Escola d'Enginyeria de Telecomunicació i Aeroespacial de Castelldefels

UNIVERSITAT POLITÈCNICA DE CATALUNYA

TREBALL FINAL DE GRAU

TÍTOL DEL TFG: Defining a Helicopter Emergency Medical Services

TITULACIÓ: Grau en Enginyeria en Sistemes Aeroespacials

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DATA: 1 de Juliol del 2022

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Resum

Els serveis d'emergències mèdiques en helicòpter són serveis complementaris al servei d'emergències mèdiques de països desenvolupats, on els pacients que es troben en una situació crítica són traslladats a l'hospital el més ràpid possible, proporcionant-los atenció medicalitzada a bord de l'aeronau.

En aquest treball s'explicaran els serveis existents a Catalunya que tenen helicòpters per al transport del pacient crític. Posteriorment, els serveis existents a Catalunya es compararan amb altres serveis d'àmbit geogràfic i poblacional diferents als serveis catalans, per establir una comparativa i entendre com planificar aquest tipus de servei.

D'altra banda, s'analitzarà també la flota d'aeronaus que cada servei mèdic necessita per poder realitzar el trasllat i portar el pacient fins a l'hospital. Cada servei d'emergència mèdica considera el millor tipus d'helicòpter que s'adapti a les seves necessitats, tenint en compte el tipus de regió on opera, la població que hi viu i el tipus d'operació que realitzarà. Tot això serà explicat a continuació, analitzant els helicòpters que pertanyen a cadascun d'aquests serveis, les característiques tècniques, les missions i les configuracions de cada helicòpter, i es realitzarà una comparativa entre tots els helicòpters pertanyents als serveis.

Finalment, s'analitzaran els heliports on operen aquest tipus de servei, ja que per transportar el pacient fins a l'hospital, necessitem que l'hospital tingui un heliport a la part superior o al costat de l'edifici. Per això, també s'expliquen les característiques que han de tenir els heliports segons si estan situats a la superfície o estan elevats, els tipus d'heliports que hi ha i tot seguit l'anàlisi de les propostes per als diferents tipus de serveis per millorar la xarxa d'heliports de rescat.

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Overview

Helicopter Emergency Medical Services are complementary services to the emergency medical service of developed countries that allow to give medical assistance to remote areas and assist patients who are in a critical situation to be transferred to the hospital as soon as possible providing them with medicalised care on board. This thesis will explain the existing services in Catalonia that have helicopters for the transport of critically ill patient. Subsequently, the existing services in Catalonia will be compared with other services of a different geographic and population scope than the Catalan services, to establish a comparison and understand how to plan this type of service.

In addition, the fleet of aircraft that each medical service needs to be able to make the transfer and take the patient to the hospital will also be analysed. Therefore, each medical emergency considers the best type of helicopter that suits its need considering the type of region in which it operates, the population that lives there and the type of operation that it will perform. All these will be explained below, analysing the helicopters belonging to each of those services, the technical characteristics of each of them, the missions that each helicopter can perform, the configurations of each helicopter and a comparison will be made between all the helicopters belonging to the services.

Finally, the heliports where this type of service operates will be analysed, as to transport the patient to the hospital, this hospital needs to have a heliport at the top or next to the building. Therefore, it also explains the characteristics that heliports must have, depending on whether they are located on the surface or elevated, the types of heliports that exist and then the analysis of the proposals for the different types of services for improve the network of rescue heliports.

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List of acronyms

EOS → Electro-opticalsystem

FADEC → Full Authority Digital Engine

FATO → Final Approach and Take-off Area

FLI → Flight Limit Indicator

FLIR → Installation of Forward-Looking Infrared

GRAE → Special Actions Support Group of the fire brigade of the Generalitat de Catalunya

HEEL → Helicopter Emergency Egress Lightning

HEMS → Helicopter Emergency Medical Services

ICU → Intensive Care Unit

IFR → Instrumental Flight Conditions

NVG → Night Vision Google

OEI → One engine inoperative

SARP → Standard and Recommended Practice

SASEMAR → Maritime Rescue and Safety Society

SEM → Medical Emergency System

SLO → Obstacle Limitations Surfaces

STC → Supplemental Type Certification

TBO → Time Between Overhauls

VEMD → Vehicle & Engine Multifunction Display

INTRODUCTION

Helicopter emergency medical services (HEMS) are an integral part in many health care systems in the developed world. The effect of HEMS has several practical advantages, such as bringing advanced medical care and medical competence to the scene, shortening the transport time, providing access to remote areas, and reducing the time elapsed until definitive care is available. Positive associations with increased survival due to faster care and effective transfer have been found with the service provided by HEMS. [68]

In Catalonia, the emergency medical services that use medicalised helicopters are the Medical Emergency System (SEM) and the Special Actions Support Group of the fire brigade of Generalitat de Catalunya (GRAE).

SEM offers medical assistance service by helicopter to assist serious and critical patients guaranteeing the access to public health system to all the population living in Catalonia. During the last 10 years, the SEM's Air Resources Unit has provided over 23,000 patient assistances and since 2018, a helicopter is operating 24 hours a day, 365 days a year providing health care. [69]

GRAE is a group of the fire brigade of the Generalitat de Catalunya, specialized in rescues in the natural environment and in places with a difficult access. Since 2020, GRAE and SEM cooperates jointly to improve health assistance in rescues and other emergencies. The firefighting teams have doctors and nurses from the SEM, who are experts in rescue and intervention in risk areas and have been trained by the fire brigade to be able to act in a rescue. [70]

The cooperation of those services is essential to have a better health response obtained immediately from the scene of the incident. For this reason, during this thesis both services will be analysed, assessing the characteristics of each one and based on the interviews carried out with the managers of the air medical services in Catalonia. A comparison of these services will be made with others from abroad to evaluate the differences and analyse possible improvements. Afterwards, it will be explained the different helicopters that use each of those services, their configurations, and technical specifications. It will be reviewed that those helicopters will have to be qualified to operate in Performance Class 1 in order to overfly urban areas and land in hospitals located in a congested environment [73]. Finally, it will be seen the characteristics of building a heliport and the analysis of possible heliport proposals that SEM and GRAE will like to have.

The aim of this thesis is to understand, identify the defining parameters and propose improvements or solutions to identified issues of the services operating with medicalized helicopters in Catalonia. Trying to imply that Helicopters Emergency Medical Services (HEMS) are a need in our society to save lives and improve all the health care in Catalonia.

CHAPTER 1. EXISTING SERVICES IN CATALONIA

In this first chapter, all the existing services that operate in Catalonia and use a helicopter for Emergency Medical Services will be analysed. Those services are the Medical Emergency System (SEM) and Special Actions Support Group of the fire brigade of the Generalitat de Catalunya (GRAE).

1.1. The Medical Emergency System (SEM)

The Medical Emergency System (SEM) is a public organization of the Catalan Health Service that operates in the whole region of Catalonia. Their function is to provide health care services to respond to emergencies and give information and health advice. SEM offers medical assistance service by helicopter to manage better some incidents as assisting serious and critical patients at the same place of the accident or move patients from one hospital to another.

Their objectives are to guarantee the access to public health system to all the population living in Catalonia, especially those people who live far away from hospitals, reduce the time of transferring people between hospitals and improve health coverage in remote areas.

The air transport of patients complements ground transport, offering improvements to some factors like distance, accessibility and patient care such as in mountain or peripheral areas.

1.1.1. Fleet and material inside the helicopter

Nowadays, SEM has four medicalized helicopters with their respective teams. On board there is a team formed by healthcare personnel which include a doctor and a nurse and the aeronautical crew with a pilot and a co-pilot. There is one place more for the person who has had the accident.

The doctor must be specialized in anaesthesiologists, internists or care for critical patients. However, the nurses do not have a speciality in emergency as it does not exist, but they must have experience in prehospital emergencies.

It is a multi-disciplinary team where everyone has their own specific role, but they help each other. Every time that the helicopter takes off, the doctor and the nurse assist in the safety tasks. For example, when landing the helicopter to assist the patient in the emergency, others should check that there are no objects that could be dangerous for the landing of the helicopter, either on the runway or in the place where it lands. Otherwise, when the doctor and the nurse are assisting the patient, the pilot or the co-pilot give them medical support, always following their instructions.

In each base, apart from the four people who form the crew, there is also a mechanic, who is the person that makes the maintenance of the helicopter and helps the pilot to make the departure and landing manoeuvres at the base. Every day before starting to operate, the helicopter is checked to make sure that everything is correct both mechanically and also, they look if any health material is needed. In addition, when the helicopter comes back from a service, the mechanic checks the helicopter to verify that all is correct and that there is not any issue in the airplane.

The crews coordinate 24 hours a day. 4 professionals work during the day and another 4 at night. However, the pilots can only work for 12 hours due to aeronautics laws.

Inside the helicopter there is some essential medical material such as a defibrillator, a respirator, medication infusion pumps to be carried by patients, a vacuum cleaner, a vacuum mattress to pack a person with a polytrauma so that the patient does not suffer during the transfer, briefcases with serums and tracks and medication. The medical material inside the helicopter is the same as in the ambulance but smaller, because the weights in the airplane are important. There is a Maximum Landing Weight (MLW) and Maximum Take-off Weight (MTOW) in all heliports. Depending on the weight of the aircraft, the helicopter will be able to take-off or land in some heliports or not. Afterwards, the weights of each helicopter will be compared in **Table 2.1**.

