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Promulgation of report Finabel Study Nr **FDE.4.R**

**RELEVANCE AND POSSIBLE FUTURE ROLE OF ROBOTIC/UNMANNED SYSTEMS FOR FINABEL LAND FORCES**

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## Aim of the study

The aim of this study is to provide Finabel Land forces with a common understanding and coordinated terms/classifications in the future key sector of robotics to facilitate subsequent cooperation and/or allow achieving synergies in the fields of concepts and procurement. So this study could be the basis and line of departure for a common concept for use and employment of robotic systems in operations. Of course, this future document will have to be in accordance with the different documents from NATO and EU.

## Scope of the study

Robotics is a most promising future technology. Use of robotic systems is expected to constitute a substantial capability gain for FINABEL land forces. It is conceivable to employ the systems in a wide range of scenarios. Unmanned systems have already been successfully fielded in the areas of airborne reconnaissance and ground-based, standoff-capable explosive ordnance defense. However, the technological developments to be expected in future exceed these developments by far, and open new possibilities for the employment of unmanned systems. It is important for the FINABEL countries to start this development in good time, to find its place, and to actively shape the development process at an early stage. The employment of robotic systems could be particularly desirable in situations in which friendly forces could still be required to expose themselves to considerable risks. Since the technology is still in its infancy, with no extensive use of robotic system by FINABEL land forces at present, not much progress has been made as far as the conceptual study of the subject is concerned. FINABEL land forces can avail themselves of the opportunity to close this conceptual gap by presenting a uniform document agreed within FINABEL. This is how potential for close cooperation in this promising field will be developed.

## Introduction

The first use of robotic systems by armed forces took place during WW2. After this conflict, the eventuality of a symmetric and conventional conflict in Centre Europe between occidental nations and Soviet bloc, but also the colonial wars, did not contribute to the development of this capacity, which was only experimental in 1945. The recent conflicts (Iraq, Afghanistan, Middle East) associated with the important technological development in recent years, created the opportunity to quickly develop these systems. The conditions were particularly favorable because robots seemed to be the ideal solution for western societies which are less and less able to accept human casualties in action.

The final goal of military use of robotic systems is to increase military capability and security of forces and allow soldiers to concentrate on specific tasks which can only be fulfilled by manpower. In achieving this, robots are likely to operate in a range of roles, from closely interacting with deployed troops at a tactical level through to undertaking unsupervised tasks in support of strategic level planning and operations.

# 1. Definitions of robotic systems and terms

## 1.1. Terms and definitions in relation to robotic systems

There is no global and approved definition of a military robot. NATO, which is the most powerful alliance in which the majority of FINABEL countries are concerned, does not define the term "robot". FINABEL countries, suggest it could be possible to define a robot as « an automatic machine with electronic command able to replace or augment men/soldiers in order to conduct certain tasks. Based on this general definition, a military robot can be further described as:

*"an unmanned, man-made electro-mechanical device, guided by a remote operator, a computer program and/or electronic circuitry capable of sensing, comprehending, and interacting with its environment. The main parts of a robot are mechanical systems, computers, and sensors.*
*They can be autonomous, semi-autonomous or remotely controlled and range from small stationary devices to large complex vehicles. Current robotics applications, with some exceptions, are geared towards performing repetitive, dangerous, or difficult work that humans cannot perform well or would not want to perform."*

The most developed area of military robotics is in the Air Domain, with several FINABEL countries employing Unmanned Aerial Vehicles (UAVs) operationally. NATO defines the closely relate term 'Unmanned Aircraft System' (UAS) as *"A system whose components include the unmanned aircraft, the supporting network and all equipment and personnel necessary to control the unmanned aircraft".* This reinforces the difference between the unmanned vehicles itself and the overall system, which includes the additional equipment, infrastructure and personnel required to operate the vehicle. NATO also defines the related term 'Drone' as *"An unmanned vehicle which conducts its mission without guidance from an external source"*[1].

Due to increasing public concern over the nature and use of Drones, the term Remotely Piloted Air System (RPAS) is increasingly used to refer to such vehicles, emphasising the presence of a human in the loop.

The final goal of military use of robotic systems is to allow soldiers to concentrate on specific tasks which can only be fulfilled by manpower, and finally to increase capability and security of land forces.

The interest to employ robotic systems is mainly founded on the following characteristics:

- A certain level of autonomy, for a specific mission that is given by the embarked sensors and electronic systems, permitting forward action at a certain distance, particularly in a hostile environment;

- The capability to realize one or several tasks, with a high degree of performance and liability, without being limited by physiological or environmental limitations.

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[1] AAP-06 Edition 2013, NATO Glossary of Terms and Definitions (English and French), NATO Standardization Agency 2013

So, with technological progress, the robots employment seems to be particularly relevant to preserve human potential, contributing to the principle of economy of forces.

## 1.2. Notion of autonomy

The level of autonomy is one of the most important parameters in order to assess the capability of a robot. Previously a number of organizations have attempted to define scales describing specific levels of autonomy to assist in assessing platforms, however these must consider at a minimum mission complexity, environmental difficulty and human independence. Subsequently, current consensus is that it is very difficult to define a precise scale that is suitable for a range of different robotic systems and therefore such generic scales should be avoided and instead focus given to accurately describing tasks, processes and decisions that can be undertaken autonomously, the ultimate effect of these and any associated limitations.

Beyond the necessary technical autonomy, in terms of energy and power supply, the notion of autonomy covers two aspects for robot. On the one hand, the link between the robot and the "human system" in which it is integrated **(decision making autonomy),** and on the other hand, the link between the robot and its physical environment **(functional autonomy).** In FINABEL land forces, it seems to be very difficult to dedicate specific operators for the employment of robotic systems, particularly because of the reduction in number of soldiers. Consequently robotic systems will require a level of autonomous capability (functional autonomy, and sometimes decision making autonomy), but it is important to note that for Finabel forces, a human will be the ultimate decision authority, particularly in case of kinetic effects.

### 1.2.1. Decision making autonomy

Robots can be divided in two categories.

