The Swiss Center of Drones and Robotics (SDRZ) of the Federal Department of Defence, Civil Protection and Sport (DDPS) was launched to support the Swiss Armed Forces in dealing with robotics. Drones and robots are increasingly finding their way into the civilian and military environment and gaining in significance. Armasuisse Science and Technology (S+T) is therefore steadily building up the SDRZ. The Centre assesses the state of the art in technologies as well as possible applications and threats for the armed forces. In terms of applications, the focus is on disaster relief; in terms of threats, it is on the danger posed by mini-drones.

Text: Pascal Vörös
Drones are successfully deployed in a wide range of applications worldwide, both strategically and tactically, varying in size from aircraft to micro-drone. In general, we have to assume that the use of robotic systems will become even more significant in the future. Today we are effectively in a arms race driven by artificial intelligence and autonomy. Superpowers such as the USA, Russia and the People’s Republic of China are investing more and more in these technologies for military applications. There is a particular focus on rapidly adapting commercial technological breakthroughs to the military area to gain a competitive advantage.

One aspect that should be mentioned along with these developments is the intensifying discussion about ethical and legal issues. Which decisions are made by humans and which by robots, and how is responsibility regulated? These questions are tougher than they look. The largest upcoming European defence programme, the Future Combat Air System (FCAS) has with good reason set up an accompanying working group dedicated to responsible use of new technologies and operational application of ethical and legal principles. Another example is a Group of Governmental Experts at the United Nations dedicated to the problems of lethal autonomous weapons systems, which has drafted eleven guiding principles on this topic.

And let’s be honest: the thought that one day a technical system could be given the ability to kill a human being based solely on a calculation by an algorithm is indeed terrifying and deserves our attention.

Effect: Building up and commitment of the SDRZ

The DDPS has reacted to these developments. The Swiss Center of Drones and Robotics (SDRZ) of the DDPS was set up in 2017 by the Head of the Armed Forces Staff, Major General Claude Meier, and the Head of armasuisse Science and Technology (S+T), Dr Thomas Rothacher. Last year, the anticipated development of the SDRZ was designed and approved in a business plan. Over the coming three years the SDRZ aims to take on further expert staff and build up its competencies and services so it can deploy its full potential in 2023.

The goals are to be able to support the Swiss Armed Forces in dealing with robotics, seize opportunities and assess risks.

Cause: rapid global developments in robotics

The development of drones and robots is continuing at high speed. Their abilities are rapidly improving and becoming an increasing part of our lives. This is most evident in the increase of mini-drones, available cheaply from retailers. Without any previous technical knowledge, we use them to discover the world from a bird’s eye view and record our parties, downhill ski rides or breathtaking panoramic views. This is possible thanks to the technological advances in the software and hardware installed. In general, the rapid technological development in robotics is heavily driven by civilian companies. They are addressing the enormous market potential of commercial robots, self-driving cars, or automated logistics and agriculture, to name just a few examples. In the process, they are investing vast sums in research and development.

The Armed Forces use drones and robots too. Drones in particular have been playing a key role for some time. They are successfully deployed in a wide range of applications worldwide, both strategically and tactically, varying in size from aircraft to micro-drone.
The SDRZ also engages in non-technical research projects that are rather less tangible but sometimes just as important. As introduced at the beginning, an important point to mention is addressing ethical issues. For instance, an ethical evaluation scheme is being developed with the universities of Zurich and St Gallen. This seeks to find a soundly based way of assessing and addressing ethical risks (see the graphic on the ethical evaluation on the next page).