1.1.2. Type of helicopter

The SEM helicopters are strategically distributed around all the region to be able to assist any patient who suffers a medical or traumatological emergency. [11]

The technical specifications that the helicopters have obey the operational needs of SEM. For instance, they need a helicopter which can land in mountains or right there without any problems so for this reason, it should have the rotor protected. On the other hand, they need a helicopter that can be able to go to the beaches and land without any problem, so the helicopter should have skids instead of wheels because otherwise it would sink into the sand. It must be twin-engine because they need to arrive to the accident scene as fast as they can and in case of having an engine failure, they will have the other engine to arrive to the emergency. It must be able to operate in Performance Class 1, so the aircraft should be able to land in all the certified heliports of Catalonia and the most important and critical one, the aircraft is allowed to overfly urban areas.

The SEM helicopters are Airbus H135 and they are equipped with the latest technology innovations. These helicopters are in operation since 2016, before these were in operation Eurocopter EC135. [12]

The new ones have different advantages compared to the previous ones. Airbus H135 is a helicopter that has a cruising speed of 260 kilometres per hour and it has a maximum speed of 278 kilometres per hour. The take-off weight can reach 2,980 kilograms, 70 kilograms more than the previous ones and they have GPS, automatic pilot and air conditioning. Airbus H135 has the possibility of flying at night to rescue someone sick or injured and it is possible to treat the patient in the same helicopter due to the stability that the helicopter has. In the case of SEM, they have only one helicopter that operates at night for rescuing people and transporting them.

Airbus H135 is fitted with a main rotor and reliable turboshaft engines that deliver exceptional performance. The helicopter has a low fuel consumption. It is the most successful light helicopter and is known for its resistance, compact construction, low levels of noise and cost effectiveness. This helicopter has the lowest operating and maintenance costs in the twin-engine category. It has the advantage of landing in almost anywhere, for example, in high and hot conditions, so this is a good reason for being a SEM helicopter.

SEM rents the helicopter from a third company, who is the owner of the helicopters. In case that a helicopter breaks down, the external company who works for them must guarantee another one. So, each day there will be 4 helicopters in Catalonia regardless of the circumstances.

Every time that the helicopter arrives from an emergency service, the maintenance personnel check that there are no particles or anything that could affect the safety of the airplane or the crew. In addition, each helicopter once it has exceeded the number of flight hours specified by the manufacturer shall undergo maintenance.

1.1.3. Geographical ambit and their bases

The SEM helicopters operate in a geographical area of 3 million hectares which is all the region of Catalonia, and they serve up to 7 and a half million people. During the day, there are four helicopters for all Catalonia and each helicopter operate in a different province: Barcelona, Tarragona, Lleida or Girona. These helicopters operate from sunrise to sunset. At night, there is only one helicopter for all Catalonia which is the one that operates during the day in the province of Barcelona and the one situated in Parc Taulí (Sabadell).

The base of the SEM helicopter that operates in Barcelona, as mentioned, is located in Sabadell, specifically in Parc Taulí. The Josep Trueta's Hospital is the base for the helicopter that operates in Girona, in Tarragona the base is Parc de Bombers de Móra d'Ebre and finally, in Lleida it is the Parc de Bombers de Tremp.

The following figure (**Fig 1.1**) shows the location of the SEM helicopter bases. The helicopter that operates in the Lleida's province is located in the sanitary region of Alt Pirineu (top left), the one that operates in Girona's province is in

the sanitary region of Girona (top right), the one that operates in Tarragona's province is in the sanitary region of Terres de l'Ebre (down) and finally the one that operates in Barcelona's region is located in the sanitary region of Barcelona (middle).

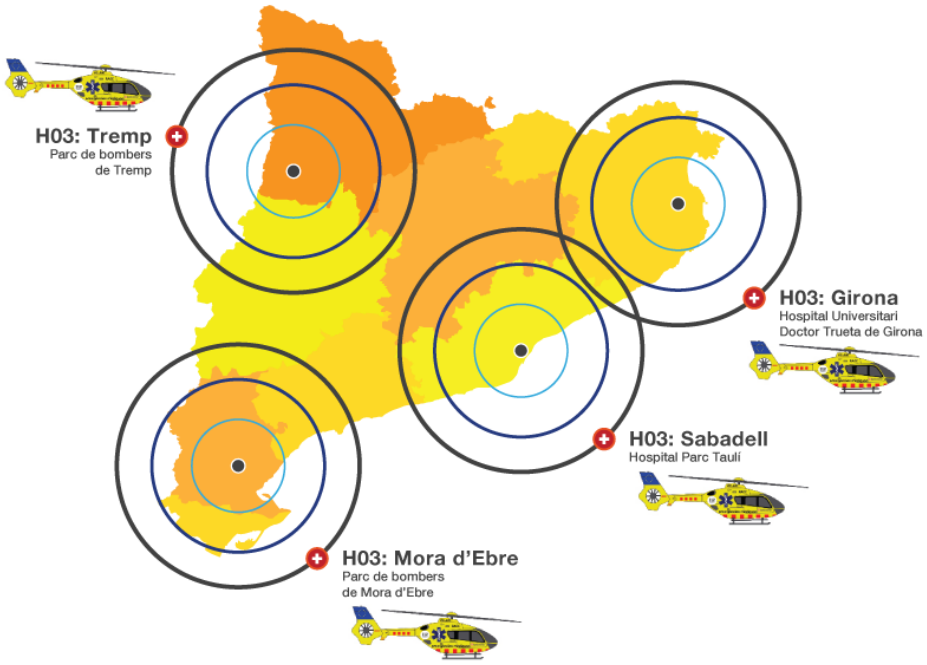

Fig. 1.1 Territorial distribution of the SEM helicopters [11]

Although each helicopter is associated with a certain region, if the one belonging to that region is occupied, another helicopter may take over the service under medical criteria. For example, if the patient would arrive faster in the ambulance, the helicopter will not go to help the patient because it will arrive later.

The SEM bases must be situated in a certified heliport (Annex 3.6) so that the helicopter can move, lift and take off safely. The medical helicopters are based in hospitals, considering which of these hospitals can best cover as many people as possible. The Parc Taulí Hospital is a very centralized area that gives the most coverage in the whole territory. It can cover the southern metropolitan region, the northern metropolitan area and central Catalonia. For this reason, this is the helicopter that operates at night for all Catalonia. The greatest distance that the helicopter can cover is from Sabadell to Vielha and in this case, the helicopter will take only one hour to arrive there. In the other destinations of around, the helicopter will take less time than an hour. For this reason, the maximum time the helicopter will take to arrive to any place of Catalonia will be one hour.

1.1.4. Operations

The SEM helicopters carry out two types of services: primary services and interhospital services. Primary services mean assisting to a critically ill patient that has suffered a heart attack, a polytrauma or some illness that need a quick attention to save their lives. Interhospital services mean moving the patient from one hospital to another, for all those critical people who need a transfer.

The most frequent operations carried out by the SEM air force are heart attacks, strokes and polytrauma (in traffic accidents and at work), interhospital transfer and assistance to the mountains due to falls or accidents. The services are always focusing the most critical patients to take advantage of the flying speed to get a quick and reliable transfer.

All operations are designed in the same way, if adults are involved, the human teams are the same for each type of operation. However, if the patients are children, then there is the paediatric team who should go. There are two paediatric teams, one in Hospital Parc Taulí and the other in Hospital Sant Pau. When a baby, a child or a premature baby needs an ICU (Intensive Care Unit), they take the incubator to the helicopter to be able to take care of the baby and take him/her to Sant Joan de Déu, Vall d'Hebron, Sant Pau or Parc Taulí, depending on where he/she is derived.

There is never a flight plan because current legislation requires a flight plan to be submitted at least 30 minutes in advance. It is not feasible to do prior to the emergency as they have to arrive to the patient as soon as they can. When the alert is entered to SEM, there are some criteria in the computer system that determines if a helicopter is needed or not. In case that the helicopter is a candidate, those on the flight table verify that the helicopter really has to go and finally the resource is assigned. All the mechanisms are set in motion, coordinates are searched and passed to the aircraft, the aircraft goes there and lands.

All the people that are in the control centre will suggest a place to land if there is not a heliport there. However, the pilot has the last decision to land because it is the responsible of the aircraft. At night the helicopter can only land at a certified heliport.

Among all the SEM helicopters make a total average between 5 to 7 operations a day. The most active helicopters are the one based at Parc Taulí and the one at Girona because they have the largest population to cover and assist. The one that operates in Barcelona’s province makes an average of 4 departures per day and it is the only helicopter that operates at night. At night, there is low visibility and the helicopter that operates, has to be authorized for flying with low visibility and in IFR conditions. However, the most important thing is that heliports should be prepared for IFR conditions, and they have to be well marked and with the respective lights so that the pilot can land easily at night.

The nocturnal helicopter of SEM did in its first operation year accounted for 177 services: 86 primary services and 91 interhospital services [14]. With the

nocturnal helicopter is easier to guarantee access to the public health system for the entire population, especially those in areas farthest from hospitals.