- **Tele-operated robots/remotely- controlled robots**, which remain under the operator's control.
- **Autonomous systems for which the level of autonomy may vary**: from the system which is programmed to go from one point to another, to the totally autonomous system which is able to take the decision to change its track, while continuing to realize different tasks. In this case, the highest degree of development would consist of giving a capability to take autonomous decisions to the robot depending on given circumstances, and becoming more and more autonomous because of its experience. Nowadays, this domain of decision-making autonomy is the most important challenge, from the technological, the conceptual, the ethical and the legal point of view. (cf. chapter legal and ethical issues)

The concept of "adjustable autonomy" is important, as it enables the operator, to configure the autonomy level of the robotic system, in accordance to the given environment and the context of employment.

### 1.2.2. Functional autonomy

The diverse and complex ground environment, increases the constraints for the employment of robotic systems, compared to more homogenous environments like air or water. This explains that the development of ground systems takes longer that of air or naval systems.

## 2. Categorization methods of robotic systems

At the highest level, robotic systems are divided into broad categories relating to the environment in which they operate, as either Unmanned Ground Vehicles (UGV), Unmanned Maritime Vehicles (UMV) or Unmanned Air Vehicles (UAV).

Robotic systems can be further categorized by their technical and operational characteristics and also by their generic capabilities.

2.1. It is possible to use a matrix to classify robotic systems, following their technical and operational characteristics

For UGS, it could be based on the weight of the systems.

| | |
|---|---|
| CLASS I (less 25kg) | Portable by 1 person |
| CLASS II (25 kg to 50 kg) | Portable by 2 persons |
| CLASS III (50 kg to 350 kg) | Air and ground transportable |
| CLASS IV (More than 350 kg) | Self propelled / drivable |

UMVs are typically classified as either Unmanned Surface Vehicles (USV) or Unmanned Underwater Vehicles (UUV) and the term UMV is less widely used. Any UMVs which are tethered are normally classified as a Remotely Operated Vehicle (ROV).

For UAS, the NATO classification is also based on the maximum gross take-off weight of the system (this classification is also used in study ENG.4.R):

| | |
|---|---|
| CLASS I (less 150 kg) | SMALL >20 kg |
| | MINI 2-20 kg |
| | MICRO <2 kg |
| CLASS II (150 kg a 600 kg) | TACTICAL |
| CLASS III (more than 600 kg) | Strike / Combat |
| | HALE (High Altitude, Long Endurance) |
| | MALE (Medium Altitude, Long Endurance) |

Additionally, NATO further defines the typical maximum altitude and mission radius associated with each class; however UAS class is ultimately determined by weight. Under CLASS I, the UK further defines the category "Nano" as systems weighing < 60 g.

2.2. It is possible to classify robots following their generic capabilities. It's possible to determine two categories of robots.

PASSIVE ROBOTS: Robots with sensors, particularly used in missions to provide intelligence, which would be able to observe, to identify, and to survey, transmitting video without delay, taking photos, listening and collecting information. These robots could also be used for protection and security of deployment installations (e.g. FOBs….). In these cases, robots are clearly the remoted sensors of the soldier.

ACTIVE ROBOTS: Robots producing effects, which could be equipped with various assets, with the possibility to produce effects supporting the forces mission (such as radio relay), with the capacity to conduct engineers' missions or to support the tactical mobility (e.g. destruction of obstacles, building of positions, logistic transport, etc…). Finally, these types of robots could produce effects on the enemy both non-lethally (e.g. smoke….), and even eventually lethally, however FINABEL forces would require a human in-the-loop as the ultimate decision authority.

# 3. Strengths and weaknesses of robotic systems

## 3.1. Strengths

In many cases, the use of robotic systems reduces the exposure of personnel to risk or frees them up to undertake other tasks, both of which are attractive to FINABEL forces. Contrary to humans, performance of robots is typically constant overtime. Within their operating limits, robotic systems should be less sensitive than humans to adverse environmental and climatic conditions, and the effect such factors have on an individual robot's performance can usually be well understood and managed/mitigated.

Robotic systems make decisions based on pre-specified rules and behaviours, which facilitates a consistent level of performance in the realization of tasks. However should the system encounter environments outside of those it has been designed for, its behavior could be unpredictable or undesirable. This is particularly pertinent to UGVs, especially in comparison to UAVs, due to the broad range of terrain, obstacles, personnel and other systems which the UGV may encounter in its operating environment.

So, the principal strength of a robotic system is to never be tired (within the duration of its power supply), and to deliver a consistent level of performance regardless of task duration, within the intended operating environment.

## 3.2. Weaknesses

Tactical weaknesses are linked with the major threats. Robotic vehicles are susceptible to many of the same tactical threats as their non-robotic equivalents. For instance, UAVs could meet the following threats:

- Ground to air missiles;
- Anti-air artillery;
- Fighter aircraft or attack helicopters, armed with air to air missiles.

However, robotic systems have specific additional tactical vulnerabilities:

- Reliance on electrical components and sensor suites, susceptible to anti-robotic measures like jamming, electronic effect, ELINT (Electronic Intelligence), blinding, spoofing;
- Increased exposure to high risk environments, resulting in greater likelihood of damage/destruction e.g. detonation of the object that EOD/IEDD-robot is operating

- Requirement for wider components supporting the robotic system which can be targeted by adversaries e.g. attack of a flying UAS´s land components (air strike/SOF strike against control site, jamming);

- Elements of predictability in operation and responses to certain situations, resulting in trivial mechanisms of defeat if well understood by adversaries.

Principal functional weaknesses of a robotic system are linked with the current technology: difficulties and reliability in the interface between the robot and the operator and shortfalls in the overall capability of the system. The interface has to be 100% reliable and the system must fulfill the user's expectations, otherwise soldier's trust in the system will be undermined and the introduction of technology will not be accepted. The robot should not be a additional problem for the soldier, it should be a supplementary tool able to increase the efficiency of the unit and give it an operational superiority.

