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SPECIAL FOCUS

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TEAMING UP WITH UAVs

BEtter Response and Improved Safety through Unmanned Aircraft Systems - BERISUAS

2 Mers Seas Zeeën
INTERREG IV A
FRANCE - ENGLAND - VLAANDEREN - NEDERLAND

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Ivo Opstelten

Minister of Security and Justice

FORWARD! Together

Security is a complex issue. Many, often specialised, organisations are involved, and they each look at issues from their own perspective. These views combined can lead to unexpected partnerships and solutions. I therefore support collaboration between different parties and challenge them to get into action.

Regional teams lay the basis for successful combat of calamities. My responsibility as Minister of Security and Justice is to give full responsibility to the safety regions and allow them to collaborate - and to justify this in my country. Their strengths are reinforced by cross-border collaboration with similar teams in bordering countries. Cross-border collaboration is about sharing. We share our knowledge, experience and equipment to protect our citizens. It should not matter which country provides assistance - it is important that assistance is given promptly and with a minimum of red tape.

The Interreg IV A 2 Seas cluster BERISUAS complements this idea. Sharing knowledge and experience about the use of drones to solve security issues at sea will undoubtedly lead to a better, more accurate, response. Additionally, the methods developed will trigger new ideas and solutions that will improve the life saving activities of our emergency services.

Drones are a relatively new phenomenon. The Scientific Research and Documentation Centre (WODC) of the Netherlands Ministry of Security and Justice have been investigating the implications of drone deployment to enable the formation of sensible policies. The WODC has charted types of drones and their technological possibilities, with the study concluding in November 2014. The results will get the work of BERISUAS into the air.

Ivo Opstelten
Netherlands Minister of Security and Justice

CHAPTER 1
UNMANNED AERIAL VEHICLES CAN SOLVE MIRG PROBLEMS

The INTERREG IV A 2 Seas Programme prompted the initiation of many different projects. Each had their own aims, and the partners worked hard to deliver the expected results within the lifespan of the project. In many cases there was little time to focus on the world outside the project, and obvious or simple solutions were frequently overlooked as a result. The 2 Seas Programme challenged project leaders to look beyond the scope of their work and set up unexpected collaboration with other projects, enabling knowledge and experience to be exchanged and expanded. This is key in enabling projects to step up to the next level.

BERISUAS brings 3i and MIRG-EU together

The 3i and MIRG-EU projects accepted this challenge and teamed up to form the BERISUAS cluster. BERISUAS is an acronym of BEtter Response and Improved Safety through Unmanned Aircraft Systems. The 3i project stimulates the use of Unmanned Aerial Vehicles, UAVs, in the maritime environment. The project partners developed a prototype UAV that can be used by organizations such as Police, harbour masters, and environmental agencies for monitoring movements and activities of ships in the Channel and southern North Sea. However, with specific equipment, these UAVs can do much more, including temperature measurement or detection of chemical substances in the air. Such abilities are of interest of fire fighters who combat incidents on board ships.

This is the topic of the MIRG-EU project. MIRG stands for Maritime Incident Response Groups; expertly trained, fully equipped firefighting teams, ready to be flown out to a ship in need on the waters in the 2 Seas area. Their job can be dangerous; in order to work safely and effectively, the teams must create a detailed risk assessment and an efficient combatting plan. They therefore require as much information as possible about the situation- and they need it fast. Working with UAVs can address many problems MIRGs are confronted with.

Far from dull

Brian Tice postulated in his publication "Unmanned Aerial Vehicles" in the 1990s that: "When used, UAVs should generally perform missions characterised by the three Ds: dull, dirty, and dangerous". While it is true that a UAV can be more suited to these roles than manned aircraft, today, a drone's mission is often far from dull. Drones are used in many applications, from hobby use to military purposes, and from serving beers to fighting calamities in busy sea areas. As Guido de Croon from TU Delft would rather put it: "UAVs are functional, friendly, and fun!"

Eyes, ears and noses

To build a suitable UAV for MIRG, it is necessary to know exactly what information the teams need; for example, whether toxic fumes are emitted, whether people are overboard, and the nature of possible leakages. The unmanned aircraft should therefore be equipped with eyes, ears and noses – i.e. cameras, heat sensors, and gas sensors. Jeroen Zonnevijlle, Project Manager of MIRG-EU: "the more information we have at our disposal, the better we will be able to make a risk assessment. This way, we won't be sending our people on perilous journeys unprepared. And when we do send them, we know more precisely which equipment they have to take along. After all, the space inside a helicopter is limited, and the more efficiently we can work, the better."

BERISUAS cluster partners in brief

BERISUAS brings together MIRG-EU and 3i, two unique projects that find each other in their aim for safety.

MIRG-EU helps to 'contain and maintain'

Maritime accidents demand specific skills and knowledge from rescuers to fight on-board fires. In some countries, regular fire fighters are sent out to control fires on board ships. However, due to lack of specific knowledge, skills and proper equipment, their actions aren't always as effective as they could or should be. As a result, crew and passengers may need to be evacuated from the ship, a procedure that in itself is not without risk.

Maritime Incident Response Groups

A Maritime Incident Response Group, MIRG, will help tackle on-board problems such as fires and chemical incidents. Dutch, Belgian, French and English fire brigades have joined forces in MIRG-EU. Their primary mission is to 'contain and maintain'. This means that a fire is contained to safe proportions, after which the ship's transport to a port is facilitated for further handling of the incident. This avoids evacuation of crew and passengers at mid-sea and limits the effects on the environment and the economy as shipping lanes will be cleared as fast as possible.

Teamwork and learning from each other are central to the project. Each partner country assembled its own complete MIRG team, comprising 36 people. "A MIRG team member has to have many qualities," Project Leader Jeroen Zonnevijlle of Safety Region Zeeland, explained. "In addition to training and experience, **they have to be fast learners, be excellent team players, be highly motivated, be able to resolve problems quickly, and not be afraid to take responsibility."** Not being afraid is certainly an important character trait, as is team spirit.

Four countries, one standard procedure

The MIRGs from the four partner countries developed a standard operational procedure and education, training and exercise programme, as well as making sure that all equipment of the teams was compatible. Different training sessions were organised, comprising real-life operations such as helicopter hoist training, both in daylight conditions and at night. During these important exercises, people learned to collaborate and use various techniques that will help them save lives in future.

By following the same training schemes and procedures, and using compatible equipment, the teams can seamlessly take over the work from one another when necessary. Zonnevijlle: "It is a very satisfying experience to team up with people from other countries in the 2 Seas area. You can learn from everyone's experiences, and make better and efficient use of the means provided." The project ended with a large scale exercise on board the DFDS Princess Seaways, where all teams were deployed, demonstrating they are ready for the job.

More information: www.mirg.eu

3i proposes a suitable UAV

In the 3i project a consortium of Scientific & Specialist organizations (Universities, Schools, SME and Economic development agencies) and Public Sector organizations (e.g., Police, harbours, fire-fighting & emergency departments) worked together in research and development, in producing a joint prototype UAV, and in performing joint tests and demonstrations.