On the other hand, all helicopters of SEM can only operate in case that meteorology conditions allow it. In the event of a day with a wind greater that the permitted for flying or fog, the helicopter will not operate, since if it goes to the place where the emergency took place, the pilot will not be able to land and rescue the person, due to adverse conditions. In addition, the helicopter will not be able to perform inter-hospital transport either. If the meteorology does not allow to go to the place of the accident or transport patients to another hospital with helicopter, they will have to go by an ambulance, taking a little longer to arrive there.

1.2. Special Actions Support Group of the fire brigade of the Generalitat de Catalunya (GRAE)

The Special Actions Group (GRAE) is a public service that belongs to the fire brigade of the Generalitat de Catalunya. It is specialized in rescues in the natural environment and in places that are difficult to access. Mountain rescues in Catalonia are made by the Generalitat Fire Brigade in accordance with the Civil Protection Act of 1994, which gives them full powers. In 1997 the Mountain Rescue Group (GRM) and the Underwater Rescue (GRS) joined forces to create the Special Actions Group (GRAE), which carries out mountain and underwater rescues. [24]

1.2.1. Fleet and material inside the helicopter

The crew that goes in the helicopters of GRAE is formed by a pilot, a crane operator, two members of GRAE and the SEM health professional. The requirements for all GRAE members are that they have to be firefighters first and then they can take mountain climbing and skiing tests to become part of the GRAE. In the case of the doctor, he/she also has to make some tests of climbing and skiing because in case of having to rescue someone who is at the top of the mountain, first he/she will have to arrive to him/her and then treat the injured.

GRAE helicopters can only operate from sunrise to sunset, as the three daily helicopters of SEM. In the other case, there will have to arrive to the accident by a land vehicle.

GRAE personnel are people who are on duty 24 hours a day and rest for 3 consecutive days and so on during the whole month. In total, there are 4 teams of GRAEs which take turns according to the above schedule. When three teams are resting another is on duty and then they take turns all time. However, in case that appears an emergency which cannot be covered for those that are on duty, some of the resting personnel will have to help their partners in that

emergency without resting three days. This will take place if the complexity of the emergency requires a higher mobilization of resources than the one established, it may lead to the activation of operational or off-duty personnel to cover the entire emergency. The duration phase of the emergency is expected to have a significant duration to require the activation of all teams and may be associated with a severe weather event. [86] [88]

The pilot is on duty only from sunrise to sunset, which is when the helicopter can fly, instead of the 24 hours a day that the other members of GRAE does. During the waiting time, GRAEs are practising climbing in a rock-climbing wall, maintenance of the helicopter, emergency practices and equipment preparation.

Since January 2020, GRAE and SEM have been working together with the aim of offering a better operational response, coordination and health care in all areas of Catalonia and specially in the mountain rescues [28]. Currently, each team of GRAE is formed by a doctor or a nurse that belongs to SEM. In addition, the cooperation that exists between GRAE and SEM improve the services and quality of both of them. If somebody has fallen off a mountain, GRAE will go to rescue that person including the pilot, the GRAE operators and the nurse belonging to SEM.

The Law 5/1994 defines the competences, scope of action, and charter that GRAE has. This law does not give the competence to GRAE to transport patients directly to the hospital. For this reason, instead that the doctor of SEM, who is a member of the crew, order it, GRAE cannot transport the patient to the hospital. If the person injured needs hospital care, GRAE will transfer the patient to SEM and then SEM will transport him to the hospital. SEM is the unique service that can transport patients to hospitals. In the case of a difficult-to-access rescue, GRAE will be in charge of rescuing the patient and then they have always to transfer the patient to SEM in case of a necessity of hospital care.

The Special Operations group has four helicopters: three Airbus H135 and one BELL429. Two of those Airbus H135 are leased from an external company. As it can be seen in **Fig. 1.2**, the callsign, which is the number that goes up of the vertical rotor, is a non-Spanish one indicating that the helicopter is registered abroad. In addition, they have one H135 in property as it can be seen in **Fig. 1.3**, and one BELL429 which is also leased (**Fig. 1.4**).

Fig. 1.2 H135 helicopter from GRAE rented from an external company located in the airport of Sabadell

Fig. 1.3 H135 helicopter from GRAE located in the airport of Sabadell

Fig. 1.4 BELL429 helicopter from GRAE [57]

1.2.2. Type of vehicles

The technical specifications that the helicopters should have, obey the operational needs of the GRAE. For instance, they need a helicopter which can land in mountains or right there, it must be twin-engine, it must be able to operate in Performance Class 1 to overfly urban areas and it must have the weights that they determine in order to fulfil their needs.

GRAE is a service that rescues people who are in difficult situations. The type of rescue that they do is also dangerous. For this reason, one of the important components that helicopters of GRAE have and distinguish from other services, is the crane. The crane allows to rescue patients that have injured and there are in an inaccessible place. During these rescues, the helicopter has to make a stationary flight to allow the GRAE to tie the person down and lift him/her up with the crane. On the other hand, the helicopter is equipped with a defibrillator and a stretcher, so that they can be used if necessary to save or assist the patient.

Each helicopter shall undergo maintenance when it has exceeded the number of flight hours specified by the manufacturer. The crane shall also undergo maintenance when it has exceeded the cycles determined.

The BELL429 is equipped with a crane that allows to rescue patients from a higher height due to the longitude of the cable and allows to operate from about 90 meters. The helicopter can also travel at a higher speed. Apart from the improvement in operational and work capabilities, it is also a multi-purpose aircraft, as it will be able to support, for example, the extinction of forest fires.

1.2.3. Geographical ambit and their bases

The Special Actions Group (GRAE) is a group that belongs to fire Brigade of Generalitat de Catalunya that operates in all the province of Catalonia. However, they make high risk rescues at the mountains or in natural areas such as rivers where the places have a difficult access and, they search for people that have been lost in the mountain and he/she does not know how to return.

GRAE has three bases, two situated at the Pyrenees and the other located in Sabadell. At the Pyrenees there are two bases, one of those is a permanent base, and it is situated at the airport Andorra-La Seu d'Urgell and the other one is situated in Tírvia, where it will be the days with a highest inflow of people in the Pyrenees. The bases of Andorra-La Seu d'Urgell and Sabadell are operative 365 days a year from sunrise to sunset, while the Tírvia is operative only when it is necessary.

The two Airbus H135 are situated in Sabadell while the other H135 and the BELL429 are situated at the airport of Andorra-La Seu d'Urgell.

1.2.4. Operations

The operations that they perform are classified into 3 different types: mountain rescues, aquatic environment and urban or industrial environment.
The mountain rescues are usually activities such as hiking, downhill skiing, avalanches, climbing, mountaineering, caving, canyoning, mountain biking, lost people, paragliding, base jumping, skydiving, via ferrata… On the other hand, there are the activities in an aquatic environment like in rivers, inland waters and collaboration at sea. Finally, they carry out activities in an urban or industrial environment such as wells, pits or any environment which is difficult to access.

However, the most frequent operations are heart attacks, unconscious climbers, skiers, cyclists, etc. In any case, the team that goes to rescue the patient is the one who is on duty. They will catch one bag or another depending on the type of accident the patient has had in case they know before leaving for the emergency, otherwise they will take the usual bag.

The operations carried out in a day depend on the calls that are made to them or to the emergency number (112). Some days there may not be operations and others having 10 or 12 operations a day and all the helicopters flying from one place to another. Similarly to SEM, there is not a flight plan because it is an emergency and they have to go as fast as they can, so there is no time for planning. In the event of fog or precipitation in the form of stones, the helicopters will not be able to come, and they will have to move by van overland.

In all the operations that GRAE makes, in case that it will be necessary to transfer the patient to a hospital, the patient must be referred to an ambulance or to a helicopter of the SEM for such a transfer. As mentioned above, the GRAE cannot transfer the patient to the hospital, as they are not authorized, due to LAW 5/1994.

Finally, the safety protocols used when landing are to make a 360º turn to visualise where you are going to land and when it is clear and the pilot is sure, he/she lands.

1.2.5. Costs

GRAE is a public service supported by the money from taxes' payers. Every time that the helicopter goes for a rescue, there are operational, personnel and maintenance costs. However, it is difficult to calculate the cost of this service due to every emergency is different. In some of the emergencies, GRAE will know exactly where the person is and in others, they will have to search for him/her. It also depends on the place where the accident took place if it is far away from the base or near the base.

On the other hand, the costs of a leased helicopter are not the same as those of one in property. A leased helicopter is twice expensive to fly, maintain and replace compared with an owned helicopter.

In terms of the costs of the personnel, they do not depend on the number of emergencies or operations they have, as they have their own salary set each month.

Finally, an additional cost will be all the facilities, hangars, heliports and fuel that GRAE has distributed throughout the region of Catalonia.

However, as Xavi Toledo told me in the interview, as a public service and within the criteria of simple common sense, the final cost of the rescue is of little importance if it can be solved satisfactorily for the patient.

1.3. Comparison between the Medical Emergency System and the Special Actions Support Group of the fire brigade of Generalitat de Catalunya

The Medical Emergency System (SEM) is a service which is focused on the medical emergencies, transporting the patient to the hospital and, if necessary, providing treatment or medicine in the helicopter and make interhospital transfers. However, the Special Actions Support Group of the fire brigade (GRAE) is a service focus on mountain activities where there is a difficult access to rescue the patient and in some cases, it can be dangerous. Both are public services that are supported by the money from taxes' payers which must be spent consciously and rationally.