In this way, the main equipment limitations are nowadays technological. It is possible to deceive a computer algorithm with relatively minor effort. If the data link from operating station to HQ is broken, sensor systems will be useless and the link of confidence will be broken. However there are a whole host of issues which must be addressed (doctrine, training,etc) for the successful introduction of such capabilities

### 3.3. Integration of robotic systems in Land Forces

Robotic systems will have to be interoperable with all these systems and armaments, in FINABEL land forces. This interoperability will be ensured by (common) control and command communications systems and by common standards of digitization.

### 3.4. Basic requirements to be met by robotic systems

The conditions of deployment of robots in land forces permit to determine the general requirements to be met.

- Be able to progress and/or stay in a complex and hostile environment (aggressive and dangerous), particularly in urban areas, on the surface, or underground;The imperative of mobility is really a key point. The different robotic systems will have to be able to follow the same route as the ground forces, or at least to join a specific way point in order to support troops in contact. Nevertheless, it is important not to imagine robotic systems with a mobility equivalent to soldiers because the ground environment is so specific and so difficult that such an objective will not be realistic in a reasonable future.

- Be able to analyze and understand the situation it is being used in and modify its behavior appropriately. Although the artificial knowledge of a robot will never replace the situational awareness and adaptation capability of the human being, this capability of analysis of its environment is an important feature of the autonomy of robotic systems.

- Be able to realize an operational effect or conduct technical processes (e.g. the opening of an itinerary, intervention on an IED, survey and alert, etc.). In this way, robotic systems will offer the tactical commander a specific capability and advantage. They will permit to reduce risks for soldiers, and will ensure to engage them in contact, in the best conditions.

- Be able to fulfill its missions permanently. In the future, the question of protection of robotic systems should be covered, in order to determine the balance between operational interest, efficiency and cost; the perceived value of the system needs to be commensurate with the level of risk it is exposed to.

- The appropriation of robotic systems by the soldier represents an important challenge. So, robots should be simple to be employed, robust and reliable in order to be trusted in during the manoeuver. The success of this integration depends first of all on the human – machine interface. This Human Machine Interface should be intuitive and simply accessible to the soldier, whatever the conditions of employment and the characteristics of the environment.

The level of development of each aptitude will be determined by the robots principal mission and its environment, and it could be decided to give the priority to one or another.

### 3.5. Basic requirements to be met by units/forces

Robotic systems aim at the support to the combined manoeuver. They are not dedicated to replace the action of soldiers completely. The aim is not to obtain a technological gadget but to achieve either an effect on the enemy or to increase the force capacities. Integrated into tactical operations, the use of robot systems should multiply its effects and results by complementing already fielded capabilities, or by increasing the efficiency of the force. This integration will necessarily lead to the modification of courses of action and traditional procedures or TTPs, which robotic systems must be totally integrated in these new TTPs. It will be achieved, only if, at the different levels of hierarchy, robotic systems are totally accepted, requiring very high levels of user trust, which can only be established through consistent and reliable performance of the robotic system.

This integration will impose an adapted formation and a regular training in operational conditions.

## 4. Employment options for robotic systems

### 4.1. Operational employment

The global need for robots is corresponding to **three general axes – DANGEROUS – DIRTY – DULL tasks**:

**1/ Increase the survivability of the troops in contact**, reducing the exposure to the dangers of the battle field. The aim is not to replace the human soldier by robotic systems during the different phases of the combat, but to preserve the human potential and strength as long as possible, permitting them to be engaged at the best time, in the best conditions.

**2/ Increase the soldiers capacities and finally the operational efficiency of the different units**. The efficiency of the soldier is being limited by the human adaptability to the environment (cold, hot, wind, night, snow, rain, NBC threat,….) and by his natural capacities, even if the soldier is equipped with different materials and assets that facilitate his perception and analysis of the current situation. The operational capacity could be increased by robotic systems, in terms of execution quickness, permanency of the action, mission length.

**3/ Permit the realization of repetitive and fastidious tasks.** The robot efficiency, adapted to a particular environment and to pre-defined tasks, is clearly superior to that of man. Robotic systems are able to ensure an excellent permanency in the execution of the mission and are able to give a regular performance. For example, robotic systems could allow reducing the burden of soldiers in logistic missions.

## 5. Legal and Ethical issues

### 5.1. Legal issues

As yet, no international or national law imposes specific limits to robotic systems on the battlefield. It is expected that the international community will create regulations as the use of robots becomes more widespread. Some restrictions pertaining to armament control are likely to emerge. However, the key principle of keeping a man in the loop as the ultimate decision authority, whatever the effects delivered by an automated system, makes it possible not to be confronted with insurmountable legal difficulties regarding liability matters and thus minimize the restrictions which could arise in the employment of robots.

In general terms, the association of robots and weapons is legally acceptable, if human operators can immediately, directly and unequivocally observe, assess and evaluate the effects of fire on the objective; clearly discriminate between friendly forces, enemy forces and civilians; and intervene and abort the mission in case of malfunctioning or mistakes (blue on blue fire or civilian casualties). Remotely Operated Weapon Stations mounted on vehicles meet these requirements and are an example of the integration between a weapon and a robotic (but not autonomous) system.

In all the other cases, as already stated, it is necessary to carefully consider the legal and ethical aspects, especially if human judgment is limited by the nature of the data transmitted. It is important to remind that currently there is no robotic system able to differentiate between friendly and non-friendly or hostile behavior or identify a difference between a civilian and a combatant. So, the robotic system will always have to be considered as a tool under control of a human mind. The responsibility will always be the result of a human action or decision, including the initial decision to use a robot.

In some cases, such as driving and route navigation, there may not be a requirement to have a human in the loop as the robot is not directly making decisions regarding lethal effects. However, there is still the possibility of a robot causing, or otherwise being involved in, situations, such as road traffic accidents, where people are injured or property is damaged. In these cases, where an autonomous robot is undertaking tasks previously assigned to a human operator, consideration must also be given to the legal implications. For technologies where there is a civilian market, such as autonomous driving of vehicles, it is to be expected that civilian law will also be updated and therefore provide some level of guidance.

### 5.2. Ethical implications

The widespread introduction of robotic systems will push us to question ourselves because their employment on the battlefield transforms and modifies the most fundamental rules of war. The introduction of robotic systems on the battlefield will increase the physical and mental distance between the soldier and his opponent, which is a permanency in the history of war. This question is critical to the use of robotic systems in the battlefield and should be developed.