**Operational infrastructure** (e.g. robotics laboratory, test site and DDPS testing facilities)

**Human Resources management** (recruiting, deploying and ongoing training of the required specialists)

**Developing the Center** (ensuring it is properly set up and structured)

**Purchasing** (expertise, prototypes, demonstrators, measuring instruments, etc.)

**Development and expansion of competencies**
- Federal government-research
- Studies and scientific publications
- Developing and expanding networks

**Service provision**
- Technology and market monitoring
- Supporting WEA, Procurement
- Blue/red teaming
- Events, workshops
- Training
- Technology transfer
- Backing start-ups
- Operational

**Communications**
- Information to stakeholders
- Positioning and awareness

**Consulting**
- National hub for drone and robot technology

**Primary activities**

**Secondary activities**

![Schematic diagram of the value chain of the SDRZ in 2023.](image)

**REASONS FOR THE INCREASE IN ROBOTIC SYSTEMS IN THE MILITARY**
- Robots are rapidly becoming more capable and cheaper due to technological advances (with AI, Big Data and 5G as technology drivers)
- Robots increase military capabilities (e.g. they can detect, warn, decide and execute rapidly) in all spheres of operation (space, air, ground, sea, cyber, information and electromagnetic space) and simultaneously reduce the exposure of own troops in war zones
- Robots are suitable for tedious, challenging, dangerous and lengthy deployments (e.g. site surveillance, support in contaminated areas, detection and elimination of IEDs, fire fighting, etc.)
- Robots can be deployed in places which are difficult or impossible for humans to reach (e.g. mountainous regions, space, deep sea, etc.)
- Robots do not suffer from human emotions (e.g. fatigue, stress, fear, hate, etc.)

**Recognising and anticipating risks: new threats**
While there are multiple benefits to using drones and robots, on the downside they give rise to new threats. Public awareness has changed since the drone incident at Gatwick airport in December 2018, when hundreds of flights were cancelled and around 140,000 passengers and 1,000 flights were affected. The potential threats are manifold and extend from the future deployment of lethal autonomous weapons systems to misuse or even terrorist use of commercially available systems.

The SDRZ is paying particular attention to possible threats by mini-drones as an urgent issue. The spectrum includes developments such as modified commercially available civilian drones, armed mini-drones, loitering munition (a type of unmanned aircraft which waits in the air for instructions over an extended period until a target presents itself, and then attacks it with an explosive warhead) and swarms of drones. Together with colleagues in armasuisse S+T, the SDRZ is also monitoring developments in drone defence along the entire chain from detection, identification and tracking to neutralisation and evaluation.
**Conclusion**

A global arms race is under way in drones and robots. One key factor for success here is building bridges between civilian developments and military applications. It is also important to anticipate new threat scenarios and react to them. For Switzerland, this raises the question of how we wish to deal with these. The Swiss Center of Drones and Robotics (SDRZ) of the DDPS is the hub which helps provide facts, assessments and possible responses.

**ARCHE** stands for Advanced Robotic Capabilities for Hazardous Environment and is a research tool of the SDRZ. It is managed together with the Engineering/Rescue/ABC Training Unit of the Armed Forces, ETH Zurich and the National Centre of Competence in Research (NCCR) Robotics and assesses the suitability of robots for use in disaster relief.

---

**Ethics evaluation scheme:** The graphic shows the preliminary results of a pilot test using the ethics evaluation scheme in four research demonstrators as part of ARCHE (for information on ARCHE see box at top right). For each criterion, an assessment was made of its relevance for the system (Weight: the larger the symbol, the higher the weighting), and ethical concerns about its application in the specific system (Rating: using the symbols – the square denotes greatest concerns). The Mobula system, for example, implemented a net gun, which represents a potential risk of injury for humans, so physical security measures have been classified as an important criterion and a high ethical risk in implementation. It is also interesting to see, for example, that cyber security has been classified as problematic in all systems – as it would be relatively easy to hack the systems and use them contrary to their intended purpose. However, it must be noted for both examples that comprehensive technical security aspects are not a priority for research demonstrators in the controlled test bed, and accordingly they are not yet certified.
Seizing opportunities: Research and innovation for the Armed Forces

The SDRZ carries out research into drones and robots for the Swiss Armed Forces. It does not do this alone, but with the assistance of a strong research network within armasuisse S+T and partners from the “Silicon Valley of Robotics”, as Internet guru Chris Anderson once described Switzerland due to the skills available here. Combined with the innovative strength of Switzerland, which has already produced numerous start-ups in robotics, this creates an energy here which should be utilised.

The following overview provides some examples of research robots. These enable the SDRZ to better assess the state of the art in technologies and possible applications for the Armed Forces.