In terms of the crew on board the helicopters, SEM has 4 people in each one who are a pilot, a co-pilot, a doctor and a nurse, while GRAE has 5 people in the helicopter involving a pilot, a crane operator, two members of the GRAE and the doctor who belongs to the SEM. In both cases, the whole team helps each other in the different tasks they have to carry out during emergencies.

In the case of SEM, both the helicopter, which is prepared as an ICU, and the material they carry inside is more medical based than those of GRAE. The GRAE only carry defibrillators and the helicopter is not prepared at a medical level, but rather at a rescue level. Helicopter of SEM and GRAE are Airbus H135, but in some cases GRAE uses BELL429 which is slightly bigger than Airbus H135. All are twin-engine helicopters, that are allowed to fly in Performance Class 1, over urban areas, and are equipped with the most appropriate configuration and material for each situation.

Both of the services operate in the region of Catalonia. The 4 helicopter bases of SEM are distributed along all the territory of Catalonia and there is one in each region: Barcelona, Tarragona, Lleida and Girona. While the 3 helicopter bases of GRAE are situated two at the Pyrenees and the other situated in Sabadell. So, as it can be seen the GRAE is focused on mountains activities

and for this reason has 2 bases near the Pyrenees and the other in Sabadell which is at the middle of all the territory. However, the SEM have the four bases well distributed in order to reach all the places as quickly as possible across the territory. The bases of SEM are situated on hospitals while those of GRAE are situated on airports.

SEM and GRAE are different emergency services that complement each other because in case that the patient has fallen off a mountain which is very difficult to access, the first service that will go to save the patient will be GRAE. But then if the patient needs intensive cures or he/she need to go to the hospital, GRAE will must transfer the patient to SEM, and then SEM transporting him/her to the most adequate hospital, depending on his/her illness. The people working on 112 are the ones who decide, depending on the type of accident, which is the emergency system that has to go to the place where the accident has taken: GRAE, SEM or both of them.

1.4. Comparison between all the existing services

SEM and GRAE are the existing services that operate in Catalonia and that in case of an emergency, they will go to the place where the accident took place by a helicopter, and they will try to save the person. Afterwards, if necessary, SEM will transport him/her to the hospital.

Thus, this thesis is focused on the existing services that operate in Catalonia. However, in this section the existing services in Catalonia will be compared with two more from abroad of the Catalan region that are the Maritime Rescue and Safety Society (SASEMAR) and Rega. SASEMAR is an entity that operates in rescues in the seas of Spain while Rega is a private emergency medical assistance in Switzerland and Liechtenstein, both services are explained in Annex 1. With this comparison, it will be analysed all the technical characteristics of each one and see if it is possible to improve the existing services that are currently available in Catalonia.

SEM and Rega are similar services in terms of what they perform. Both of them provide emergency medical assistance, and in case that the patient has to go to the hospital, they transport him/her to the most appropriate one depending on his/her illness or injury. However, Rega has also some similitudes with GRAE because both make high risk rescues the most part of their time, in the Alps, in the case of Rega and in the Pyrenees, in the case of GRAE.

Finally, between GRAE and SASEMAR there is also a similarity because they make rescues in mountain areas and at the sea, respectively. Then in case that the patient needs hospital attention, they transfer the patient to SEM and SEM is the service that cares about him/her and transport him/her to the most appropriate hospital.

In the next table (**Table 1.1**), a comparison between the most important technical characteristics of the services is presented.

Table 1.1. Comparison table of all the existing services [1] [2] [3] [4] [14] [16] [23] [25] [31]

	SEM	GRAE	SASEMAR	REGA
Type of organization	Public	Public	Public	Private
Function	Responds to emergencies and transport people to another hospital	Makes high risk rescues in the natural environment and in places with difficult access	Protection of human life at sea and protection of marine animal and plant life	Provides emergency medical assistance
Number of helicopters	4	4	11	18
Model of helicopter	H135 (4)	H135 (3) and BELL429 (1)	AW139 (9) and EC225 (2)	H145 (7) and AW Da Vinci (11)
Crew inside	4 people	5 people		3 people
Operative area	Catalonia	Catalonia	Spain	Switzerland and Liechtenstein
Geographical area	30,000 km^2	30,000 km^2	1,500,000 km^2	41,450 km2
People in the area	7.5 million people	7.5 million people	47 million people	8.67 million people
People that can assist	All people	All people	All people	Approximately 38% of the population. Only members of Rega.
Bases	4	3	11	12
Can operate at night?	Yes. 1 helicopter	No	No	Yes
Types of operations	Attention to critically ill patients and interhospital service to move a patient from one hospital to another	Mountain rescues, aquatic environment and urban or industrial environment	Rescue of human life at sea, prevention and flight against pollution of the marine environment, maritime safety and navigation services.	Operations for patient with illness, to deal with winter sports, road, occupational and alpine accidents

The first three services are all public and correspond to the Catalan and Spanish services. On the other hand, Rega is a private service that only assists its members and those people that pay for the service on an occasion.

SEM and GRAE have 4 helicopters each one for assisting the same population as it is the people living in Catalonia which correspond to 7.5 million people. So, the relation between the number of helicopters that they have and the geographical area where they can operate is given in **(1.1)**. The result is one helicopter for each 1.875 million people in the region.

$$\text{People per helicopter} = \frac{7{,}5 \text{ M people}}{4 \text{ helicopters}} = 1{,}875 \text{ million people per helicopter} \quad \textbf{(1.1)}$$

In the case of SASEMAR, it has 11 helicopters for the whole population that lives in Spain, which accounts for 47 million people. However, SASEMAR only assists people that has suffered an illness at the sea, which would not be all the population at the same time. People who live near the sea correspond to 40% of the whole population of Spain. Even so, all the population of Spain could be assisted by SASEMAR if they go to the sea. So, as it can be seen in **(1.2)**, they have one helicopter for making rescues in the sea for each 4.27 million people.

$$\text{People per helicopter} = \frac{47 \text{ M people}}{11 \text{ helicopters}} = 4{,}27 \text{ million people per helicopter} \quad \textbf{(1.2)}$$

Considering only the people who live near the sea, which is 40% of the population of Spain, it can be seen in **(1.3)** that they have one helicopter for 1.71 million people.

$$\text{People per helicopter} = \frac{40\% \text{ of } 47 \text{ M people}}{11 \text{ helicopters}} = 1{,}709 \text{ million people per helicopter} \quad \textbf{(1.3)}$$

Finally, Rega has 18 helicopters for the members that belong to them living in Switzerland and Liechtenstein, which is approximately 38% of 8.67 million people, which is all the population living in both countries. Making the same operation as in the other cases **(1.4)**, a helicopter is obtained per 0.18 million people in that region.

$$\text{People per helicopter} = \frac{38\% \text{ of } 8{,}67 \text{ M people}}{18 \text{ helicopters}} = 0{,}18 \text{ million people per helicopter} \quad \textbf{(1.4)}$$

As it can be seen in the previous results, Rega is the service which has more helicopters per people, 1 helicopter for each 0.18 million people, and then it follows SEM and GRAE that have both of them 1 helicopter for each 1.875 million people and finally SASEMAR which has 1 helicopter for each 4.27

million people. However, the last one operates most of all its operations at sea and it is less probable that somebody will fail into the sea or drown in the sea, so probably for this reason there are less helicopters relating to the number of people.

On the other hand, it is possible to compare the territory region where helicopters operate in relation to the number of helicopters that they have, to make a statistic for each case.

First of all, SEM and GRAE have 4 helicopters each and both operate in the region of Catalonia that corresponds to 30,000 km^2. In **(1.5)**, it can be seen the relationship to obtain how many square kilometres correspond to each helicopter.

$$\text{Territory per helicopter} = \frac{30000\ \text{km}^2}{4} = 7500\ \text{km}^2\ \text{per helicopter} \quad \textbf{(1.5)}$$

Secondly, the case of SASEMAR which has 11 helicopters and operates in the sea region of Spain that is equivalent to 1,500,000 km^2. So, in **(1.6)** there approximates the km^2 that corresponds to each helicopter of SASEMAR.

$$\text{Territory per helicopter} = \frac{1500000\ \text{km}^2}{11\ \text{helicopters}} = 136363{,}63\ \text{km}^2\ \text{per helicopter} \quad \textbf{(1.6)}$$

Finally, the case of Rega that has 18 helicopters and operates in the region of Switzerland and Liechtenstein that is equal to 41,450 km^2. In **(1.7)**, it can be seen how it is calculated to obtain the square kilometres per each helicopter.

$$\text{Territory per helicopter} = \frac{41450\ \text{km}^2}{18\ \text{helicopters}} = 2302{,}778\ \text{km}^2\ \text{per helicopter} \quad \textbf{(1.7)}$$

As it can be seen in the previous results, Rega has more helicopters per square kilometre than the other ones. It is true that in the case of SASEMAR is less likely to have more emergencies once one goes deeper into the sea because it is not possible to have people swimming. Therefore, it only depends on the ships sailing on the sea and if they need a rescue. For this reason, there can be less helicopters per square kilometre. Finally, SEM and GRAE have one helicopter per each 7,500 km^2. In this case, both services have 4 helicopters each and operate in the same region having different functions. These services coordinate and depending on the type of emergency it will go one or another. For this reason, Catalonia, in total it has 8 helicopters and both services coordinate for assisting the whole population. If it is considered both services together, in the Catalan region there is one helicopter per each 3,750 km^2. This is mostly the same as Switzerland considering that their territory has more

mountain areas, and it is more probable to have an accident there than in Catalonia.