3i stands for:

Integrated Coastal Zone Management via Increased situational awareness through Innovations on Unmanned Aircraft Systems

Busy port bordering busy seas

Ghent Fire and Rescue Service was a partner in the MIRG-EU project. Together with fire fighters from Antwerp and Beveren, they formed the Belgian MIRG. Didier de Wulf, administration director with the Ghent Fire and Rescue service explains why they participated in the project; "Ghent is an important port bordering the 2 Seas area. The area is getting busier all the time, and ships are getting larger and faster. The town also has an important industrial area. Many ships moor in this busy port to have their cargoes transhipped to the hinterland. The ISPS Code has become a familiar set of rules with which ships have to comply. However, when a disaster happens on board a vessel, there are many issues involved. A ship in distress is very unlike a building on fire. For example, there is always a real danger that hazardous substances are released, which may be detrimental to the environment."

The physiology of a ship is very different as well. The sharp, steel bottom and the spacious hold pose their own problems. "Our mission is to rescue people, while not endangering the lives of our own men and women. As a fire brigade, we have limited experience with ships. That is why, four years ago, we joined the MIRG, also comprising teams from the UK, the Netherlands and France. Together with them, we developed a procedure to board a ship in distress. We started from scratch in this European project, which turns out to offer major advantages to all parties. For example, we are able to make joint purchases of personal protective and other equipment. Such equipment has to meet strict requirements and quality is important. Thanks to our collaboration, we were able to purchase the right materials."

The helicopter has to fly a couple of hundred metres above the ship, into the wind, while the members of a MIRG team are winched onto the deck.

The project partners stimulate the use of UAVs in the maritime environment as there is no better view of a calamity at sea than one provided from above, using an unmanned aerial vehicle. In 3i, partners from England, France, and the Netherlands combined research efforts into UAVs for maritime applications. The resultant platform has been proposed for use by MIRG-EU.

The UAV in action

The disassembled aircraft can be transported to the desired location by van and deployed in minutes. The specially designed van also serves as the ground station from which the aircraft can be remotely operated, and receives images, live video and other information from the UAV during operation.

More information:
www.2seas-uav.com

3i present the envisaged unmanned aerial vehicle

The UAV's characteristics

The UAV developed for MIRG has a skeleton made of carbon fibre, making it robust and lightweight. The central part of the wing contains five litres of fuel, and also provides the attachment point for interchangeable payloads, such as cameras and sensors. The UAV has 2 x two-stroke 28 cc engines with 3.35 horsepower a maximum of 8000 rotations per minute. Should one engine fail, the aircraft is able to return to base on the other one. The engine pods, fuel tank and other crucial components have been manufactured from laser-sintered nylon, a highly robust material that is resistant to chemicals and prolonged exposure to UV radiation.

The term 'drone' makes technologists shudder

UAVS and their synonyms

There are many terms used for unmanned aerial vehicles, UAVs. Drone is just one of these. Although it makes technologists shudder, it is the term used most frequently by the media and the general public. Hence, rather than avoid the term altogether, we have used it occasionally in this publication, where its use seemed appropriate. On the next page are some of the synonyms of the term 'drone'. Which one do you prefer?

Type: unmanned, twin-engine, remotely piloted aircraft
Wingspan: 3.74 metres
Weight: 20 kg, excluding fuel and payload
Maximum payload: 5 kg, excluding fuel
Maximum speed: 148 km/h
Cruising speed: 94 km/h
Air-borne endurance: 2.75 hours

There is no better view of a calamity at sea than one provided from above – using an unmanned aerial vehicle

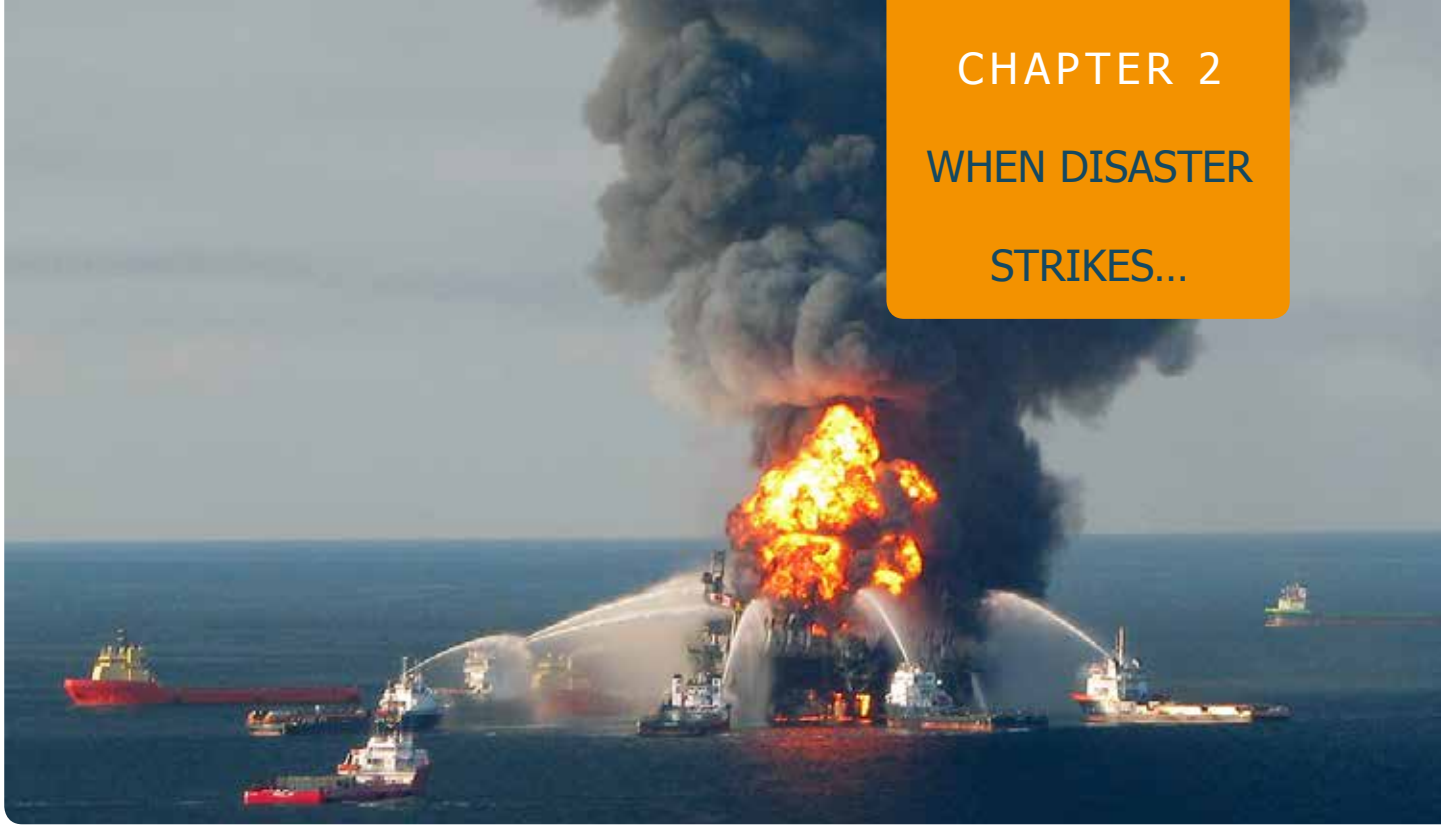
Reading guide

The partners of the BERISUAS cluster worked together for a year. In this time, they developed a realistic scenario that captures the problems a MIRG can be confronted with at sea, and discussed and researched possible solutions UAVs could provide and how they could be implemented. With this publication the BERISUAS cluster wants to share its experience, inform stakeholders and the wider community in the 2 Seas area on the developments, possibilities and challenges the partnership is facing in the further development of the concept.