In addition to the focus on research, the SDRZ is also committed to enabling promising systems to be more broadly and rapidly transferred and deployed in the Swiss Armed Forces. The focus here is on supporting disaster relief.

**Technology Readiness Level**

The Technology Readiness Level (TRL) is a scale for assessing the development status of new technologies. On a scale of 1 to 9, it determines how advanced a technology is.

- **TRL 9**: Qualified system with proof of successful deployment
- **TRL 8**: Qualified system with proof of proper functioning in the area of deployment
- **TRL 7**: Prototype in use
- **TRL 6**: Prototype in the operating environment
- **TRL 5**: Test setup in the operating environment
- **TRL 4**: Test setup in the laboratory
- **TRL 3**: Proof of the functionality of a technology
- **TRL 2**: Description of the application of a technology
- **TRL 1**: Observation and description of the functional principle

**Legend for drone and robot criteria**

- **F**: Research goal
- **P**: Partner
- **A**: Application focus
- **G**: Size and weight
- **E**: Energy supply
- **S**: Speed

Hold your smart phone camera over the QR code to see a film sequence of the robot.
Ascento

"As a compact jumping robot with legs and wheels, I move agilely in confined spaces and overcome obstacles by jumping."

F Examining options for moving in buildings
P ETH Zurich, Autonomous Systems Lab, Ascento
A Indoor reconnaissance
D L: 1.2 m, W: 2.2 m, H: 0.67 m; 2.2 kg
E approx. 15 min
S 180 km/h

ARMANO

"You have seen me in armafolio 2020/1 and the press as the ‘bomb excavator from Mitholz’."

F Automating an unmanned walking excavator for deployment in terrain that is difficult to access and dangerous for people
P ETH Zurich, Robotic Systems Lab, Menzi Muck, Leica Geosystems, Moog
A Clearing dangerous terrain
D L: 6.2 m, W: 2.4–6 m, H: 2.5 m (transport height); 13,000 kg
E 20–24 hours, depending on the intensity of work
S 10 km/h

DroGone | “Peregrine”

"I try to capture mini-drones in one piece in my net — without damaging the drone or bystanders."

F Meeting the increasing threats to public security from drones
P ETH Zurich, Autonomous Systems Lab, DroGone
A Defence against drones
D L: 1.6 m, W: 1.6 m, H: 0.6 m, 6.7 kg
E 5–9 min
S 66 km/h

Mobula

“As a fixed-wing aircraft with a high degree of manoeuvrability, I am suitable for long-range operations and pursuing moving targets.”

F Semi-autonomous defence against mini-drones
P HSR – University of Applied Sciences Rapperswil, Institute for Materials Technology and Plastic Processing, Mobula
A Defence against mini-drones
D L: 2 m, W: 1.86 m, H: 0.75 m; 18.5 kg
E approx. 15 min
S 180 km/h

RoBoa

“Thanks to my snake-like shape and unique pneumatic way of moving, I can even creep through small holes.”

F Supporting emergency responders in locating victims in rubble and collapsed buildings
P ETHZ, Autonomous Systems Lab, RoBoa
A Locating victims in rubble
D (snake) L: 17 m, W: 0.1 m, H: 0.1 m; 2 kg; (supply box) L: 0.5 m, W: 0.5 m, H: 0.5 m; 50 kg
E as long as external power supply is provided
S 0.36 km/h

Scubo 2.0

“My eight drives enable me to move under water in any direction and align my gripper arm as desired.”

F Examining how underwater robots can support divers in their work
P ETHZ, Autonomous Systems Lab, Tethys Robotics
A Supporting diving missions
D L: 0.73 m, W: 0.66 m, H: 0.4 m; 28 kg
E as long as external power supply is provided
S approx. 5 km/h

Sentinel Catch

“I carry a net and parachute so I can catch drones in a rapid flyby and bring them safely back to the ground.”

F Intercepting mini-drones with a drone
P SkySec GmbH
A Intercepting small drones
D L: 0.7 m, W: 0.3 m, H: 0.3 m; 1.8 kg
E approx. 2–3 min
S 230 km/h

Dipper

“I can plunge into water dynamically from the air, manoeuvre freely under water and take off again into the air from the water.”