Catalonia has an area of 30,000 km^2, while Switzerland has an area of 41,450 km^2. In the **Fig 1.5 & 1.6**, it can be observed that Catalonia having less geographical area than Switzerland, have also less mountain areas which represents approximately one third to one quarter of the total territory of Catalonia. However, in Switzerland having 1.3 times the territory of Catalonia, they also have lots of mountain areas and represent approximately a half of the territory of Switzerland. In addition, there will be also more areas where the access for rescue the patient is very difficult and Rega will need to operate for rescuing the person. For this reason, it is probably that in Switzerland having to assist only the members of Rega they need more helicopters than in Catalonia because it has more mountain areas and also more areas with difficult access. So, an accident is more likely to occur there than in Catalonia with less mountain and less difficult areas.

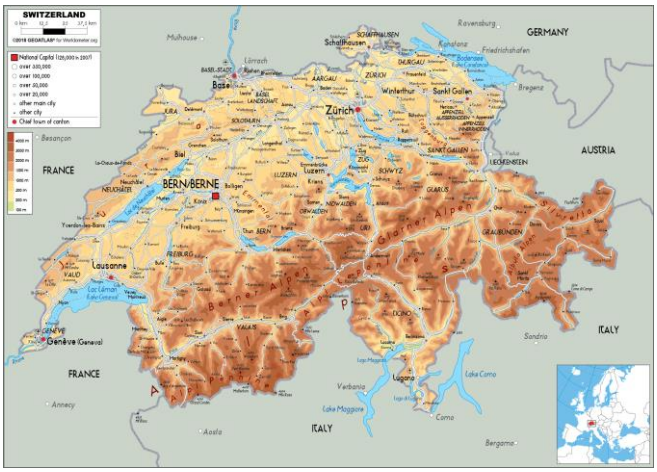

Fig. 1.5 Physic map of Catalonia [55] **Fig. 1.6** Physic map of Switzerland [56]

On the other hand, the bases that each service has, is equivalent to the number of helicopters that they have, and the bases are well distributed throughout the territory. For example, SEM has four helicopters and four bases, one helicopter for each base in each of the provinces of Catalonia (**Fig. 1.1**). GRAE has four helicopters and three bases due that it has two helicopters in the base of Sabadell and two more in Andorra-La Seu d'Urgell. SASEMAR has 11 helicopters and 11 bases all of them distributed along the territory of Spain (**Fig. A.1.1**). Finally, Rega has 18 helicopters distributed in 12 bases along the territory of Switzerland and Liechtenstein (**Fig. A.1.9**).

The crew is similar in all cases; including a pilot, a co-pilot, a doctor and a nurse, although in some cases, as happens with GRAE, the co-pilot is replaced by a crane operator.

Finally, SEM and Rega are the only services that are operative 24 hours a day for 365 days a year. However, in the case of Rega all the helicopters are ready

to operate at night in any condition in Switzerland and Liechtenstein. In SEM there is only one helicopter for all Catalonia operating at night. Comparing the territory of Switzerland and Liechtenstein with Catalonia, in proportion Catalonia having only one helicopter at night is too little to cover all the geographical area involved. The same applies when compared to the number of people living in Catalonia. Therefore, probably it will be better to have more operatives' helicopters at night, so it can save more people if needed.

As a conclusion, if all the four helicopters would be operative at night, there will be a well-covered network during day and night in Catalonia. Considering that SEM is preparing most part of the heliports in hospitals for being operative at night, one can easily understand that the service that will follow will enable all vehicles operating at night.

CHAPTER 2. HELICOPTERS

In this chapter, the characteristics of the helicopters that belongs to the existing services of Catalonia, namely SEM and GRAE, will be analysed. As already mentioned, SEM has a fleet of four helicopters, all of them being Airbus H135 and GRAE has also a fleet of four helicopters which three of those are Airbus H135 and one is a BELL 429.

2.1. Airbus H135

The Airbus H135 is one of the most successful lightweight helicopters of Airbus. It is known for its endurance, compact build, low sound levels, reliability, versatility, and cost-competitiveness. This is one of the quietest twin-engine helicopters as its sound footprint is markedly lower than others rotorcraft in its category. It is also authorised to fly in the United States' Grand Canyon, which has one of the country's most stringent noise limitations. [39]

The H135 has the lowest operating and maintenance costs within the twin-engine category. In addition, it can perform various missions, and can land almost anywhere, particularly in high and hot conditions, while carrying more payload over longer distances than other helicopters in its category.
The H135's advanced cockpit with its new 4-axis autopilot provides the highest-possible safety levels.

2.1.1. Specifications

The Airbus H135 is fitted with a bearingless main rotor, engine software modifications, a new lateral air intake, additional payload and delivers best-in-class performance throughout its flight envelope, all compared to the helicopter model that existed prior to the Airbus H135, called the Eurocopter EC135.

There are two different options of engines equipped with digital engine control: Safran Helicopter Engines' Arrius 2B2plus and Pratt & Whitney Canada's 206B3. Both turboshaft powerplants provide outstanding performance and vital power reserves, in case of having one engine inoperative, and has a low fuel consumption, what is a requirement that allow helicopters to operate in Performance Class 1.

2.1.2. Missions

The Airbus H135 can perform a wide range of missions. It can perform emergency medical services, rescue/disaster relief and military training or private and business aviation.

This helicopter is world leader in Helicopter Emergency Medical Services and is available in a wide range of dedicated Emergency Medical Services interiors that give operators a choice of configurations, providing ample room for patient care. Its cabin volume allows a direct access of the patient in case of emergency.

The aircraft meet the highest standard in patient care as the European EN13718 standard [39]. This European Standard specifies the requirements for medical devices carried in HEMS and used therein and outside hospitals and clinics in situations where the ambient conditions may differ from normal indoor conditions. [77]

The H135 is also used for rescue and disaster relief. This helicopter has excellent slope landing capabilities and can perform demanding mountain rescue intervention, as what GRAE does. This helicopter can accommodate up to two stretcher patients in case of a disaster relief missions as floods, earthquakes or heavy snowfalls. The latest improvements of H135 increase its hover performance which is very important in high-altitude mountain rescues.

Finally, this helicopter is also used for other missions such as law enforcement, environmental energy market, VIP transport and military training due to its high safety standards and good performance. [40]

2.1.3. Equipment

The H135 is equipped with the latest technology and the aircraft has an integrated tactical infrastructure by connecting the helicopter to the ground through various means (SATCOM, GSM, G4, Tetra, digital downlink systems, etc.). Thus, every time the aircraft goes to perform a rescue or emergency, the people on the ground who control it know where the helicopter is at all times. The aircraft is also equipped with an up-to-date Wi-Fi connectivity, a tablet-compatible cockpit, and enhanced reality system (vector maps overlay on video images), which GRAE and SEM have in their helicopters. [40]

The H135 fulfils safety and mission requirements for offshore work and there is some extra equipment which correspond to Emergency floatation system (Sea State 6 certified), External life raft system (Sea State 6 certified), Helicopter emergency egress lighting (HEEL) and Automatic deployable emergency locator transmitter (ADELT) [40], which means that this helicopter can also be used for rescuing missions in the sea, as for example by a company as SASEMAR.

2.1.4. Configurations

There are different types of configurations depending on the mission and the equipment required. HEMS configuration will be explained below, and the other configurations can be seen in Annex 2.

2.1.4.1 HEMS configuration

There are different configurations for Helicopter Emergency Medical Services (HEMS) depending on each operators' need. In **Fig. 2.1**, it can be seen a sample layout of the pilot and the co-pilot with two medical attendants which leaves sufficient space to administer care and easily load/unload the patient.

Fig. 2.1 HEMS configuration of the Airbus H135 [41]

As GRAE explained us, the configuration that they have is based on 5 seats according to the crew that go inside the helicopter and the stretcher is not always fixed, they put it when the patient needs it. In case that the patient has to be transported to another place lying on the stretcher, one person of the crew should be sitting on the floor, otherwise the stretcher will not fit on the helicopter. When the stretcher has to be moved from the helicopter there is a rear door that allows the stretcher to be removed from the helicopter.

2.2. BELL 429

The BELL 429 is a light twin-engine helicopter developed by Bell Helicopter and Korea Aerospace Industries. The BELL 429 is able to fly with a single pilot in IFR and make Category A Runways Operations. The BELL 429 is designed considering the comfort of its passengers. It has a capacity up to 8 passengers and can reach a speed of 155 kts (287,06 km/h). [52]

2.2.1. Specifications and equipment

This helicopter has a four-bladed rotor system with flexible rotor blades in the plane. The rotor blades are made of composite material and have bent tips to reduce the noise. In addition, to reduce the noise the tail rotor is placed at unequal intervals, forming an X.