But first things first: the waters in the 2 Seas area are notoriously busy, with a high risk of incidents and accidents. The next chapter will give insight into what MIRGs can be called upon. The focus is then on the work of MIRGs. A realistic scenario was developed to describe the problems they can encounter at sea. Such a scenario does not describe a worst case, but a kind of incident that happens at least once a year somewhere in the world. With the problems made clear, the solutions that UAVs can provide and the hurdles that have to be overcome in order to implement the new techniques are described. This publication concludes with a look into the future, because UAVs developed for MIRGs are just the first step in a whole new world.

Glossary

3i system	A system developed by 3i (see Glossary)
AAR	Autonomous Aerial Robot
Drone	This name is based on the humming noise resembling the sound made by the male bee, called a drone. It was originally a military air force term for an unmanned aerial vehicle used in exercises to be eliminated as a flying target. Today, the International Civil Aviation Organisation (ICAO) uses the term RPAS, while 'drone' is most frequently applied to hobby versions
MAV	Micro Air Vehicle
Microcopter	
Quadrocopter	
RPA	Remotely Piloted Aircraft
RPAS	Remotely Piloted Aircraft System
RUAV	Rotor UAV
SUAS	Small Unmanned Aircraft System
UAS	Unmanned Aircraft System
UAV	Unmanned Air Vehicle



CHAPTER 2

WHEN DISASTER STRIKES...

"The fire was intense, and the on-board fire-fighting response flawed. Despite regular emergency drills, the crew on board of the huge ocean-going tanker carrying various chemicals panicked. They had instantly forgotten their scant knowledge of the English language and were uttering cries for help in their various home tongues and running around in a frenzy. A deep black smoke was developing, drowning out the glaring sun and the endless waves surrounding the disoriented vessel. Some people were even jumping overboard, in a desperate attempt to escape the flames and the toxic fumes. And they were among the lucky ones. Some of their colleagues were trapped inside..."

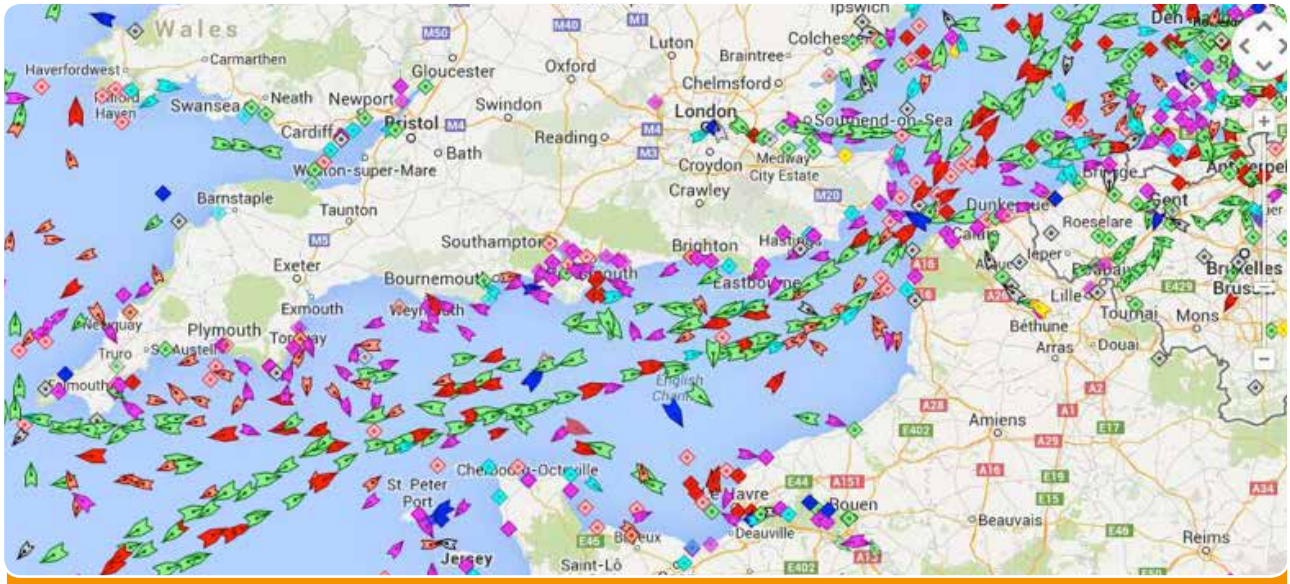
55 fires and explosions

The 2 Seas area, comprised of The Channel and the southern part of the North Sea, is one of the busiest seaways in the world. Traffic is guided safely through these waters thanks to radar and state-of-the-art communication tools. Many of the vessels carry dangerous cargoes, which if accidentally released into the sea, could have disastrous consequences to the environment, marine life, and the coastlines of England, France, Belgium, and the Netherlands.

The passage of ships through the Strait of Dover is further complicated by the presence of strong tides, sandbanks, shoals, and a great deal of concentrated cross-channel traffic. Much of this crossing traffic is made up of high-speed ferries carrying as many as 2400 passengers. This extremely busy area brings many risks.

Incidents similar to the scenario outlined above do in fact occur in the busy waters of the 2 Seas area. According to risk analyses carried out in 2007 and 2010, there were an average of 55 fires and explosions per year on vessels in the Atlantic and North Sea area, which includes the 2 Seas area. Many other incidents occur also, including groundings, sinkings, and collisions. Altogether, an average of 450 incidents take place in this area every year.

The MSC Flaminia on 14 June 2012



Maritime traffic in the 2 Seas Area – the 2 Seas area is one of the busiest international seaways in the world. During a random 24-hour period, there are more than 500 shipping movements in all directions.

An additional risk at sea is the possible leakage of hazardous substances, including toxic fumes, nuclear radiation, and biochemical compounds. Recent examples of incidents in the 2 Seas area include the MOL Comfort, which broke in two and sank on 17 June 2013 and the MSC Flaminia, on which explosions and a fire occurred on 14 June 2012. On 28 December 2013, a fire broke out on the DFDS ferry King Seaways.

Kent has one of the longest coastlines of any County in the UK. Since the 1980s, Kent Fire & Rescue Service has responded to serious incidents including the Herald of Free Enterprise and the Ever Decent. After the outcome of the Maritime and Coastguard Agency's 'Sea of Change' project in 2007, the British MIRG was established. Since then, MIRG UK has responded to incidents including the MV Calypso, Commodore Clipper and Yeoman Bontrup.

