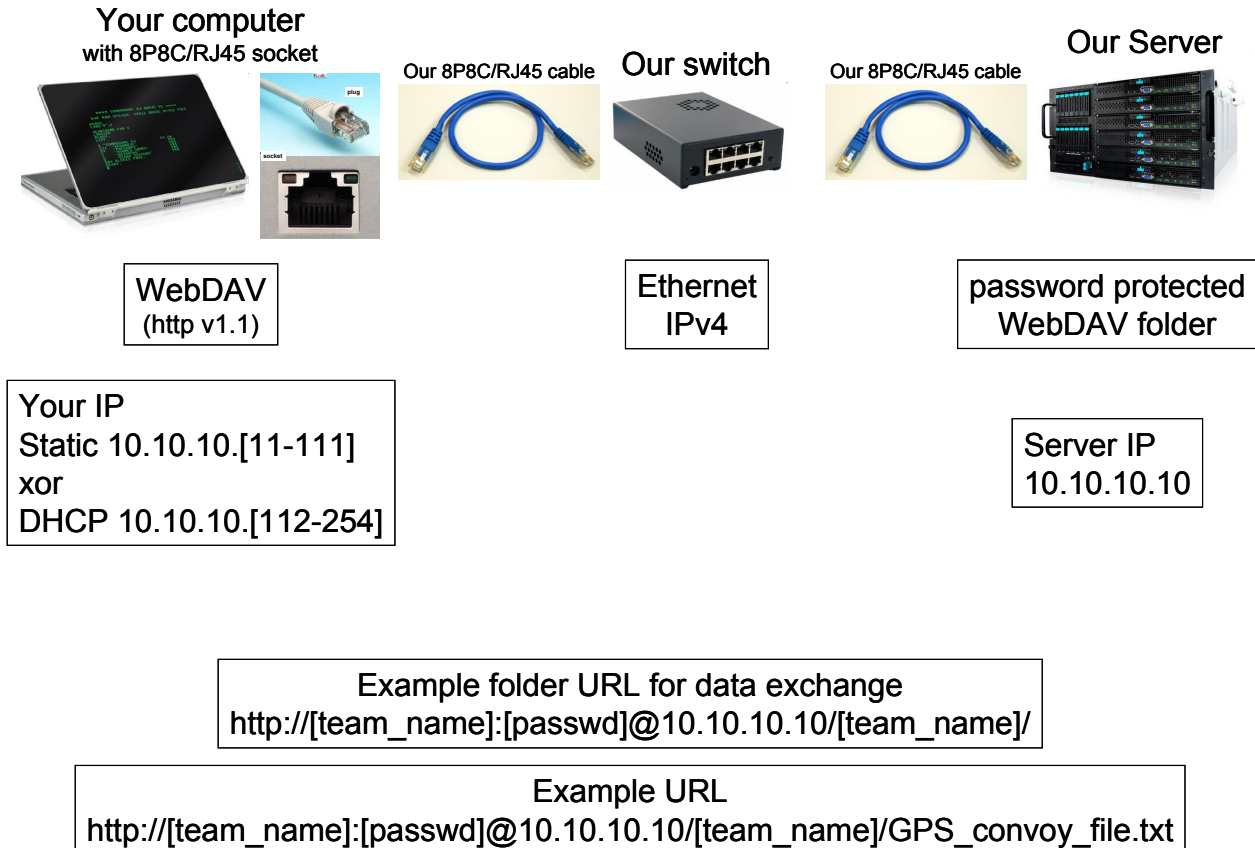
For a list of standards and references related to this electronic data exchange mechanism, refer to appendix C.