The helicopter has a cabin volume of 5.78 m^3, a passenger cabin of 3.68 m^3 and a baggage area of 2.21 m^3, with a flat floor for patient loading. A rear door system under the tail which is optional to facilitate patient loading, as in the previous helicopter with GRAE and SEM.

The BELL429 is equipped with a glass cockpit with three-axis autopilot and standard flight director. It has standard skid landing gear, and it can be equipped with retractable landing gear too which increase in 5 knots the cruise speed. The helicopter is able to fly in IFR conditions and it is able to operate with one engine inoperative, according to Performance Class 1. It has a spacious and large cockpit that can be designed to suit the owner's taste. In addition, it has a cabin door that is one of the widest in its class. It is also equipped with intuitive screens where the flight information is displayed.

The aircraft has landing aids for complex situations thanks to satellite guidance systems that allow you to see the way precisely, and in the case of the medical services allows them to land easily. It also has high-performance engines that can operate at any temperature and altitude, which is also a good point in the case of rescuing people from high mountains as GRAE. It has a retractable landing gear with optional wheels that allows it to land anywhere. [51]

2.2.2. Missions and configurations

This helicopter can be used for multiple missions, while this section will only explain the configuration of HEMS. The other configurations are explained in Annex 2.

BELL is used in Helicopter Emergency Medical Services to rescue patients that have an injured or an illness. The cabin can be prepared for patient care as it can be seen in **Fig. 2.2**, folding rear doors and a stretcher-height platform make loading even easier. In HEMS missions, the configuration will be for 1 pilot, 3 medical assistance, one patient lying on the stretcher and another patient in case of being necessary.

Fig. 2.2 BELL 429 configured for HEMS missions [51]

2.3. Comparison of technical information for all helicopters

All the existing services in the region of Catalonia that have been analysed above, use different helicopters depending on each service. The other services that have been compared previously, they have also different helicopters that will be compared as well as in the case of services. With this comparison, it will be seen if depending on the type of emergency and the region where they operate, it is necessary a specific type of helicopter. The first thing to know is that for landing in a hospital located in a congested hostile environment, the helicopters have to be able to operate in Performance Class 1, otherwise they will not land in the hospital heliport [73]. Performance Class 1 operations means flights where, in the event of an engine failure, the helicopter will be able to safely continue the flight and land at an appropriate landing area unless the engine failure recognition occurs during take-off at or prior to reaching the take-off decision point in which case the helicopter will be able to safely land back within the area from which it has taken off [72].

As mentioned previously, SEM and GRAE have a fleet of Airbus H135 and BELL 429 helicopters. In this section, the characteristics of all those helicopters will be compared. However, as done in the previous section, the comparison will be also performed with other helicopters as H125, H145 and AW Da Vinci from Rega and AW139 from SASEMAR which is explained in Annex 2. For this reason, it will be analysed if there can be some improvements in the services operating in Catalonia: SEM and GRAE.

In the following table (**Table 2.1**), one can observe the most important technical characteristics of each helicopter. The H125 belongs to Rega but it is only for training purposes. The H135 belongs to SEM that has 4 of it and GRAE that have 3 of it. The other helicopter that GRAE owns is BELL429 that is based in the Pyrenees. The H145 and AW Da Vinci belong to Rega. Finally, the AW139 belongs to SASEMAR.

Table 2.1. Comparison table of technical information of each helicopter [38] [41] [44] [45] [47] [48] [51] [52]

	H125	**H135**	**H145**	**AW139**	**BELL429**	**AW Da Vinci**
Max speed (km/h)	260	252	262	305	287	289
Max range (km)	630	633	650	1,032	722	859
Max endurance (min)	270	216	215	305	270	271
D-value (m)	12.94	12.26	13.54	16.66	12.7	12.96
Height (m)	3.34	3.9	3.96	4.98	4	3.40
Rotor diameter (m)	10.69	10.4	10.8	13.8	11	10.83
Crew+passengers	7	8	12	17	8	7
Max take-off weight (kg)	2,800	2,980	3,800	6,400	3,175	3,175
Useful load (kg)	976	1,418	1,905	2,500	1,250	
Fuel tank capacity (kg)	426	560	723	1,568	814	
Engine	Safran Helicopter Engines arriel 2D	2 x Safran Arrius 2B2 Plus or Pratt & Whitney PW206B3	2 x Safran Helicopter Engines Arriel 2E	2 x Pratt & Whitney PT6C-67C Turboshafts with FADEC	2× Turboshaft Pratt & Whitney Canada PW207D1.	2 engines (Pratt & Whitney) Canada PW207C

The principal difference between all these helicopters is that the H125 is a single-engine, and all the others are twin-engine. This helicopter is only use for training purposes by Rega and probably it is not necessary to have more than one engine. The five helicopters apart from the H125 are twin-engine, having the two engines of Safran Helicopter Engines or Pratt & Whitney.

As it can be seen in the **Table 2.1**, all these helicopters have similar maximum speeds, maximum ranges, which is the maximum distance that the helicopter can fly with a full tank of fuel, and maximum endurance, which is the maximum time that the helicopter can fly with a full tank of fuel. The H125, H135 and H145 have mostly the same values of those. However, the AW139, BELL429 and AW Da Vinci have slightly higher values than the others, in particular AW139 with a maximum speed of 305 km/h, a maximum range of 1,032 km and a maximum endurance of 305 min flying that has the higher values of all these helicopters. The AW139 is the helicopter that is use by SASEMAR to save people inside the sea of Spain.

In terms of dimension, the biggest helicopter is AW139, having a *D-Value,* which is the largest dimension of the helicopter used to evaluate the helideck when its rotors are rotating, of 16.66 metres, a *Height* of 4.98 metres and a

Rotor diameter of 13.8 metres. The second biggest helicopter, in terms of *Height* and *Rotor diameter*, is BELL429 having 4 and 11 metres respectively, and in terms of the *D-value* is H145 having a measure of 13.54 metres. Then, it will go H135, in terms of *Height* and *Rotor diameter* and finally, AW Da Vinci and H125, in terms of the *D-value*.

In terms of capacity, the biggest one is AW139 that can transport up to 17 people, then H145 that can carry up to 12 people, and finally H135 and BELL429 transporting 8 people and H125 and AW Da Vinci 7 people. In all the cases the capacity depends on the type of configuration that the helicopter is prepared for.

Depending on the dimensions and the capacity, each helicopter has a determined Maximum Take-off Weight (MTOW) which is the maximum weight that these helicopters can have to take off. In this case, AW139 is the heaviest helicopter having 6,400 kg, followed by H145 that weights 3,800 kg. Finally, it is the BELL429 and the AW Da Vinci that can weight up to 3,175 kg and then H125 and H135 that can weight up to 2,800 kg at the maximum take-off weight.

The biggest and heaviest helicopter is the one that is used for making rescues in the sea in Spain (SASEMAR). In Switzerland and Liechtenstein, they also use helicopters that are very big and heavy such as the H145 and the AW Da Vinci. These helicopters have a very high speed, range and endurance to arrive to their patients and a big capacity inside it. With this high speed, they can arrive to any part of the territory in less time than others that have a lower speed. For this reason, the helicopters belong to Rega can provide the best performance in the lowest possible time.

GRAE and SEM uses the Airbus H135. This helicopter is not as powerful as the AW139, H145 or AW DaVinci of SASEMAR and Rega but GRAE and SEM only have to cover the territory of Catalonia. It is much less geographical area than the others, so they can also move to any part of the territory in a fast way and with a lower cost. Rega has to cover 41,450 km^2, SASEMAR 1,500,000 km^2 and GRAE and SEM 30,000 km^2, so as it can be seen here is a lower region to cover by them. They also have their helicopters distributed around all the territory of Catalonia and in case of an emergency, they can choose the helicopter that is closer to the emergency.

It should be said that a helicopter which is larger, heavier, more powerful and faster will cost more to fly and maintain than smaller or less powerful helicopter. Thus, the medical service should balance the number of helicopters with the number of people to be served and the territory, with the model according to its needs but without exceeding costs. After contacting SEM and GRAE, neither of these services provided information on their costs. However, to make an estimation of the cost of a helicopter it could be around 3,120 € for one hour. [90]

CHAPTER 3. HELIPORTS

A heliport is a small airport use by helicopters and other vertical lift aircraft. Heliports typically contain one or more touchdown and lift-off areas, and they can have limited facilities such as fuel stations or hangars.

Helicopters are often used to transport injured persons from the site of an accident to a hospital and to transfer patients from one hospital to another. A hospital heliport accommodates helicopters used by Emergency Medical Services [74]. In **Fig. 3.1**, it can be seen some essential features of a ground-level heliport hospital.