**Conclusion/Summary**

Robotic systems are tools in support of deployed forces. They complement the action of soldiers, or replace them for specific tasks but the intention is not to entirely replace humans. Robots have different cognative and sensory capabilities to humans and only perceive part of the reality, but do not tire and do not act with impulsivity. Most importantly, robots do not have the instinct of the soldier and his subtlety when confronting a specific threat, or his ability to adapt in the face of a specific event.

At the political-strategic level of war, an objective of the employment of robotic systems is the maintaining of sufficient public support to the national war effort which would otherwise vanish if the casualty rate were deemed unacceptable and unsustainable by “casualty-phobic” public opinions. Ultimately, the objective is to guarantee the contribution of the nation to the war effort along with the other contributing nations.

A common objective of the automation of land forces at the tactical level is to guarantee a tool to detect, predict and neutralize enemy threats maintaining a safe standoff for soldiers. The immediate effect is a reduction of casualties and wounded soldiers.

This paper has discussed high level descriptive terms and classifications of robotic systems which should begin to provide FINABEL forces with a common language to use in future discussions.

Beyond the robotic systems which are already in use in FINABEL land forces, the arrival of robots in our armies is already planned in the next 10 years. This arrival, in order to be totally controlled and to allow a real high value in operational efficiency, requires a particular effort in R&D but also in doctrine and tactical evaluation. This effort will have to be conducted in prolongation of this study.

The approach of FINABEL land forces must be incremental and pragmatic. We have, case by case, to appreciate the real high value of robotic systems, for each operational situation. For this, the principal criteria must be the preservation of human potential.

**Annex 01**

**French classification for useful Robotic systems**

Integrated in the tactical manoeuver, robotic systems will have to demultipliate the effects, by completing or increasing the efficiency of soldiers.

**MICRO-GROUND ROBOTS:**

Micro-robots are the deported eyes of the soldier. Their employment is particularly efficient in urban area, in a building or underground, in order to collect intelligence. Equipped with a camera, their action range is limited to 100 meters, and they are easily controlled with a portable HMI (PALM, ….). They can send images. These systems are robust, easy to put in order, and they can be thrown by a soldier (in a stair…).

**MINI-GROUND ROBOTS:**

Mini-robots can be equipped with various kits, and effectors or sensors. They can be transported in the BG vehicles, but also can be transported on a short distance by one or two soldiers. Their weight is not superior to 50 kgs. Their employment is particularly efficient out of buildings, but their use in urban area is priority. Their range of action is few hundred meters, depending with the kit. They can collect intelligence (to scout a progression,), unable a mine or an IED, deliver specific effects on the terrain (to breach) or on the enemy. They are robust, and can be put in order easily by a single man from a portable control station. A concrete level of functional autonomy is necessary and should be developed.

**MICRO – UAS:**

Micro-UAVs are light systems, (about 1 or 2 kgs), “flying binoculars” for the soldier, easily transportable by one soldier. Their action range is about one or two kms and is adapted to the operational request of infantry units. They permit to see “the other side of the hill” or the other side of the wall, of the building. They are equipped with a camera. They are easy to put in order and can be executed by a single man with a portable control station.
Some more performing systems, with a more important tactical range (about 4-5 kms) could be used particularly in recce units. These systems should nether the less stay simple and easy to use in order to follow the manoeuver rhythm.

**TACTICAL POLYVALENT GROUND ROBOTS:**

Tactical polyvalent ground systems are more complex robots, characterized by a high level of functional autonomy and a capability to ensure a larger spectrum of missions and tasks because of the capability to transport various kits. Their mobility could authorize them to easily integrate and follow the battle group manoeuver.

These kinds of robots could ensure missions in intelligence collect, transport, logistics,area survey. They could also be equipped with effectors, or active kits able to produce kinetic effects on terrain or enemy. Their support could be more complex but could be ensured by non-specialist soldiers, from a portable control station.

**AUTOMAT ROBOTIC SYSTEMS:**

Automat systems could give the opportunity to “robotize” temporarily the BG vehicle, according to the different missions and the operational need. The vehicles could be desequipped after the specific missions and return in a normal configuration. This occasional robotization could permit to ensure the full spectrum of the BG missions. Nethertheless, this robotization could be used in priority for intelligence missions in contact, convoy escort, logistics of advanced elements and terrain organization. The automatized vehicles could have a limited functional autonomy. The control and “tele-operation” should be preferentially ensured by current users (pilots…) from dedicated portable and dismounted control station.

**HEAVY TACTICAL ROBOTS:**

Heavy tactical robots are systems with a high functional autonomy, specifically created and developed for specific missions. More complex, they could be put in order from portable and dismounted control station but should need specialists’ operators. Two kinds of robots could be developed:
Robots dedicated to support directly the engagement of units. They could conduct recce missions, and potentially combat missions. Their capabilities could also permit to use them in missions of control of areas.
Robots dedicated for engineers missions (terrain organization – mobility support) with specific capability to open itineraries, counter IED missions,

**Annex 02**

**Short term uses and primary requirements**
***Source: Perspective on the employment of unmanned systems in the German Army***

Primary requirements for robotic systems in Finabel land forces could be declined as follow. The following list is exhaustive, and all systems are not dedicated to be employed in all Finabel land forces. But, all these systems could be used in Finabel land forces:

| | Working term | Employed with |
|---|---|---|
| C2 capability | Relay drone | Arm/branch immaterial |
| Intelligence collection and reconnaissance | Reconnaissance UAS/UGS | ISR corps, Army air defence, Artillery, Infantry, Armour, Special forces, Army aviation corps |
| | Target acquisition UAS/UGS | Artillery, ISR corps, Infantry, Armour, Special forces |
| Support and sustainability | Transport UGS | Army logistic services, Infantry, Armour, Special forces, ISR corps |
| | Engineer reconnaissance UGS for urban operations | Corps of enginneers |
| Survivability and protection | Reconnaissance NBC UGS | NBC defence corps |

**Short term Relay Drone**

A universally employable UAS could be required to ensure the autonomous relay operation as an interface in data-capable battlefield radio networks. This could be efficient to reduce radio shadowing and increase ranges to ensure continuous and stable radio communications.
The transmission/reception range of the forces employed will be thus improved. The system should have to be remote-controlled by the operator with automatic trim at distances of up to 1,000 m. In the mid-term the system should have to identify and move into the optimum relay position. Its use should have to be ensured whatever the visibility and weather conditions.