5.3.2   Character Encoding

The character encoding that is used in all ELROB activities is:

UTF-8 (8-bit UCS/Unicode Transformation Format)
http://en.wikipedia.org/wiki/UTF-8

5.3.3   Position Encoding

The geographic coordinate system that is used in all ELROB activities is:

Universal Transverse Mercator (UTM) coordinate system
http://en.wikipedia.org/wiki/Universal_Transverse_Mercator_coordinate_system

The geodetic reference system that is used in all ELROB activities is:

World Geodetic System (WGS) 84
http://en.wikipedia.org/wiki/World_Geodetic_System

The following example shows how a waypoint list (e.g. as part of the mission data) will look like:

```
#UTM (WGS84) 3 waypoints
#alpha
32U 559431.82 5545416.83
#bravo
32U 559427.28 5545324.43
#exit point
32U 559422.03 5545299.19
```

5.3.4   Time Encoding

The time zone and time formats that are used in all ELROB activities are:

Central European Time (CET) resp. Central European Summer Time (CEST)
http://en.wikipedia.org/wiki/Central_European_Time

for example: 1971-05-16T23:46:01 CET

and for program use:

UNIX Time/POSIX Time
http://en.wikipedia.org/wiki/POSIX_time

The following code sample produces a valid "full UNIX time stamp":

```c
#include <stdio.h>
#include <sys/time.h>
int main(void)
{
    struct timeval  tv;
    gettimeofday (&tv, 0);
    printf ("%d.%06d", tv.tv_sec, tv.tv_usec);
    return 0;
}
```

It should, for example, result in an output like: 915148798.750000.

5.3.5   Graphics Encoding

The graphics file formats that are used in all ELROB activities are:

Portable Network Graphics (PNG)
http://en.wikipedia.org/wiki/Portable_Network_Graphics

and/or

JPEG (ITU-T T.81, ISO/IEC IS 10918-1 and, if needed, ITU-T T.84)
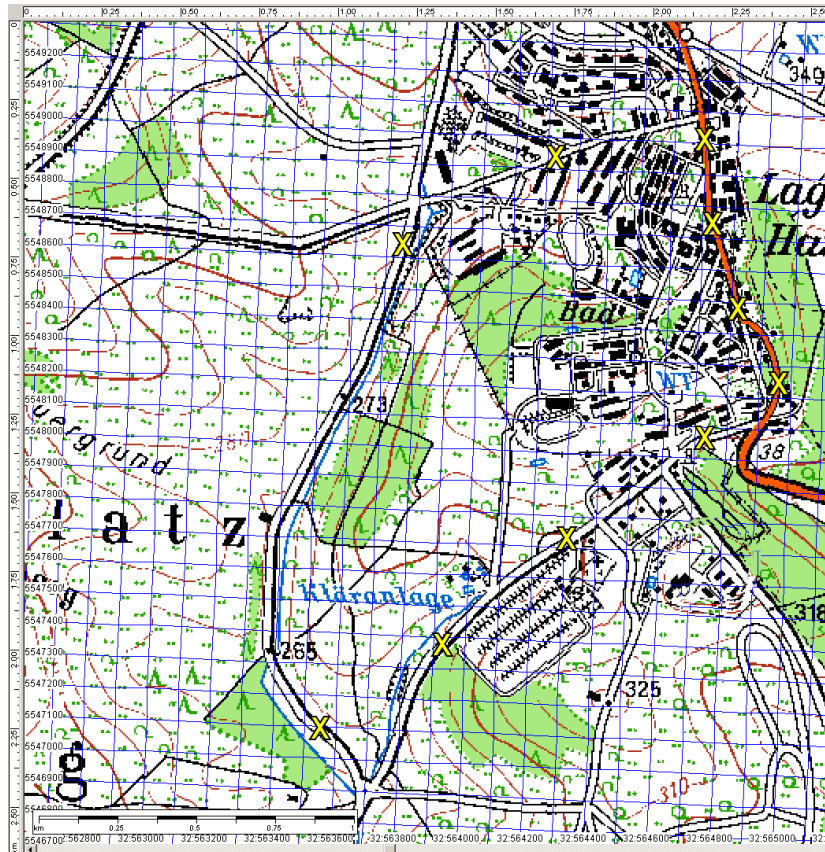http://en.wikipedia.org/wiki/Jpg

5.3.6   Input Data

Input data refers to the data that will be received from the ELROB officials in electronic format via the data link described in section 5.3.1.