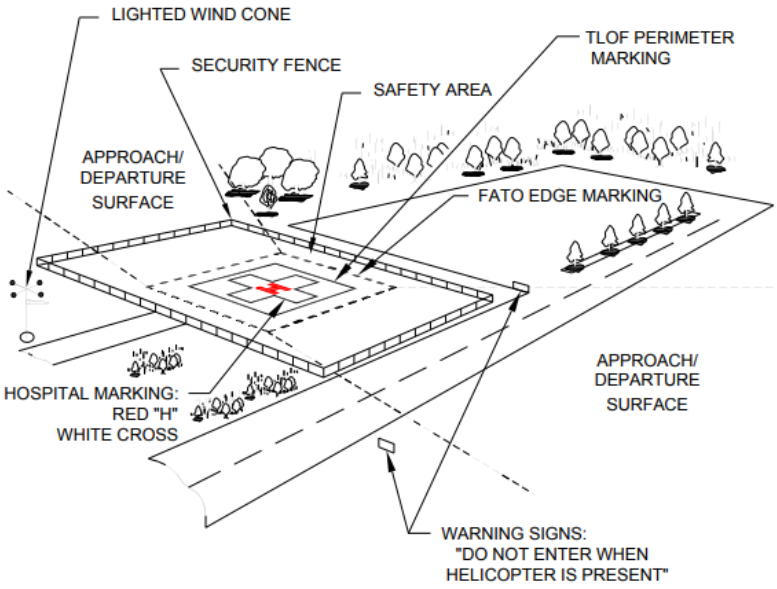

Fig. 3.2 Essential Features of a Ground-level Hospital Heliport: Hospital [74]

In big cities, the heliports are situated closer to the city centre than airports which gives them advantages in terms of flying time for operations such as transport services or emergency services.

A heliport is usually much smaller than an airport, as a helicopter can take off and land vertically. Apart from being smaller in size, it does not have as many things around it as some airports. They have limited services like hangars for storage and maintenance of the helicopters, fuel tanks for refuelling and they all must have beacons, which are lights for making operations at night, and windsocks.

There are different types of heliports depending on their location such as surface heliports, elevated heliports, maritime heliports or heliports on ships. In this case, as this is an analysis of heliports that will be located in hospitals or in their close vicinity, it will only be looked at surface and elevated heliports. In

addition, heliports can also be classified according to their function as transport heliports, helipads and helistations. Both classifications and their specifications are explained in detail in Annex 3.

3.1 Analysis of Heliports

The versatility of helicopters allows them to land anywhere with sufficient dimensions, which they can always do in case of emergency or with the authorisation of the owner if other types of flights are carried out. The trend in recent years has been towards the progressive certification of these aeronautical installations to be able to operate without restrictions on the number of flights and also guaranteeing obstacle-free areas for these aircraft. In Catalonia there are 69 heliports located in hospitals, fire stations, hotels and in some towns of the regions. However, according to the basic aeronautical information manual published by ENAIRE, there are already 41 certified heliports in Catalonia that makes it the area of Spain having the highest number, followed by the Community of Madrid, which has 17. Among 41 Catalan heliports, 23 are located in the province of Barcelona, 8 in Tarragona, 6 in Girona and 4 in Lleida [53]. In Annex 4, there is a list of all the heliports that exist in Catalonia.

After having interviewed two managers of SEM and GRAE, in this chapter it will be analysed the different possibilities of building new heliports in areas that are less equipped with these services in order to be able to transfer the patient more quickly. It will be analysed the zones that are near the hospitals, in case of SEM, or fire stations or airports, in case of GRAE.

They both (SEM and GRAE) agree that in Barcelona they are well covered with heliports. In Barcelona, there are 11 heliports attached to hospitals and clinics. Within the city, the most active hospitals are Sant Pau that has an elevated landing platform over the most modern part of the complex, and Vall d'Hebron University Hospital where they have built a new elevated landing platform over the traumatology and emergency building to speed up the time it takes to assist, diagnose and treat patients. The egress time, from the moment that helicopter lands until the patient enters the traumatology, rehabilitation and burns emergency department, has been reduced to just two minutes compared to the approximately fifteen minutes needed before the opening of this new infrastructure. [54]

Another hospital with an important ambulance helicopter activity is Sant Joan de Déu, which is specialised in paediatrics, gynaecology and obstetrics. The fourth medical centre in Barcelona city that also has a heliport is the Teknon, in Sarrià-Sant Gervasi, owned by the Quirón hospital group.

In the metropolitan area of Barcelona there are also other important hospitals where the most serious patients can be transferred by helicopter, such as the Hospital Trias i Pujol which is also known as Can Ruti, in Badalona, and Bellvitge, in L'Hospitalet. A little further away from the capital, although

reasonably close and even more in case of traveling by helicopter, one can also find medical centres with certified aeronautical facilities such as the Hospital de Mataró, the Hospital General de Catalunya in Sant Cugat del Vallès and the Hospital Parc Taulí in Sabadell, operational base of the SEM.

On the other hand, the Hospital del Mar of Barcelona is carrying out an expansion work of the hospital that will last until 2030. In these construction works, they will include a heliport, to bring people who have suffered an emergency injured or heart attack.

3.1.1 Proposals by SEM

The proposals and needs that SEM has, are to build new heliports in hospitals in near zones that are not as covered as Barcelona. These hospitals that were mentioned during the SEM interview are l'Hospital Arnau de Vilanova, Hospital de Móra d'Ebre and Hospital de Palamós.

It is important that when building a hospital, somebody think about the need for a heliport. As Merche Val said in the interview, the future is aeronautical, and all hospitals will need to have a heliport. In Catalonia, there is not the philosophy when it comes to building a hospital as in other countries, where from the first moment they think about having a heliport.

3.1.1.1 Hospital Arnau de Vilanova

Arnau de Vilanova is the reference hospital for public health in the lands of Lleida and some countries in the western strip. It does not have a heliport but there are studies to build that heliport in the next years. The nearest heliport is located in a fire station at less than one kilometre, but the patient has to be moved from the helicopter to the ambulance and with the new heliport the patient will arrive directly to the hospital and will be assisted fast. In **Fig. 3.3**, it can be seen in a yellow circle the Hospital Arnau de Vilanova, and in a red circle the fire station where is the heliport.

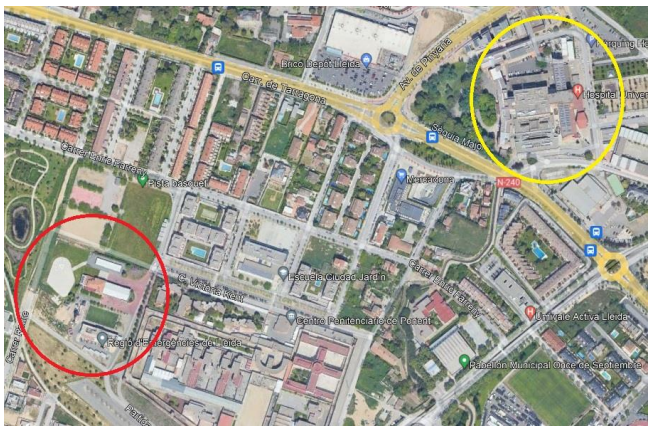

Fig. 3.3 Top view of Hospital Arnau de Vilanova and fire station of Lleida [75]

The project to expand the hospital envisages equipping the hospital with 16 new centralized operating rooms on the third floor, compared to the current 12. Additionally, two lifts will connect the most intensive use areas, such as emergency and radiology, and from the basement to the roof, where a heliport is planned for the upper part of the building. The work, which will be carried out in phases to ensure the continuity of health care, has a term of execution between two and three years. [76]

So, in this case, the proposal suggested by SEM for Hospital Arnau de Vilanova will be carried out in the coming years. As the access to the studies carried out is not public, another study verifying the possibility of building a heliport in the top of the building will be made.

As it can be seen in **Fig. 3.4**, at the top of the building there is enough space to locate the heliport there. In addition, placing the heliport at the top of the building allows the patient to be transferred as quickly as possible by connecting the heliport to the emergency department via a lift. The improvements will reduce the transfer time between the helicopter, ambulance and health centre by 5 minutes, which can be essential for the patient. [76]

Fig. 3.4 Top view of the Hospital Arnau de Vilanova [75]

According to the location of the hospital and the surroundings, different paths will be defined by analysing the best option. **Fig. 3.5**, shows the different routes that could be the most appropriate ones considering the different population centres in order to keep the noise down and avoid overflying urban areas.

Fig. 3.5 3 different paths of arriving to Hospital Arnau de Vilanova [75]

First, the elevation profile of the green path that can be seen in **Fig. 3.6** will be analysed. During the last kilometre of the approaching to the hospital there is an elevation profile that moves between 180 and 174 metres. The last one, 174 metres, is the height of the hospital. As observed, using this route the helicopter will not have any problem in the final approach segment. However, there are some houses that may be affected by the noise of the helicopters.

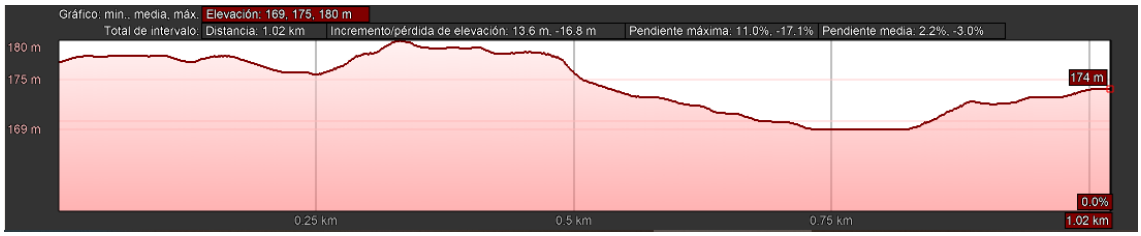

Fig. 3.6 Elevation profile of the green path [75]

Secondly, **Fig. 3.7** presents the elevation profile of the red path. This route does not overfly any houses and therefore will not disturb the neighbours. At the same time, it has lower heights before reaching the hospital, which has a height of 174 metres, as said earlier. Thus, this seems to be a good option for arriving to the hospital without disturbing.