**Intelligence collection and reconnaissance**

On operations, personnel are substantially at risk from direct fire, ambushes, booby traps, etc. This is particularly true for operations in an urban environment with an asymmetric threat. Unmanned, ground-based and/or airborne systems for situation, target and post-strike reconnaissance as well as tactical reconnaissance significantly should improve the reconnaissance capability and decisively reduce the threat to employed personnel. In addition to force protection and the effective improvement of the intelligence collection and reconnaissance capability, the sustainability of forces employed will also clearly improve.
Potential unmanned systems that largely come under the intelligence collection and reconnaissance capability category should have a high potential for universal use throughout the Finabel Land Forces and beyond, wherever they serve tactical reconnaissance as a general operational task. The names of

the unmanned systems listed in the following include the term "reconnaissance" when they primarily used for situation and tactical reconnaissance purposes. The term "target acquisition" on the other hand, describes systems that are mainly employed for target acquisition and post-strike reconnaissance.
Generally, the employment of reconnaissance UAS/UGS by trained forces within the contingent across all arms and services should also be an option for graduated tactical reconnaissance on stabilisation operations.
Furthermore, a distinction is made between ground-based (UGS) and airborne (UAS) reconnaissance systems. Concerning UAS, some of which are already used by some Finabel armed forces, generally lend themselves more to reconnaissance missions thanks to their speed and straightforward navigation systems. Nevertheless, UGS are equally useful as the period of stationary employment is obviously much longer. In addition, only UGS can be employed in any weather conditions. They have the capability to gain reconnaissance results about objects that are hidden from bird’s eye view by buildings, vegetation or artificial camouflage.

**Reconnaissance UAV**

A large part of Finabel land forces already operates the airborne systems in the ISR Corps, Combat Forces, Special Forces, and the Artillery Corps. They can be employed in almost any visibility conditions for situation reconnaissance, target acquisition and post-strike reconnaissance at close-in, close and medium ranges depending on the tasks assigned to the arm in question.
Follow-on systems must have more flexible flight profiles with significantly more endurance, and be capable of multiple starts and landings during a mission. In addition, the functionality for a relay system of several UAS as well as starts from / touch-downs on moving platforms in motion should be realised.
An airborne unmanned system for imagery reconnaissance in urban areas should be employed in almost any visibility conditions. It would primarily permit reconnaissance in urban areas or terrain sections that are difficult to access and offer numerous possibilities for camouflage and cover.
In addition, Infantry forces, Special Forces and the Armour Corps should require a UAS that could be modularly employed from the combat vehicle to conduct situation and tactical reconnaissance at the lowest tactical level immediately and directly without endangering own forces. Imaging sensors to locate and identify individuals, groups of people, weapons, obstacles, vehicles/platforms and other objects at short and close-in range (up to 5,000 m) should be required to quickly provide an adequate situation picture at platoon and company level. Furthermore, start, landing and operation should be realisable from the combat vehicle.
Air Defence Artillery should require a reconnaissance UAS that could provide reconnaissance data both as an individual system and in combination with groundbased systems. The sensors should detect, track and identify even the slightest fast-flying target and thus close the capability gap existing among the Army Air Defence Artillery to detect targets beyond the direct line of sight which is particularly limited in urban terrain.
Fixed, static variants as well as mobile platforms should be provided. The Army Aviation Corps should require a mission-specific robotic sensor platform that could fly ahead and be optionally controlled from a command and control helicopter. Its tactical mobility should follow that of an airborne taskforce. Its task should be to scout and reconnoitre an area ahead of manned aircraft during low-level and very low-level flights in an operational radius of up to about 600 km. Current information

requirements in the area of operation should be thus met and Army Aviation-specific and specialised data necessary for an airmobile operation collected. This should include the capability to collect topographic, and meteorological data (among other aspects to reconnoitre air routes, landing zones, possible positions for combat helicopters or forward supply facilities) as well as information for situation reconnaissance.
For these future "manned-unmanned-teaming" procedure a "reconnaissance mission equipment package" should be required for a specific number of helicopters, that could be, an airmobile work place or an airmobile control station to command and control unmanned – possibly organic – airborne scouting and reconnaissance platforms. Interoperability with other command and control facilities on the ground and in the air should be ensured.

**Reconnaissance UGV**

The ISR Corps should require unmanned ground-based systems that could be employed to support these forces while collecting situation information at short, close-in, and close range. Their purpose of employment should be the collection of reconnaissance results in unknown, difficult or enemy-controlled terrain, in particular in urban environment as well as surveillance of sections of areas or movement and convoy routes. The size and weight may vary depending on the reconnaissance range, the operational environment, and the sensor systems required. One essential common capability characteristic should be the highly mobile employment whatever the visibility, in almost any weather conditions and geographic locations/ climate zones. Unmanned ground-based class IV systems should also be capable of delivering payloads and conducting transports. The sensors should permit recognition and identification of individuals, vehicles, objects and events at visibility ranges of up to 10,000 m (identification at 1,000 m) and acoustic reconnaissance by direction, distance and target classification. A link with a command, control, information and weapons control system should be catered for to permit sensor-effector data transmission without media discontinuity. Semi-autonomous to autonomous drive, reconnaissance and scouting programmes should be provided to ease the strain on operators. Ideally, an alternative to draw on universal system platforms should be developed.
Hence, the requirements of the ISR Corps should be differentiated as two different systems. On the one hand, a mobile sensor system to be employed as a subsystem by scout teams and light reconnaissance patrols. On the other, hand a semi-autonomous robotic system that should be employed self-sufficiently and independently of scout teams and light reconnaissance patrols to autonomously monitor larger areas.
Infantry, Special Forces and Long-Range Reconnaissance Forces should require two unmanned ground-based systems that could be employed on operations at section or platoon level at short and close range. Both systems should be easy to operate and respond promptly.
On the one hand, a mobile sensor system for short ranges should be required to collect reconnaissance results in broken terrain, particularly in built-up areas. The commando team/long-range reconnaissance patrol or commando platoon/long-range reconnaissance platoon should carry the system which must therefore not weigh more than 5 kg. The system should to be used for imagery transmission, as well as to detect individuals (day/ night/heat signature), trip wires and obstacles, and to identify individuals.
On the other hand, a semi-autonomous mobile system should be required for surveillance, observation, scouting and reconnaissance of terrain sections at a range of up to 5,000 m. Covering a