F Movement in multiple environments (water and air)
P ETHZ, Autonomous Systems Lab, Dipper
A Air and water reconnaissance
D L: 1.2 m, W: 2.2 m, H: 0.2 m; 2.2 kg
E approx. 4 min (flight); 10 min (water)
S 70 km/h (flight); 9 km/h (water)

AtlantikSolar

“As a solar-powered autonomous aircraft I can theoretically remain in the air indefinitely.”

F Examining energy efficiency during prolonged periods of flight
P ETHZ, Autonomous Systems Lab, AtlantikSolar
A Autonomously searching for people and automatically identifying landing sites
D L: 2 m, W: 5.7 m, H: 0.4 m; 7.5 kg
E up to 13–81 hours (world record set 14-17 July 2015; theoretically unlimited)
S approx. 32 km/h

ARMANO TRL 5

Mobula TRL 4–5

Ascento TRL 5

RoBoa TRL 4–5

DroGone | “Peregrine” TRL 4–5

Scubo 2.0 TRL 5–6

Sentinel Catch TRL 5–6

Dipper TRL 4–5

AtlantikSolar TRL 5
**ATHLAS**

"My legs let me land safely on sloping and uneven ground, and soften hard landings."

P: ETH Zurich, Robotic Systems Lab, Athlas

F: Examining active landing gear for landing helicopters on uneven terrain

A: Helicopter landing on uneven terrain

G: L: 3.3 m, B: 1 m, H: 1.3 m; 15 kg

E: approx. 1.5 h

S: 60-80 km/h

**ARTOR**

"As I can change my payload according to requirements, I am very versatile."

P: ETHZ, RUAG

F: Demonstrator for medium-size experimental unmanned platform with a high degree of autonomy, can be equipped with modular payloads depending on the mission.

A: Possible modular applications (modules: manipulator, mapping, CBRN, ISR, flying eye dock, water cannon)

G: L: 1 m, B: 0.8 m, H: 0.8 m; 250 kg

E: approx. 4 h

S: 15 km/h

**ASIO**

"Thanks to my coaxial drive setup, I am able to fly quietly with only two rotors in a way that is also energy-efficient."

P: Flybotix SA

F: Innovative, magnetic component control to increase energy efficiency and reduce flight noise

A: Indoor inspections

G: L: 0.39 m, B: 0.39 m, H: 0.29 m; 1 kg

E: 24 min

S: approx. 7 km/h

**Voliro T**

"I am a flying robot and can swivel my engines with the propellers by up to 180°. This enables me to move in a new way in the air."

P: ETHZ, Autonomous Systems Lab, Voliro Airborne Robotics

F: Examining new methods of movement in the air

A: Inspection and manipulation from the air

G: L: 0.8 m, B: 1 m, H: 0.4 m; 5.5 kg

E: 15 min

S: 72 km/h

**Wingtra One**

"I can take off vertically like a helicopter and then switch to horizontal flight."

P: Wingtra AG

F: Detecting munitions in terrain using hyperspectral cameras

A: Support for clearing firing ranges

G: L: 1.25 m, B: 0.68 m, H: 0.12 m; 4.5 kg

E: 59 min

S: 58 km/h

**Ellos 2**

"Thanks to my cage I am well-protected, resistant to collisions and able to fly in confined conditions."

P: Flyability

F: Navigation in confined spaces

A: Navigation and cartography in confined conditions

G: L: 0.4 m, B: 0.4 m, H: 0.4 m; 1.4 kg

E: approx. 10 min

S: 23 km/h

**IGNIS**

“So far I have only existed as a CAD drawing and am waiting for the students at ETHZ to bring me to life.”

P: ETHZ, Autonomous System Lab, IGNIS

F: Autonomous fire fighting by fire-extinguishing drones

A: Fire fighting

G: L: 1.7 m, B: 2.5 m, H: 0.5 m; 25-32 kg

E: approx. 25 min

S: approx. 69-80 km/h

**TRL**

- TRL 8–9
- TRL 4–5
- TRL 4
- TRL 7
- TRL 2–3