Fire on the cruise ship MS Calypso – example of a successful 'Contain and Maintain' intervention by MIRG-EU

How MIRGs come to the rescue

A fire on board an ocean-going vessel will always be a frightening experience. If the fire is small, it is usually quickly controlled by a competent crew, who have been trained to ensure their own safety, protect their passengers, and look after the equipment. However, sometimes a fire occurs that cannot be contained by the crew themselves, and it becomes a different story altogether. In this case, the captain of the ship will notify the Maritime Rescue Coordination Centre, MRCC, to request assistance from a maritime incident response group, MIRG.

Protocol

According to a protocol, the MRCC will ask a number of questions to find out more information about the ship, its crew, the cargo, and the particular incident. The location, which is registered by the automatic identification system, AIS, will be

verified. Based on the information provided by this interrogation protocol, the officer on duty will contact the emergency room of the nearest MIRG. Next, a primary risk assessment is made. In most cases, a helicopter will be sent out carrying crew and equipment that should suffice in general incident control. However, nothing specific can be done, for the simple reason that space in a helicopter is limited. On average, it will take one to one and a half hours before the helicopter will arrive at the location where the MIRG team members will be picked up. They will use this time to prepare themselves and their equipment. Upon their leaving the heliport, the MRCC will notify the captain of the ship in distress that the team is underway.

Maritime Rescue Coordination Centre

Being informed saves lives

For MIRGs it is important to know in detail what they can expect when they are flown out to a ship in distress. First and foremost they must know whether they can reach the ship safely. Is there strong heat from a fire? Are there chemical substances in the air to be taken into consideration, what are the weather conditions? Secondly the fire crew must know the nature of the incident and what they have to combat once on board in order to put on the right gear and

Put on the right gear and bring along the right equipment.

bring the right equipment. And they need the information fast. Some of the information can be provided by the captain and from manned exploration flights. But a lot remains unknown.

UAVs come to the rescue

If unmanned aerial vehicles were to be deployed, this would help MIRGs in many ways. UAVs can be equipped with many different sensors and cameras passing on live images of the disaster, analysing smoke samples, and transferring data regarding stability, weather conditions, and the exact coordinates. Consequently, the risk assessment will be more accurate and deployment of the team and its equipment more efficient. Shore-based coordinators are kept informed, since the data is transmitted directly from the UAV by means of live streams or infrared images. These unmanned aerial vehicles would provide great added value to MIRG, because data can be collected without putting lives at stake, and actions can be taken promptly and in a very focused way. Fires and other calamities can be contained sooner, preventing further damage to the ship and the environment. And UAVs can do this work cost effectively.

The advantages of unmanned aerial vehicles

BERISUAS has identified a number of advantages, which are listed below. Most importantly, a UAV will be able to provide an early overview of the scene of the disaster, giving vital information about hazardous situations upon which the MIRG team can act. The UAV may be able to fly through a smoke plume possibly containing high concentrations of hazardous

substances and take samples without risking the health of its operators. In future, such samples may even be analysed on board the UAV itself.

The more often a UAV is deployed, the more cost-effective it will be

From the cost and benefit analysis, it emerged that deployment of UAVs is more expensive than was first envisaged. In addition, Schumann advised to use a couple of them to obtain optimum results. "It will prove cost-effective to purchase UAVs," Schumann explained, "especially if they are deployed for other applications as well, besides maritime incident response." One UAV would cost around forty thousand Euros, which is a lot less than a helicopter, while its operating costs are considerably lower as well: a UAV is estimated to cost approximately 250 Euros per hour to run; a helicopter between 4000 and 5000 Euros per hour. "While the value of the lives saved is hardly quantifiable and much damage to equipment and the environment will be prevented, **it has been demonstrated that the use of a UAV will pay for itself after three or four times checking out a calamity at sea."**

A manned helicopter costs between 4000 and 5000 Euros per hour.

The advantages of UAVs regarding the performance of MIRG

• A UAV is relatively quiet and will operate effectively at all permitted altitudes (up to 400 ft.)

- Immediate and accurate overview of the situation – remotely controlled according to the operator's wishes
- Appropriate cameras will capture and transmit detailed information about the incident, from up close as well as from a distance
- The UAV may remain nearby, hovering over the scene, after the rescue team has been dropped off by the helicopter

• The UAV has many benefits compared to a manned helicopter

- No extra lives are put at stake, since the UAV is operated remotely
- It will not cause great disturbances of air currents
- It will not negatively affect the work done on board the ship
- Minimum downwash effects that could cause expansion of fire
- It will not cause undesirable dispersion of smoke and toxic compounds

• The UAV can be deployed quickly, from various locations

- It can be operated from various command rooms, including mobile ones
- Prompt risk assessment and situational reports, allowing quick deployment of MIRG teams
- Independent of regular airfields; therefore independent of regular flights
- Possibility to take off from a nearby location; even from a nearby ship
- Long-term on-site availability, depending on technology

• The UAV is remotely controlled, resulting in safety of operators

- It can fly through smoke plumes possibly containing hazardous substances, to take samples without risking the health of pilots
- It is not dependent on a minimum number of crew
- Other pilots are able to take over while the UAV is airborne
- The information transmitted is accurate and based on factual images and measured values

• The UAV saves money

- Costs of the platform are estimated at 40,000 euro
- Operating costs are 250 euro per hour

• The UAV can be deployed for many other applications

CHAPTER 3

A REALISTIC SCENARIO SPARKS REALISTIC SOLUTIONS

The BERISUAS cluster investigated how UAVs could be deployed in order to support the work of MIRGs in the 2 Seas Area. The research comprised the equipment to be carried by UAVs and the processing and interpretation of the data on the ground. Additionally the cluster ran simulations of the whole process that provided the cluster partners with information on how UAVs can be put into action. A workshop was set up to create a realistic scenario of an incident on board a ship at sea and to formulate questions from MIRGs. This scenario comprised many factors involved in actual incidents. Below, we have described this imaginary scene of a disaster at sea – which could very well have occurred in the busy 2 Seas area.