The input data consists of:

1. A section of a digital map with UTM grid and UTM coordinates in JPG or PNG format (see example below).

2. A list of UTM coordinates that might specify a list of target areas, a list of waypoints or a list of boundary points (see example for waypoints below).

```
# UTM (WGS84) 8 waypoints
35W 427433.55 7216222.93
35W 427241.47 7216235.05
35W 427117.71 7216185.88
35W 427088.03 7216191.55
35W 427108.11 7216218.62
35W 427520.44 7216880.68
35W 427503.51 7216931.69
35W 427481.76 7216963.17
```

5.3.7 Output Data

Output data refers to the data that the ELROB officials receive from a participant in electronic format via the data link described in section 5.3.1.

The output data should include:

1. A text file containing a list of UTM coordinates, including a full UNIX time stamp, that reflects the route driven by your vehicle, all in consecutive order (see example below).

```
# UTM (WGS84)
[full UNIX time stamp] 35W 427433.55 7216222.93
[full UNIX time stamp] 35W 427241.47 7216235.05
[full UNIX time stamp] 35W 427117.71 7216185.88
[full UNIX time stamp] 35W 427088.03 7216191.55
[full UNIX time stamp] 35W 427108.11 7216218.62
[full UNIX time stamp] 35W 427520.44 7216880.68
```

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```
[full UNIX time stamp] 35W 427503.51 7216931.69
[full UNIX time stamp] 35W 427481.76 7216963.17
[full UNIX time stamp] 35W 427476.80 7217015.29
```

2. Additionally, a section of a digital map in JPG or PNG format that contains the driven route as a plotted path and the position of the detected Objects of Potential Interest (OPI), labelled with an X. (See example below: driven paths are plotted as yellow lines, OPI as red X).

3. The file name of the digital pictures for the detected OPI must contain the UTM coordinate of the OPI (see example below).

```
[full UNIX time stamp]_35W427433.55_7216222.93.png
```

resp.

```
[full UNIX time stamp]_35W427433.55_7216222.93.jpg
```

4. Additionally, a text file containing the list of UTM coordinates, including a full UNIX time stamp, that reflect the positions of the detected OPI, all in consecutive order (see example below).