sensor strip of 100 m the system should intend to help detect and identify individuals, openly carried weapons, trip wires and explosives. The system should be air transportable aboard fixed and rotary wing aircraft and employable in any visibility and weather conditions, and at almost any geographic location.

**Target Acquisition UAV**

Special Forces should require unmanned airborne systems with an operational radius of at least 70 km to monitor targets, ascertain movement patterns, and detect/identify individuals. In this context it should be essential to keep the target (individuals, vehicles or static objects) under constant surveillance by day and night and to provide data in target quality.

To achieve this, the system should be employable by remote control or autonomously in any visibility and with low noise development. It should be capable of taking off from the ground and/or naval platforms and to land vertically. In addition to imagery reconnaissance with effective sensors, signal-detecting reconnaissance capability should be required. Target reconnaissance UAV should be air transportable aboard fixed and rotary wing aircraft.

Artillery forces should require an airborne system that should be capable of providing long-range and standoff capable target acquisition and post-strike reconnaissance in almost any weather conditions, at any time of day, within the entire area of responsibility of the force commander. The range/penetration depth should at least be 150 km (with a potential of extending up to 200 km). It should have a duration of employment of at least 8 hours and be relay-capable to support long-range loitering munitions. Future land forces capabilities of providing indirect fire support with high-precision, inertially controlled weapons should depend on systems with target location accuracy. This should be ensured by developing sufficiently precise sensors or as part of a system of supporting imaging systems. It should be also necessary to ensure the integrated system of command and control, reconnaissance and engagement even at long distances. For this purpose, the sensor platform (artillery) should ensure the transmission of sensor data in real time, target identification, target tracking and impact observation by multispectral sensors (IR and radar). Automatic trim and navigation should be provided for to ease the strain on the operator.

**Target Acquisition UGV**

The Artillery, Special Forces and Long-Range Reconnaissance Forces should require unmanned ground-based systems that will supplement and support Joint Fire Support Teams (JFST), reconnaissance and sniper platoons, or the special reconnaissance efforts of the Special Forces Command and Long-Range Reconnaissance Training Company. Essential performance characteristics should be the capability to reconnoitre and scout terrain and infrastructure and to detect individuals for target acquisition and post-strike reconnaissance.

For this purpose, Artillery Forces should require a system that should be capable of reaching an observation post semi-autonomously, and of autonomously establishing and maintaining readiness for reconnaissance for 12 hours. It should be capable of identifying, classifying and recording objects with target precision. The transmission of data for fire control should initially be relayed or remotely controlled by a human operator to ensure human control of effective engagement.

Special Forces and Long-Range Reconnaissance Forces should require a system that correspondingly should support the reconnaissance and sniper platoons or special reconnaissance assets within

Special Forces Commands and Long-Range Reconnaissance Training Companies. In view of the Special Forces' specific operational environment, however, the system should be portable (max. 5 kg). In addition to imagery reconnaissance with effective sensors, Special Forces and Long-Range Reconnaissance Forces should require signal-detecting reconnaissance capability. Modular NBC/reconnaissance/detection sensors should be adaptable for use.

**Effective engagement**

Unmanned systems could, however, improve the integrated system of command and control, reconnaissance and engagement, and particularly the capabilities for reconnaissance and command support when engaging targets.

**Support and sustainability**

In this capability category unmanned ground-based systems should serve to improve logistic support especially. When transporting loads (e.g. supplies, equipment, and casualties in an emergency) the strain should be taken off the staff who should be made available for other tasks (point defence). Depending on the threat situation this should reduce the immediate hazard to personnel.
In addition, the capability for engineer reconnaissance of damaged infrastructure, should come under this category. Particularly when reconnoitring destroyed buildings could remote-controlled UGS reduce the threat to personnel by taking the soldier’s place when accessing houses that have been damaged or at risk from collapsing, and digitally transmitting the reconnaissance results to the operator.

**Transport UGS**

Army Logistic Services, Infantry, Special Forces, Long-Range Reconnaissance Forces, Armour, and the Army Aviation Corps should require an unmanned ground-based system capable of transporting loads. The size and sensors may vary depending on the payload and route.
Initially, the capability for autonomous tracking of should be required of a manned command and control vehicle ("electronic tow-bar") to transport supply goods on paved roads, paths and tracks, across bridges, through tunnels, and fords, as well as in urban terrain. In the long term, this realisation should be also required for unpaved paths and open terrain. The system should be such that it should work trouble free even in adverse weather conditions or when dust builds up. It should fit all vehicles operated today or tomorrow, providing electronic transmission/control of the driving function. An operator/military driver should be capable of overriding the semi-/fully autonomous operation of unmanned transport vehicles (UTV) by hand or remote control. The outer appearance of the transport vehicle should not betray whether the vehicle is unmanned and moving autonomously or being driven by a soldier. The aim of the second configuration level should be a remote-controlled unmanned command and control vehicle. The requirement should be to exercise remote control of the vehicle over distances of up to 300 kms. The ultimate configuration level should call for a fully autonomous convoy (or section thereof). The system integrated into the command and control vehicle should be capable of autonomously following a previously entered route, and avoiding obstacles independently.