A devastating ferry fire
A realistic scenario

'It was a bleak, blustery Monday morning, early in January, when a ferry was crossing the English Channel from Ramsgate, UK, to Vlissingen, the Netherlands. The ferry carried around one thousand passengers and was manned by 150 crew. Most of the passengers were inside, hiding from the gusty winds that tormented the decks, and were comfortably enjoying their cups of tea while reading a newspaper, or playing cards over a beer. Suddenly, the alarm sounded. A fire had been reported. And although the crew were correctly carrying out the duties they were trained to do, people panicked. The ship's captain contacted the Maritime Rescue Coordination Centre, MRCC, with the following information:

- There is a fire on the car deck, involving several loaded lorries and cars
- The load of some of the lorries is unknown, and may be dangerous
- The fire is of high temperature and enormous amounts of black smoke are produced
- There is not sufficient breathing apparatus on board
- Passengers are in a state of panic; some have even jumped overboard – and the water is only 5 degrees Centigrade
- Assistance from a Maritime Incident Response Group (MIRG) team is urgently required

In the meantime, the ship's crew had taken action to prevent the fire from spreading and had managed to move most of the passengers to a relatively safe area. The ferry had stopped its motion and was floating at a steady 4 miles per hour with the local current.
The MRCC tasked MIRG to become involved, and the MIRG team on duty in Vlissingen was called in and told to get ready for deployment. Approximately 45 minutes later, the MIRG was airborne on board a Dauphin helicopter, and was due to arrive

at the scene of the burning ferry in another 45 minutes. Upon arrival, the MIRG fire-fighting team conducted a visual assessment of the situation and were lowered onto the top deck along with their equipment. Fortunately, the winds had died down somewhat. The expertly trained team members, with their professional attitude, were able to support the crew in containing and extinguishing the fire, while the helicopter returned to its base. They were still looking for the passengers who had allegedly jumped overboard.'

UAVs can carry the solutions

With the scene set and a clear view on the questions MIRGs have, the cluster partners came up with solutions. It became clear that a UAV hovering over a vessel can take away a lot of uncertainty as it can answer such questions as:

- Are there any people who have gone overboard and, if so, what is their exact location?
- What is the wind direction and wind speed on location?
- What is the stability of the ship?
- What is the location of the fire in relation to hot areas, using cameras with FLIR (forward-looking infrared) sensors?
- Does the fire include chemical, biological, radiological or nuclear (CBRN) substances or other toxic compounds? The UAV could take samples, analyse them on board, and transmit the results to the control room for quick response

Wide range of information

In addition to vital information concerning the incident – regarding toxicity of emissions, people in distress, and the state of the vessel – it was also concluded that **a UAV can provide** a wide range of other information needed by the MIRG team, such as the exact **coordinates of the imperilled ship, its dimensions, the distance between the ship and other visible objects, the extent of oil spills, the height and direction of a smoke plume, and the plotting of directions and speeds.** By using a geo-locking option, a particular point on the map may be zoomed in on, regardless of the movements of the UAV. In addition, MIRG teams may require more than one UAV in the air at the same time. End user console will allow monitoring of each of these UAVs. The remotely piloted aircraft system, or RPAS, can even fly through a plume of thick, black smoke. Quite unthinkable with a helicopter or small aeroplane!

- Have you been involved in any interesting projects lately?
- Sure, I am in the drone business.
- Drones are the future! Inspection of pipelines, dikes, crops … combating calamities and bushfires …
- Drones are a blessing to mankind!
- Indeed, chap, indeed.

An eye in the sky – with a nose, ears, and feelers…

To build a suitable UAV that can answer the MIRG's questions, the unmanned aircraft should be equipped with eyes, ears and noses – i.e. gas sensors, heat sensors, and cameras. Jeroen Zonnevijlle: "The more information we have at our disposal, the better we will be able to make a risk assessment. This way, we won't be sending our people on perilous journeys unprepared. And when we do send them, we know more precisely which equipment they have to take along. After all, the space inside a helicopter is limited, and the more efficient we can work, the better."

The importance of high-quality sensors

The most important parts of a UAV, when used to assist MIRG teams, are the high-quality sensors it can

Vice-President Siim Kallas, European Commissioner for mobility and transport: "Civil drones can check for damage on road and rail bridges, monitor natural disasters such as flooding and spray crops with pinpoint accuracy. They come in all shapes and sizes. In the future they may even deliver books from your favourite online retailer." (Source: European Commission Statement to the Media, 8 April 2014)

Jeroen Zonnevijlle: "The more we know about the situation, the better we will be able to deploy our MIRG team. And what better way than to send a UAV to the disaster site? It is fast, accurate, and does not put extra human lives at stake."

Guido de Croon, assistant professor with Delft University of Technology: "After analysing the needs of MIRG, we have compared a number of available technologies to help them decide upon the most suitable solutions"

be equipped with. After all, these will provide the MIRG with vital information about an incident on which to base their decisions.

The more information MIRGs receive about an incident, the better. Information concerning hazardous substances and people in danger is vital to the rescuers if they are to perform promptly, efficiently and effectively. A UAV can be on the scene very fast. Upon its arrival, it is able to analyse the situation and instantly transmit its findings to the emergency response room.

Guido de Croon, assistant professor with the Delft University of Technology: "We have analysed the needs of MIRG, and have compared a number of available technologies to help them decide upon the most suitable solutions. A remotely controlled aircraft system, RPAS, can be equipped with several sensors. The challenge is that MIRGs typically would like to measure everything, as they do not know in advance what substances they will be searching for. The optimum solution seems to be to measure several common types of gas in real-time, while storing important gas samples for full analysis later on, in a specialised laboratory."

Smelling, observing, listening, feeling and tasting

In fact, the 'eye in the sky' should also be equipped with ears, noses, and feelers. The UAV is to act like a robot in the air: an ultra-perceptive creature, programmed for the ultimate sensing of danger. "However, there are so many different kinds of chemicals that may be released. It would be impossible to include a sensor for each of these, but we can make a selection to measure the more common or the more hazardous ones. In future, it may be possible for the aircraft to have equipment for in-flight analysis, so that the results can be instantly transmitted to the on-shore station. For the time being, analyses of captured samples shall be carried out in shore-based laboratories."

'Hear and Avoid'

To operate a UAV, specific training is required. In addition, the aircraft must meet certain safety requirements. After all, the vehicle will be beyond visual range of its operator. How can we make sure nothing will happen? Delft University of Technology is

investigating visual and auditory sensors to achieve this. "Especially audio is important", de Croon explained. "After all, sound is omnidirectional and involves much less data per second; you are more likely to hear an aeroplane approaching before you will see it. Many challenges lie ahead of us before we will be able to actually deploy these systems and we hope to be able to continue this project, in order to help MIRG-EU carry out their tasks in an optimum way."

Suitable gas-sensing technologies

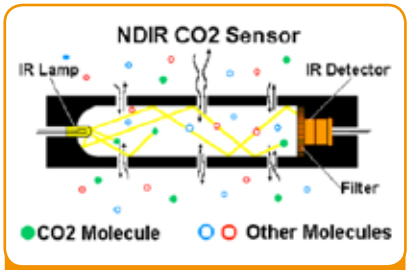
UAVs with gas sensors can be of great added value for MIRGs. The BERISUAS cluster came up with a number of suitable technologies that are both effective and efficient.

NDIR

In general, the Non-Dispersive Infra-Red Spectroscopy (NDIR) measurement method is highly accurate and selective because it measures CO2 concentrations without measuring other gas concentrations.

Another positive point of NDIR technology based sensors is their resistance against vibrations. Limiting factors regarding accuracy are the level of purity of the calibration gases and the size of the sensor; the larger the sensor, the higher the level of accuracy of measurement. NDIR technologies make use of different electronic components, including IR sources, photo detectors, and processors. Using a relatively novel technology, it is possible to combine all these elements into one electrical component. This technology is known as Micro Optical Electrical Mechanical Systems (MOEMS).