```
# UTM (WGS84)
[full UNIX time stamp] 35W 427433.55 7216222.93
[full UNIX time stamp] 35W 427117.71 7216185.88
[full UNIX time stamp] 35W 427503.51 7216931.69
[full UNIX time stamp] 35W 427481.76 7216963.17
[full UNIX time stamp] 35W 427476.80 7217015.29
```

5.4 Common Shared Data Sets (CSDS)

The organizers publish recorded real data sets for every scenario on the competition. These Common Shared Data Sets (CSDS) will be created with commonly used sensor devices and will be logged directly on the actual trial area. CSDS shall allow teams that are new to the competition or that have limited access to proper hardware and training areas to test their systems against typical settings of the competition.

The CSDS will be available as early as possible but maximum 1 year before the actual competition. In addition, CSDS from a pool of former competition data sets are available for software improvement, benchmarking, testing, and comparison.

5.4.1 Format of CSDS

All CSDS will be distributed in the ROS bag format. This is the standard log format of the openly available Robot Operating System (ROS). A variety of tools is freely available to get raw sensor information out of recorded ROS bags. See www.ros.org for further details.

The exact composition of sensor devices in a CSDS is scenario-dependent and cannot be generally specified.

5.4.2 Access and usage of CSDS

The open science driven rules of ELROB require that any participant who uses CSDS provided via the ELROB web page has to publish his own data, collected on the competition. This data will become part of the CSDS pool.

This exchange mechanism has to be supervised and verified. Thus, there is no open access to the CSDS. Instead, if a participant is interested in using one or more data sets, he is kindly requested to contact the organizer.

6 Evaluation Measures

For each ELROB trial which has not been aborted, a variety of measures will be collected. The collected parameters are:

- Total runtime (RT)
  The total runtime (RT) is the time from receipt of the mission data until the submission of the result data, limited by the maximum trial time for the scenario. Note that any data handling is part of the RT.

- Operator's interaction time (IAT)
  The operator's interaction time (IAT) measures the time span in which the vehicle does not act autonomously but is controlled by the operator. For an exact definition see section 6.1 below.

- Technician's interaction time (T-IAT)
  Same definition as for IAT, but regarding interactions by the "technical assistant"; see section 6.1 below.

  Note that technician's interactions have a significantly larger influence on the resulting evaluation than simple E-stop activations.

- Total distance driven on the track (DoT)
  The DoT does not measure the absolute driving distance of the vehicle. Instead, the covered distance regarding the optimal track of the scenario is measured.

- Number of E-stop activations
  Every activation of the E-stop has a negative influence on the resulting benchmark.

- Number of correct detections of Objects of Potential Interest (OPI)
  OPI positions must be reported in a specially formatted text file; see section 5.3.7. For a general specification of OPI in the context of the ELROB see appendix A.

- Number of false detections of OPI
  Of course, there should be the fewest possible false positives reported in the above-mentioned text file.

- Delivery of a digital map including the vehicle's track
  See section 5.3.7 for required data formats.

- Delivery of a GPS log file of the vehicle's track
  See section 5.3.7 for required data formats.

- Delivery of a digital map with correctly marked OPI
  See section 5.3.7 for required data formats.

- Delivery of OPI pictures
  Section 5.3.7 defines required data formats; refer to appendix A for required contents.

Depending on the scenario and the vehicle's mode of operation (see section 4.1), only a subset of these measures may be determined. All parameters are either derived from the delivered trial result data or they are externally measured by the organizers. Special access or interfaces to the vehicle's (software) system are not necessary.

Note that all collected data will be published on the ELROB website.

6.1   Definition of Operator's/Technician's Interaction Time (IAT/T-IAT)

Interaction time starts with the moment when someone interacts with the vehicle and/or the operator console (or any other device that interoperates with the vehicle) and ends when this interaction has finished. The operator's interaction time (IAT) measures only interactions by the operator; technician's interaction time (T-IAT) regards interactions by the technical assistant. Refer to section 5.2 for a detailed description of these two roles.

If a vehicle is completely remote-controlled, this results in an IAT identical to the runtime (RT); T-IAT is determined additionally.

Examples of IAT-relevant activities:

- Manual handling of the input data in order to put it into the system.
- The operator steers the vehicle manually.
- A new GPS waypoint is entered via the operator console.
- Only for <u>fully autonomous operation</u>: the operator passively watches a video stream, e.g. to detect potential dangers for the vehicle.

The mode of operation (see section 4.1) has an influence on what is rated as IAT-relevant interaction:

- In <u>fully autonomous operation</u> direct control as well as passive monitoring via an operator device is measured as IAT.
- In <u>supervised autonomous operation</u> the operator is allowed to execute perception tasks and to monitor the system; only active control is measured as IAT.
- For <u>tele-operation</u> the IAT is not measured since, per definition, it is identical to the runtime (RT).

Note that, in all cases, the time for manual handling of the system's input/output data is measured as IAT.