Capabilities of unmanned systems to move in urban and difficult terrain in any visibility and weather conditions with low noise emissions should be required for MULE tasks (transport of smaller payloads for dismounted forces). The systems should be capable of following personnel or a manned vehicle either by remote control or autonomously. In this context they should be capable of avoiding local obstacles autonomously. The specification of the Army Aviation Corps also should call for the capability of picking up and putting down standardised loads (pallets with fuel or ammunition). Transport UGS should be air-transportable aboard fixed and rotary wing aircraft.

**Engineer Reconnaissance UGS for Urban Operations**

The Engineer Corps should require a remote-controlled ground-based system for standoffcapable engineer reconnaissance in urban terrain.
As a matter of principle, the system should be employable at a range of up to 300 m, in any weather and visibility conditions, and for a duration of at least three hours. The system should mainly be radio-controlled but operation by wire should also be possible as an alternative. It should also have near-infrared (NIR) with infrared headlights and a thermal imaging camera. A weight of 50 kg (portable by two soldiers, class II) should not be exceeded. It should be highly mobile in built-up areas, particularly on rubble, in small rooms and on steps and stairs. The following functions should be necessary: self-righting after falling over, opening doors (also locked ones), using simple tools (hooks), and moving objects (debris).
One essential requirement for this UGS should be the capability to reconnoitre the infrastructure by electronically and optically measuring three-dimensional spaces and objects. Another capability that should be necessary should be to collect information on surface and subsurface movement axes in destroyed buildings and on infrastructure that may be exploitable as obstacles or for tactical purposes. The possibility to employ the system for semiautonomous surveillance of obstacles and areas should be provided for.

**Survivability and protection**

The use of unmanned systems should enhance the survivability of employed forces wherever the systems substituting personnel are exposed to potential dangers. As military personnel will always have a specific mission (reconnaissance, transport, point defence tasks, etc.) the required systems should be allocated to different capability categories. However, they should always serve the purpose of improving survivability and protection. NBC defence as well as EO disposal, including EO reconnaissance, and EO clearance, are among the core functions of the survivability and protection capability category. To carry out NBC defence measures, friendly forces have always had to enter the hazard zone themselves to detect NBC agents or take samples. The inherent protective measures restrict own forces. Particularly when the area in question is still occupied by adversary forces or when booby traps or other unexploded ordnance must be reckoned with, will the threat to friendly forces rise significantly. The use of robots and the resulting physical distance between potentially contaminated areas and friendly forces significantly reduces the latter’s risk.
Correspondingly, EO reconnaissance, EO clearance and EO disposal are also conducted in dangerous environments. The employment of remote controlled or semiautonomous UGS would therefore boost the survivability of friendly forces.

**NBC Reconnaissance UGV**

The NBC Defence Corps should have a need for an unmanned ground-based system for NBC reconnaissance and sampling. It should be capable of detecting and measuring radiation, detecting and preliminarily identifying radiological, biological and chemical agents, as well as collecting samples (solid, liquid and gaseous substances up to 500 g or ml). For this purpose any such system should be able to open and closing containers, as well as to pull, push, turn and hold objects. The system should be radio controlled in all terrains up to 3 km, and have diesel-electric drive. Work processes must be monitored by several rotatable optical sensors. Modular NBC sensors with a payload of more than 70 kg should be employableindividually or in combination.

**Annex 03**

**In a Future operational environment (up to 10 years)**
***Source: Perspective on the employment of unmanned systems in the German Army***

It is possible to determine and imagine in some cases the employment options for robots following the operational branches or combat functions.

| Main capability | Working term | Employed with |
|---|---|---|
| Effective engagement | Weapon system carrier UAS/UGS | Armour, infantry, special forces |
| | Landing site security UGS | Army aviation corps, Special forces |
| | Autonomous combat vehicle | Armour |
| | Autonomous gun | Artillery |
| Support and sustainability | Remote controlled engineer construction machines | Corps of engineers |
| | EO reconnaissance, clearance, disposal UUs/USS | Corps of engineers |
| | Transport UAS | Special forces |
| Survivability and protection | Point defence UGS | Army logistic services, Army aviation corps, Special forces |
| | EOD UGS | Corps of engineers, army logistic services |
| Command and control capability | Airborne relay platform | All arms and services |

**Effective engagement**

In this branch, the operational need could be double:

• On one hand, to reinforce the intelligence capacity of chief and soldier, to scout the manoeuver, in open or in urban terrain, reducing the soldiers exposure to danger.
• On the other hand, increase the mobility and agility of the soldier, reducing the permanently increasing charge of ammunition, assets and equipment.
Some of these systems are already dealt with in paragraphs 4.2.3 – 4.2.4

**Weapon System Carrier UAS/UGS**

The minimisation of threats to employed personnel can only be ensured if reconnaissance, identification and engagement are understood as a whole in one-on one situation, and robotic systems can immediately realise all three tasks under human control.
Infantry, Armour and Special Forces should require unmanned systems that can detect and identify ground targets to be engaged in a timely and graduated manner with lethal and/or non-lethal weapons. Distinctive capability characteristics should include the detection and identification of

targets (individuals, vehicles, objects), and modular equipment with weapon systems. The realisation of unambiguous target identification as a prerequisite for weapon employment should be of particular importance. Links should be established with the command and control information system.

**Landing Zone Security UGS**

As a possible modification of the weapon system carrier, Army Aviation and Special Forces should require an unmanned ground-based system that could secure a landing site for a limited period of time, detect and identify targets, and be capable of suppressing while the helicopters are on the ground at the landing zone.

**Autonomous Combat Vehicle**

Armoured Forces should require a multi-robot-system that could seize, hold and control an area of operation as a manned combat vehicle (main battle tank/infantry fighting vehicle) would. In addition to the capabilities for autonomous target acquisition, detection, and tracking, engagement with all weapons maintaining unlimited tactical manoeuvrability even in difficult terrain, tactical command and control should be exercised by a manned control system. These requirements should be the logical continuation of the "Weapon System Carrier" concept as an integrated system of unmanned systems for reconnaissance and engagement at subunit, unit and formation level.

**Autonomous Gun**

The Artillery should require a multi-robot system that autonomously could take up fire positions, establish readiness to fire, and conduct fire fights by the same standards as a manned gun/ fire control centre. The firing performance should be comparable to a modular indirect fire system for long-range fire support. The period of employment should be 12 hours with a weight of less than 24 tons (air-transportable aboard A400M).