NDIR measurement is based on the following principle: gases absorb radiation at different wavelengths, and change it into rotation and oscillation energy. The detection of the specific wavelengths makes the measuring principle selective. This method is illustrated in the figure below.



Schematic setup for the wavelength selective determination of gas concentrations

Other types of sensors

Other types of technology used to measure gas concentrations in air include photo acoustic sensors (PAS) and solid electrolyte sensors. However, PAS-based sensors are sensitive to pressure differences and acoustic interference, while solid electrolyte

Detection of gases in the smoke plume

When there is a fire at sea, one of the first questions that arise is what types of cargo are on board. After all, cargoes may contain materials that can result in toxic fumes when consumed by fire. The presence of toxic materials and gases has an important influence on the emergency response. These may be analysed with the help of a UAV equipped with sensors to capture chemicals inside a fire plume. Ideally, the UAV should be equipped with an optimum range of sensors. These should be as robust and compact as possible, have low energy requirements, and detect the most relevant substances.

The UAV will be sent to the approximate GPS coordinates of the location of the ship using a standard autopilot. These coordinates are known through the maritime surveillance radars. As the UAV nears the location of the ship in distress, it will visually locate the smoke plume and aim for it. Flying through the smoke plume, smoke sensors are used in order to locate and move towards its origin- a procedure called plume following. When the origin of the plume is reached, the UAV will keep circling and observing at that location. The smoke samples taken are brought back to base for further processing in specialised laboratories.

When flying through a plume, navigation is achieved by the use of a smoke sensor. To this end, algorithms from the field of odour source localisation can be employed. When in the smoke plume, different gas sensors will be used to determine the toxicity of the chemicals in the plume.

sensors have a rather long response time – in the order of minutes – and an accuracy that is not higher than +/- 100 ppmv (parts per million by volume).

The ideal situation

Guido de Croon: "Developing an ideal sensor will take a long time and is very expensive. That is why proven sensor technology from the regular market is preferred. **Sensors based on NDIR technology are likely to provide the best performance for use in unmanned aerial vehicles deployed by MIRG."**

In future, it may be possible to analyse samples taken on board the UAV, and have the results sent to the MIRG control room instantly. "Such on-board gas analysers should also be compact, sturdy, and energy-efficient. In addition, they should be able to resist high vibrational loads and be shock-resistant, have integrated temperature and pressure sensors to post-process the measurement data for changes in atmospheric circumstances, and provide highly accurate measuring data."

CO2 sensor
Detection Range: 0 - 10,000 ppm
Response Time: < 60s

Methane gas
Detection Range: 300-10,000 ppm
Response Time: N/A

CO sensor
Detection Range: 20 - 2,000 ppm
Response Time: <150s

Hydrogen gas
Detection Range: 100-10,000 ppm H2
Response Time: N/A

Examples of sensors used in unmanned aircraft. CO2/CO sensors can be used for navigating through the smoke plume. Other sensors can capture gases present that are relevant to emergency response

Feasibility of UAVs

To study the feasibility of UAVs for use in maritime incidents, DecisionLab, a UK consultancy firm specialised in problem solving, tackled this question in a novel way. Benjamin Schumann, PhD from BERISUAS cluster partner University of Southampton, presented a study which was part of his PhD thesis. For this thesis he developed OSCAR, a generic operational simulation programme for aerospace design. "Simply put, it will follow anything that moves across a map, such as trains, aeroplanes, cars, humans, ships, and submarines." The software can be used to calculate the amount of fuel consumed, the number of breakdowns, and other operational events. OSCAR comprises several modules, of which relevant ones are applied in specific assignments. In this particular modelling study, smoke analysis was used alongside visual camera capture of the ferry scene.

The different modules making up the computer model

The Main Module of OSCAR loads the scenario definition from a database, creates the GIS (geographic information system) map and situates all agents on the map according to their setup. Also, the output statistics are collected here. The second module concerns the Vessel Module, which is the key component of the simulation model. In this case, it defines the behaviour and characteristics of flying vessels, including their maximum and minimum speed levels, their energy consumption and fuel-tank sizes. In this particular simulation, three vessels were used: one helicopter and two UAVs - one for visual inspection and one for smoke detection. The third module is the Base Module,

Screenshot from the computer programme developed by Benjamin Schumann, PhD

defining airfields and other locations used for vessels to depart from, pause and refuel. The fourth module is the Component module. Each vessel comprises a number of components, such as wings, fuselage and engine. These components deteriorate over time and may break down at some point, necessitating repair and maintenance. The fifth component concerns the Database Module, which contains a number of input and output tables. Finally, the Value Module is used to assess the usefulness of unmanned aircraft systems, involving a simple cost and benefit analysis.

High-quality sensors for maximum efficiency

The simulation model developed will help designers of unmanned aircraft raise the efficiency level. Ideally, very high-quality sensors should be used. "This will provide great added value to the vehicle, since they will provide MIRGs with more, and better, information than cheap sensors would." Such a sensor may cost a couple of hundred Euros. In addition, our computer programme established that a UAV should be equipped with several sensors to make the most of its exploratory trips.

Benjamin Schumann, PhD

CHAPTER 4

MAKING IT HAPPEN

Thanks to the deployment of UAVs, MIRGs are able to obtain the information they need to quickly respond to a disaster at sea, and bring along exactly the right equipment to contain the incident. So much is clear. But that does not mean UAVs can be sent up to the sky this very moment. Some issues have to be tackled first. For example: who can operate the UAVs? And how does the gathered information find its way to the MIRGs? The BERISUAS cluster looked into these issues in depth and found solutions. Legislation for the use of UAVs differs from country to country, making cross border deployment difficult. It will take at least until 2020 before a set of univocal European rules will be implemented. BERISUAS tried to not let this set back their developments.

Anyone can operate a UAV – indirectly

Although UAVs are unmanned, these aircraft do need a professionally trained pilot for their remote operation. Flying a remotely piloted aerial system requires expert knowledge, both of the technology used and of the laws and regulations that apply. Knowledge that goes beyond the MIRG team members' training. And that's where Benoît Clément, professor with ENSTA Bretagne comes in. He explains: "We want to make operating a UAV a simple experience for the MIRG members, and present them with the tools to do their job better."

Regulations vary from one country to another

"There are a lot of technical aspects and laws involved in flying unmanned aircraft," Benoît Clément, ENSTA Bretagne, explains: "Moreover, there are no definite laws that cover different EU countries. Some aspects have been defined, but these are far from uniform. It is not possible to give MIRG members direct control of the UAV, but what we can do is enable them to ask questions, make requests, point out their requirements, make drawings on a map, give arguments, and generally tell us what they need."