While on the track, the technical assistant just accompanies the vehicle and operates the E-stop system (see sections 4.5.3 and 5.2). Any further interaction between technical assistant and vehicle is counted as T-IAT.

7 Awards for Participants

Highly committed/dedicated participants as well as best performance in the scenarios and also novel scientific or creative solutions will be awarded. Therefore, the organizers established two complementary award systems: selective compensation for travel costs and non-monetary awards.

The non-refundable registration fee paid by the participants and further donations from sponsors and companies build the budget the selective travel cost compensation. This budget will completely redistributed among the beneficiary.

7.1 Travel Cost Compensation

A selective compensation of travel costs for students will be granted through the "Evaluation Measures". Only receipt-proven costs resulting from traveling and accommodation will be covered. Note, however, that even for receipt-proven costs there exists an upper limit for travel compensation per student. This limit depends on the particular location of the event and will be published on the website. Refer to appendix B for an example calculation.

The basis for the selection of the teams that might receive travel support are the actual "Evaluation Measures", see section 6. The first team of each scenario will receive a compensation for travel costs for a maximum of three students. Each team can only claim this travel support once. If there is money left, then the second team of each scenario receives travel support, and so on.

NOTE: The application for travel cost compensation has to be sent to the organisers BEFORE the event takes place!

The remaining budget after considering all rightful applications will be used to cover receipt-proven travel expenses of the judge team (except those judges belonging to the organisers).

7.2 Non-monetary Awards

Nominations for these awards can be made in the categories:

- Best Scenario Performance (for each of the provided scenarios)
- Novel Scientific Solution
- Creative Solution
- Best Team Effort (commitment, dedication)

While the best performance in each scenario is clearly governed through the "Evaluation Measures" (see section 6), the beneficiaries of the other categories will be elected by the Chief Judge Team (see section 5.1) together with the votes from all official participants (each team has one vote per category). All results ("Evaluation Measures", votes etc.) and awards will be immediately published on the web pages.

> **Please be sportsmanlike and play fair!**
>
> **If there are weaknesses in this ranking system, feel free to tell us.**
>
> **If the jury gets the impression that someone is trying to cheat, trick or outsmart anybody, it will take appropriate action.**

Appendix A: Objects of Potential Interest (OPI)

Objects of Potential Interest (OPI) denote specific objects, threats or intruders. Currently, in all ELROB trials ERICard number plates are used as OPI, special hazard signs which are easily detectable and are used to mark dangerous fluids and gases in the transportation domain (see pictures below for examples).

To correctly detect an OPI resp. ERICard number plate, its position (in UTM coordinates) must be reported with a minimum accuracy of 5 m. Additionally, a photograph of the ERICard number plate shall be taken. This photo is considered as sufficient if all digits are clearly readable.
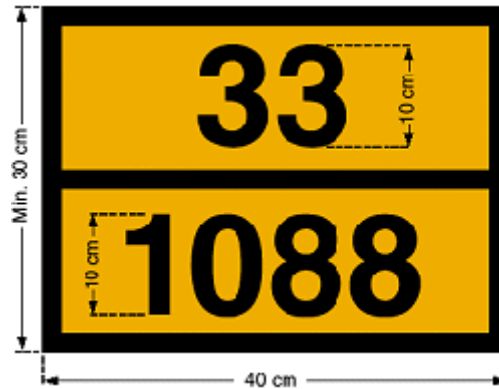
Appendix B: Example Calculation for Travel Support Limit

The amount of the travel cost compensation per student, which is distributed among the participants after the event, is limited, depending on the particular location of the event. As a general guideline, the travel support shall be high enough to cover accommodation in a basic (2*) double room for the duration of the competition event and the cost of a hypothetical economy class return flight. Note that the travel support limit is independent of a participant's place of residence. Hence, flight costs always refer to flights from Frankfurt Airport (FRA), Germany, because this is a hub airport with a large number of connections and it is located pretty near the centre of Europe.

To get an idea of the amount of money that can be expected look at the following calculation. The example refers to the ELROB 2020, taking place Trier, Germany, from August 17th until August 21st 2020. Since Trier is located relatively near to Frankfurt, instead of the above mentioned calculation we simply offer a reimbursement of up to 200€.

The exact height of the maximal travel cost compensation per student will be announced on the website prior to the event. All refunding has to be receipt-proven.

Basic accommodation (2** double room incl. breakfast) in Trier is about 35€ per person and night; 6 overnight stays for attendance at the event (including one additional day for arrival and one for departure)	210€
Economy class return flight, maximum reimbursement	200€
Total limit for travel cost compensation per student	410€

Appendix C: Standards for Electronic Data Exchange

The following links refer to standards related to the electronic data exchange mechanism used for the ELROB:

- Ethernet
  http://en.wikipedia.org/wiki/Ethernet

- IP v4
  http://en.wikipedia.org/wiki/IPv4

- DHCP
  http://en.wikipedia.org/wiki/Dhcp

- WebDAV
  http://en.wikipedia.org/wiki/WebDAV

- HTTP v1.1
  http://en.wikipedia.org/wiki/Hypertext_Transfer_Protocol

- 8P8C/RJ45
  http://en.wikipedia.org/wiki/8P8C
  http://en.wikipedia.org/wiki/Registered_jack_naming_confusion

- Twisted pair Cat6 cable
  http://en.wikipedia.org/wiki/Twisted_pair
  http://en.wikipedia.org/wiki/Category_6_cable

- IP address
  http://en.wikipedia.org/wiki/IP_adress

- URL
  http://en.wikipedia.org/wiki/URL

- Switch
  http://en.wikipedia.org/wiki/Network_switch

- Server
  http://en.wikipedia.org/wiki/Web_server
  http://en.wikipedia.org/wiki/File_server