**Support and sustainability**

For CSS missions, the priority could be to obtain a partial robotization of convoys, in order to reduce the vulnerability of logisticians.

**Remote-Controlled Engineer Construction Vehicles**

The Corps of Engineers should have a need for engineer vehicles already in service/to be introduced to be equipped with adaptable remote controls so that excavation, blade and demolition work as well as EO clearance could be carried out in EO-contaminated terrain. Operators should control the process from a distance with the working area in direct view. This could minimizes the risk from mines and booby traps for employed personnel.

**Unmanned Underwater System (UUS)/Unmanned Under Surface System (USS) for EO Reconnaissance, Clearance and Disposal in Inland Waters**

The Corps of Engineers should require an unmanned underwater or surface system that could be employed in inland waters for EO reconnaissance, clearance and disposal. The capability profile should, first and foremost, focus on remote-controlled reconnaissance (detect, search, localise and identify) of EO (USV), and, secondly, cover measures to counter the EO threat as well as the clearance of unexploded ordnance in fast moving waters. Necessary primary capabilities for reconnoitring/scouting should include moving in water, submerging, and transmitting imagery as well as high manoeuvrability and precise navigation even in poor visibility. The ability to detect metals and scan the riverbed and underwater structures should be indispensable for reconnoitring EO. Once the chief functions have been realized, possible upgrades to give the system counter-EO capability should be desirable. Recovery, clearance and disposal could, among other activities, be ensured by precisely attaching a percussion charge or a towing rope to the object to pull it from its location.

**Transport UAV**

Special and Long-Range Reconnaissance Forces should have a demand for an unmanned airborne system capable of transporting smaller payloads (<400 kg) over distances of more than 1,200 km (600 km operational radius). They should have to supply remotely employed special reconnaissance forces, replenish mission-relevant materiel, and reduce the weather dependency of manned transport aircraft. The system should be employable with remote control or autonomously in any visibility conditions with low noise emission. It should lend itself to being launched from the ground and/or from naval platforms, and to landing vertically.

**Survivability and protection**

The force protection could be increased by the use of robotic systems for dangerous and specific missions (NRBC recce, engineers recce, demining, UXOs destruction) or for repetitive tasks (area survey). In priority, the goal is to reduce the specialist vulnerability in high risks situations (NRBC, IEDS, Mines).

**Point Defence UGS**

The Army Logistic Service, the Army Aviation Corps, and Special Forces should require an unmanned system that should be capable of securing temporary facilities (e.g. field maintenance points, FARP), thus reducing the number of personnel employed on guard/security duties. Such systems should be employed universally and in particular on operations to guard checkpoints, tracts of terrain outside camps, etc., supporting security personnel who will still be required, but, in comparison to today's strength, in reduced numbers. This should improve the sustainable performance in the respective core task, enhance force protection measures, and ultimately increase lethality. Autonomous off-road movements and detection of individuals/vehicles in any visibility conditions should be required. Depending on the situation, alert-raising capability and the employment of NLW (autonomous)/ LW (semi-autonomous) should be planned. Sensor data should be transmitted to a control room at a range of up to 50 km, and for a span of operation of up to 5 hours.

**Explosive Ordnance Disposal UGV**

The majority of Finabel land forces have already small EOD manipulator UGS, small Engineer Corps manipulator vehicles, and IED manipulator vehicles The capability platforms for the EO protective task in the Army (Corps of Engineers/ Army Logistic Services) consist of a remote-controlled, ground-based platform for standoff-capable EO reconnaissance, clearance and disposal, including the manipulation of objects. Realising an automation effect of specific regularly repetitive work steps (e.g. approaching an object in easy terrain and in direct view, picking up tools carried), it should become possible to relieve the specialist operating the system.

A need for development also exists in the following areas:
- Remote-controllable and modifiable explosive charge with arming system and ignition device for radio-triggered systems and adaption for various explosive charges,
- 3D capture of the work area (outrigger range of manipulator arm) and around the tools (higher resolution) to avoid collisions,
- Integration of sensors to detect explosives, ignition components (electronic components) and jackets of explosive ordnance (geometry) and their automatic use throughout the area and space, displaying any anomalies detected,
- Uncover explosive ordnance or parts thereof buried in the ground, and system compatibility of sensors and jammers.

**Command and control capability**

In this branch, the major development will take place in the battlefield digitalization. Units need to have digital liaisons with a high degree of fiability. So, the priority could be to optimize the communication coverage, particularly when the manoeuver space is divided (mountains, urban terrain…).

In all cases, it is essential to determine the autonomy level of the robotic system and its capacity to fulfil mission without direct human intervention in a given environment. The first technical level of autonomy deals with energy and power supply. But, besides that, the question autonomy has to cover two aspects. On the one hand, the link between robot and human being (without decision-making autonomy) and on the other hand, its relation to the physical environment have to be dealt with.

**Unmanned Airborne Relay Platform**

An airborne unmanned system that could ensure autonomous relay operations as an interface in data-capable battlefield communication networks and thus the interference free battlefield communication of the deployment forces should be required by all arms and services.
As opposed to the relay UAS (relay drone), the systems should be used in an integrated system to ensure network coverage throughout the area. They should replace the currently employed relay team who, due to their exposed and fixed positions, are particularly exposed to risks.
The relay platform should have an almost static airborne position outside enemy fire to ensure communication via highly directional radio relay links. One core requirement for radio control and user signals should be high jamming resistance from adversary electronic warfare measures.

This project should be regarded as joint objective as this capability is not only required by the ground forces but by all services/ organisational areas; also, an appropriate airborne platform could take on other functions. In this context, the Army Aviation Corps should require airborne systems with relay capabilities to command and control unmanned airborne vehicles (UAV) and ensure data transfers beyond the line of sight (BLOS) within the framework of future manned - unmanned teaming (integrated system of helicopter and remote sensor platform).
The Army Air Defence Artillery should be in need of an airborne unmanned system that should ensure autonomous relay operation for tactical data links.