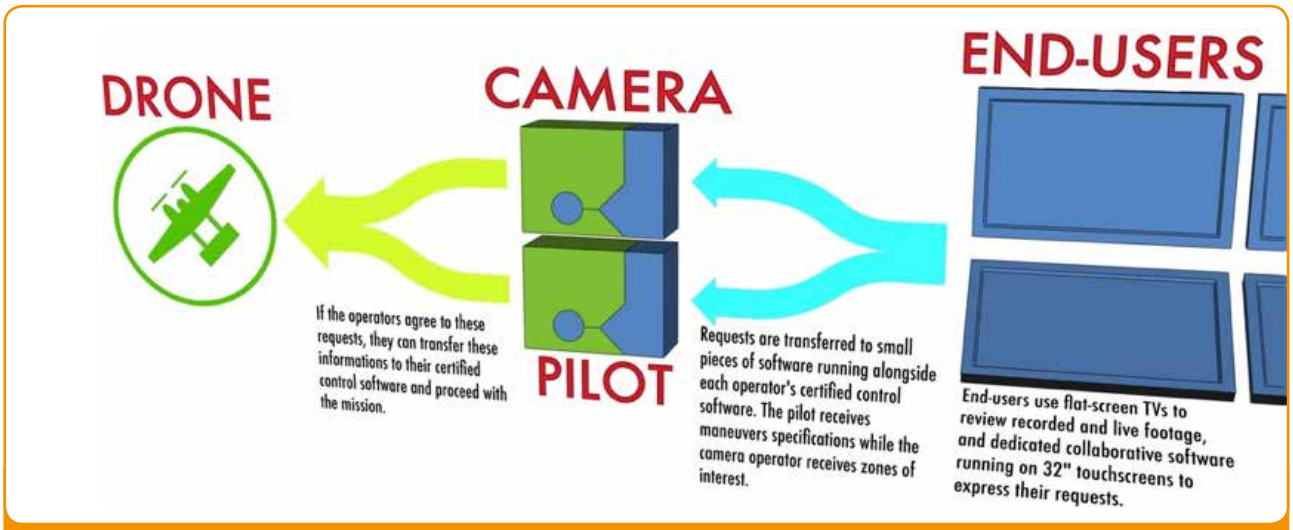
ENSTA has built the software to allow them to do just that. Communication is very direct, enabling the remote pilot of the UAV to immediately perform the required tasks.
The members of the MIRG team may be present in the mobile control centre, for example a van, or there may be remote contact via Skype, telephone, or even just text.

Looking beyond the line of sight

If desired, the mobile unit can be driven to a certain location, perhaps the location from where the UAV is launched. "Using a mobile control unit could save a lot of valuable time. The software is very efficient and user-friendly. Its communication possibilities are excellent. The MIRG members do not need any specific knowledge of flying a UAV. It merely provides a camera in the sky, providing the rescue team with eyes, ears and noses to find out all necessary details of the incident. In fact, our software allows MIRG members to look beyond the line of sight."

End-user console

Where aviation authorities are concerned, deployment of unmanned aircraft is only just beginning to become accepted. Their use is closely controlled. The operators – the remote pilots – the vehicles and the software must conform to the regulations and be certified before they are allowed to enter the airspace.



Two operators control the UAV, while end users are actively involved to express their questions

A medium-sized UAV is to have two certified operators in charge of the system: a pilot and a camera operator. The end users – the MIRG team members – are looking over their shoulders to study the data and express requests in various ways. For example, they may scribble things on a map, point to a screen, shout out their questions, etc. To assist this process, ENSTA developed dedicated collaborative software (CSCW). However, any modifications to the control software will necessitate renewed certification – a costly and long process. Within this field of tension between satisfying the rapidly evolving needs of the end users and the necessary cautiousness of regulations, the firm has managed to develop an end-user console that will enable MIRG members help direct the UAV to obtain the vital information they need. Based upon this information, a risk assessment is made, after which it is decided whether to deploy the MIRG team or not.

Active involvement of MIRG members

While the operators – the pilot and the camera operator – remain in control of the unmanned aerial vehicle itself, the MIRG members are actively involved to express their questions. This is done by means of dedicated client software, which is run on the operator's workstation, and which receives requests from the end user's touchscreen interface. Based on these requests, the operators may change the course of the UAV or reorient the cameras. The operators maintain sole responsibility of the aircraft's operation. The sharing of the workspace inside the van allows rich interpersonal communication.

Regulations should help cross-border collaboration

The disparity amongst European rules and regulations regarding unmanned aerial vehicles makes cross-border collaboration in the 2 Seas area a challenge. British law is much more lenient than Dutch law. "With my qualifications, I can operate a small UAV in England, with only a few restrictions" Walter Broeders, manager of the Dutch training institute for the operation of unmanned aircraft UAS BV, said. "But if I want to fly a UAV in the Netherlands, I have to request for an exemption weeks in advance, while I need a co-pilot as well as a person to operate the sensors. And even then, it is not allowed to fly BVLOS – beyond the visual line of sight."

Mobile UAV operating unit on location Photo ENSTA van on location

New rules are being developed

In the United-Kingdom, regulations regarding the operation of unmanned aircraft work well. In France, rules are quite liberal too, resulting in

Inside the van – the mobile UAV operation unit – MIRG team members indicate their requirements on touchscreens, after which the operators may adjust the movements of the UAV or the orientation of the cameras

Walter Broeders, founder of Dutch training institute Unmanned Aviation Solutions, demonstrates the envisaged unmanned aerial vehicle as proposed by 3i

UAV companies shooting up like mushrooms. In Belgium, one is only allowed to operate unmanned aircrafts for military and scientific purposes. And in the Netherlands, there is basically one rule: it is not allowed. "There are ways around this rule," Broeders explained, "but these involve such an incredible amount of red tape that many promising technological organisations are dropping out." And in the 2 Seas area? Obviously, this area would benefit from a set of univocal European rules. "This would greatly boost cross-border collaboration." Fortunately, the European commission has already developed an RPAS roadmap. Following this roadmap, the objective is to create a single European law covering all RPAS. "However, this law will probably not be implemented until the early 2020s." Fortunately, the Dutch Ministry of Infrastructure and the Environment is working on a common set of rules for hobby and commercial use of drones which should be in place from 1 July 2015.

One country at a time

At this moment it is not possible to fly remotely piloted aircraft as envisaged by BERISUAS in all countries with the same basic education. In future, it should be possible to fly these UAVs after having followed a specific training course that is accepted across Europe. However, this roadmap will take some time regarding BVLOS operations; such legislation will probably not come in force before the end of 2018 . The best thing will be to train in one country at a time, and start negotiations with all participating countries regarding BERISUAS operations, in order to be granted the necessary compliances and exemptions. This should promote cross-border collaboration until a set of univocal EU regulations apply. Cross-border BERISUAS operations may be possible under the following conditions:

- RPAS pilot education is accepted in all countries involved
- BERISUAS airworthiness is accepted
- The necessary exemptions are implemented
- ICAO rules for cross-border operations are followed

Since the envisaged UAV has a mass of less than 30 kg, the following rules apply in the UK, France, Belgium and the Netherlands. The differences are substantial. Cross-border collaboration in the 2 Seas area would greatly benefit from univocal EU legislation.

	Aircraft Mass	Airworthiness Approval?	Registration?	Operating Permission?	Pilot Qualification
UK	20 kg and less	No	No	Yes (Note 1)	Yes (Note 1)BNUC-STM or equivalent (Note)
	More than 20 kg, up to and including 150 kg	Yes (Note 3)	Yes (Note 3)	Yes	Yes,BNUCTM or equivalent (Note 2)
	More than 150 kg	EASA Permit to Fly or UK Permit to Fly in accordance with 'B conditions' (Note 3)	Yes	Yes	Yes,BNUCTM,CPL(A) or equivalent (Note 2)
FR	25 kg and less recreational use	Yes (Note 3)	Yes (Note 3)	Yes	Yes, theoretical part of PPL, ULV or glider pilot license.
	Above 25 kg recreational use	Yes (Note 3)	Yes (Note 3)	Yes	Yes, theoretical part of PPL, ULV or glider pilot license.
	25 kg and less aerial work	Yes (Note 3)	Yes (Note 3)	Yes	Yes, theoretical part of PPL, ULV or glider pilot license.
	2kg and less aerial work	Yes (Note 3)	Yes (Note 3)	Yes	Yes, theoretical part of PPL, ULV or glider pilot license.
	<25 kg and 2><4kg not aerial work	Yes (Note 3)	Yes (Note 3)	Yes	Yes, theoretical part of PPL, ULV or glider pilot license.
	Less than 150 kg bvlos science	Yes (Note 3)	Yes (Note 3)	Yes	Yes, theoretical part of PPL, ULV or glider pilot license.
	more than 150 kg bvlos science	EASA Permit to Fly or FR Permit to Fly in accordance with 'B conditions' (Note 3)	Yes	Yes	Yes, theoretical part of PPL, ULV or glider pilot license.
NL	Less than 150 kg	Yes (Note 3)	Yes	Yes	Yes,BNUCTM, NLR or equivalent (Note 2)
	More than 150 kg	EASA Permit to Fly or NLD Permit to Fly in accordance with 'B conditions' (Note 3)	Yes	Yes	?
BE	Less than 150 kg (Note 4)	?	?	?	?
	More than 150 kg	EASA Permit to Fly	Yes	Yes	?

Notes:

1) Applicable from 1 January 2010 for aircraft used for Aerial Work purposes or if flown within a congested area and/or close to people or property.

2) Equivalent pilot experience will be considered on a case-by-case basis during application for an operating permission.

3) It may be possible to obtain certain exemptions from the airworthiness and registration requirements.

4) In Belgium only a permit for test, education, demonstration, research and governmental RPAS flights exists. Belgium law and regulation for RPAS less than 150 kg is still in development.

BERISUAS

Operation of UAVs in 2 Seas area is complicated because of different legislations that apply

CHAPTER 5

THE FUTURE IS BRIGHT

UAVs can be safe, efficient and cost effective devices for supporting the perilous work of MIRGs in the 2 Seas area. The data they can collect is invaluable for the emergency response of the MIRG teams. However, the information should not stand on its own; it is vitally important that MIRGs incorporate it into their complex command and control structure in order to fully exploit it when an incident occurs. This is just one of the challenges that lie ahead.

Safety concerns are currently another major hurdle for the use of UAVs in the envisaged scenarios. The UAVs will have to fly beyond the line of sight of the human operator, which will result in much higher safety requirements. It is of major importance to investigate novel robust techniques for safe flight, also beyond the line of sight of a human operator. For instance, there are many promising emerging technical solutions to both collaborative and non-collaborative avoidance of other air traffic. UAVs can communicate their position to other planes actively, and can use sensors such as directional microphones, miniature smart cameras and very small radars to detect and localize other air traffic. Once such solutions have proven their worth, they will become facilitators of an entire range of new applications, including emergency response at sea.

Innovations such as the ones mentioned above are taking place at breakneck speed, which makes it a challenge to create national and cross-border regulations. A concept such as 'One European Sky' could greatly facilitate cross-border collaboration – particularly where MIRG teams operating in the 2 Seas area are concerned.

RPAS and Europe

According to the European Commission, the development of Remotely Piloted Aircraft Systems (RPAS) has opened a promising new chapter in the history of aerospace. Military exploitation of Unmanned Aircraft Systems has grown significantly in recent years. And although this trend has so far not been followed by the civil sector, RPAS may offer a wide range of applications for the benefit of European citizens and businesses. Being remotely piloted, RPA can perform tasks that manned systems cannot perform, either for safety or economic reasons.

Besides delivering profitable commercial aerial services in various areas – such as in precision agriculture and fisheries, power or gas line monitoring, infrastructure inspection, media and entertainment, and digital mapping – RPAS may also provide valuable assistance in crisis management and fire-fighting. RPAS are well suited to long duration monitoring tasks or risky flights into ash clouds and smoke plumes. They can efficiently complement existing manned aircraft and satellite infrastructures.

(Source: European Commission http://ec.europa.eu/enterprise/sectors/aerospace/uas/)

Technology and creativity

Clearly, UAVs are the future. In this publication, we have highlighted one particular application of unmanned aircraft, involving their assistance of MIRG teams in the 2 Seas area. If this application is realised, many more are likely to follow. After all, UAVs could well be deployed for the monitoring of festivals, busy inner cities, recreational areas, and other forms of surveillance, as well as a myriad of commercial and fun applications. Manufacturers of unmanned aerial vehicles are ready to start building them on a large scale as soon as the European legislation is univocal. They have the technology – including 3D printing – and the creativity. The future is just around the corner. You can almost hear it humming.

UAVs are the future

Glossary

3i	For consistency (compared to BERISUAS below), also put the full title of 3i 3i is a European Interreg 2 Seas project. In 3i, the UK, France, and the Netherlands are combining research efforts into unmanned aerial vehicles for maritime applications. More info: www.2seas-uav.com
BERISUAS	Better Response and Improved Safety through UAS: a thematic cluster entirely financed by the INTERREG 2 Seas Programme in which two Interreg projects (MIRG and 3i) come together to study complementarity of activities and results
BVLOS	Beyond Visual Line of Sight
CCD	Charge-coupled device: an image sensor employed by most digital cameras
CSCW	Computer Supported Cooperative Work
EM	Emergency Management
ER	Emergency Response
Hazmat	Hazardous materials and items
ICAO	International Civil Aviation Organisation
IMO	International Maritime Organisation
INTERREG	An EU programme to promote cross-border collaboration. Objective is to reduce regional differences in development and reinforce the social-economic cohesion within the European Union
ISPS Code	International Ship and Port facility Security Code, developed by IMO in the wake of 9/11. It comprises special measures to enhance maritime security in the International Convention for the Safety of Life at Sea (SOLAS)
MIRG-EU	Description of the MIRG-EU project (like for 3i and BERISUAS)
MIRG	Maritime Incident Response Group
MRCC	Maritime Rescue Coordination Centre
PPE	Personal Protective Equipment, such as gloves, suits and boots
RPAS	Remotely Piloted Aircraft System
SAR	Search and rescue
SOLAS	International Convention for the Safety of Life at Sea (1974)
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle

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More information: www.mirg.eu - www.2seas-uav.com

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