Fig. 3.7 Elevation profile of the red path [75]

Finally, **Fig. 3.8** shows the elevation profile of the yellow path. As in the previous case, this route has also lower heights before reaching the hospital, between 160 and 174 metres. So, this seems to be another alternative for the medical helicopter.

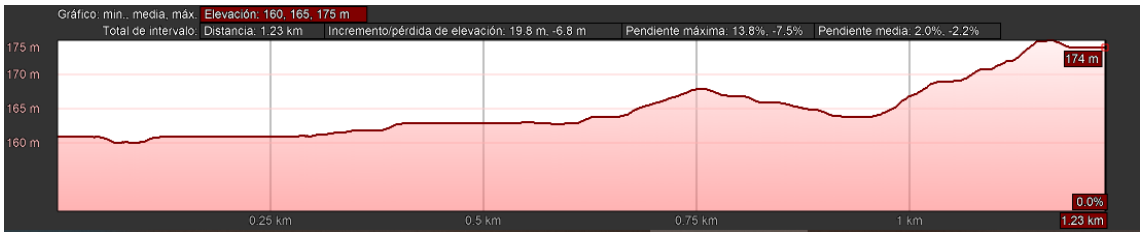

Fig. 3.8 Elevation profile of the yellow path [75]

The medical helicopter can choose different paths for arriving to the Hospital Arnau de Vilanova. However, it is proven that there is no problem in having a heliport at this hospital as it is not the space-constrained and the elevation in the surrounding area is perfectly suitable. So, when they build that heliport on top of the building that is already approved to do so, the hospital and the population will be better connected and safer.

3.1.1.2 Hospital de Móra d'Ebre

SEM has a permanent base in the Parc de Bombers of Móra d'Ebre and the helicopter based there covers all the region of Tarragona and south of Catalonia. However, that heliport has a category of an eventual heliport that means that it is not available to operate at night. For this reason, they need a heliport in that region to allow them to operate during all day including at nights.
Some possible solutions will be to move the permanent base of SEM to Tortosa, but this does not seem like a good idea because Tortosa is located far to the south of Catalonia while Móra d'Ebre is more central and can easily serve the provinces of Tarragona. For this reason, the possibility to build a heliport in Móra d'Ebre hospital as SEM suggested us will be analysed.

In the following **Fig. 3.9**, there is the top view of the hospital of Móra d'Ebre. In the picture, it can be seen that there is some place to build the heliport in the parking or another possibility could be to make an annex at the top of the building to make the heliport there.

Fig. 3.9 Top view of Móra d'Ebre Hospital [62]

Another option could be to locate the heliport in the vicinity of the hospital where there are lot of agricultural fields, as it can be seen in **Fig. 3.10**, and the heliport will have place there. However, it is not the best place to put the heliport because the patient will have to be transported to the hospital by an ambulance. So, the reader can realize that the best places to locate the heliport will be the parking and at the top of the building in an annex building connecting it directly with the hospital and reducing time that may be essential to save the patient.

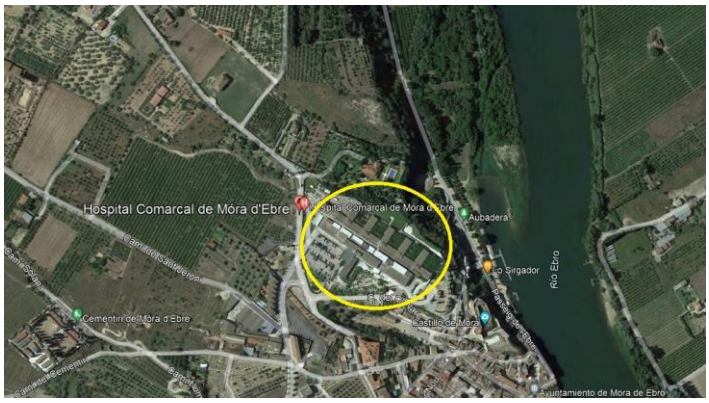

Fig. 3.10 Top view of the surroundings of the hospital and in yellow circled the hospital of Móra d'Ebre [62]

As it can be observed, the hospital has enough place to place the heliport. Therefore, it is going to analyse what is the best route according to the buildings that can be near there. For this reason, as it can be seen in **Fig. 3.11**, 5 possible paths that the helicopter can take to arrive at the hospital will be analysed. The elevation profile of these 5 paths will be analysed below distinguishing between each colour: red, green, pink, blue and yellow.

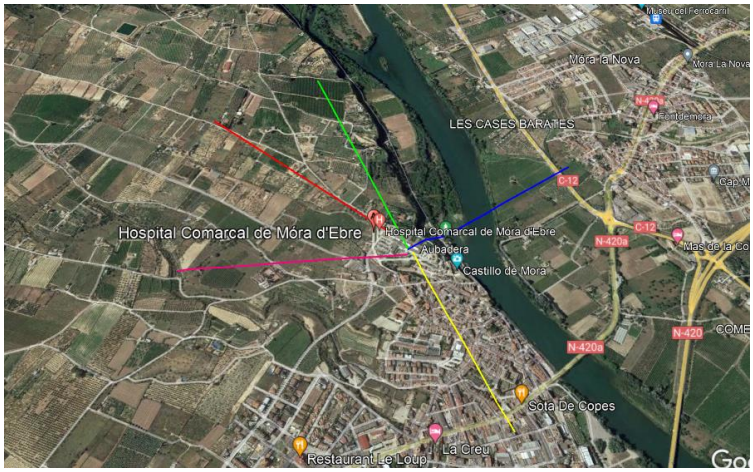

Fig. 3.11 5 different possible routes to go to the hospital of Móra d'Ebre [62]

Firstly, the elevation profile of the red path that can be seen in **Fig. 3.12** will be analysed. During the 913 metres of the helicopter approaching to the hospital there is an elevation profile that starts in 83 to 66 metres high which is the hospital building's height. So, if the helicopter uses this route, it will not have any problems to arrive due to the surrounding buildings during this path.

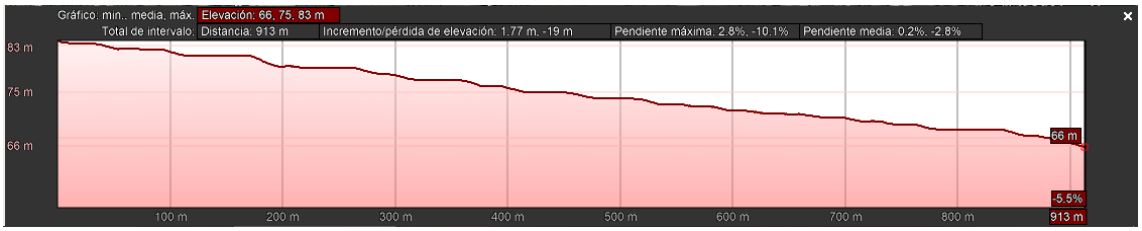

Fig. 3.12 Elevation profile of the red path of Móra d'Ebre hospital [63]

Secondly, if the helicopter follows the green path, it will have an elevation profile that can be seen in **Fig. 3.13**. In a distance of 979 metres from the hospital, the higher altitude is 77 metres high at the start of the route that is reducing to 70 metres, then go up to 75 and finally to 64 that is the height of the hospital. So, in this path the helicopter can arrive to the heliport without any problems.

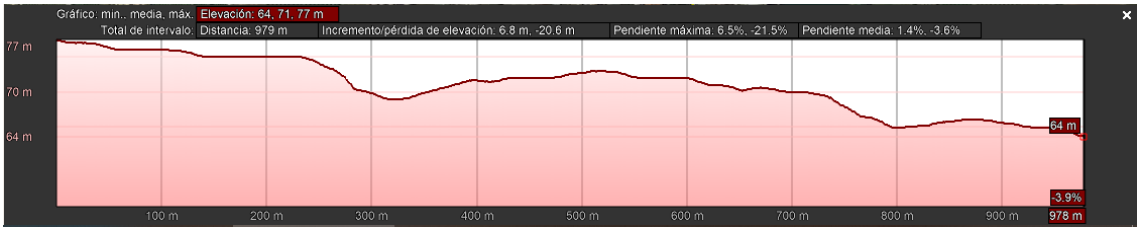

Fig. 3.13 Elevation profile of the green path of Móra d'Ebre hospital [63]

Thirdly, if the helicopter wants to go following the pink path as **Fig. 3.14**, it will have a maximum height of 76 metres at a distance of 800 metres from the hospital and 64 metres height just arriving to it. So, in this case, the helicopter can follow the green path without any problems and arrive to the hospital.

Fig. 3.14 Elevation profile of the pink path of Móra d'Ebre hospital [63]

In the case of the blue path, the elevation profile is shown in **Fig. 3.15**. It does not have any buildings before arriving to the hospital because it has an elevation between 25 and 18 metres along the path. When arriving to the hospital, it goes up to 64 metres. In this case, this path is the less high path during the final approach that can follow the helicopter to arrive at the hospital.

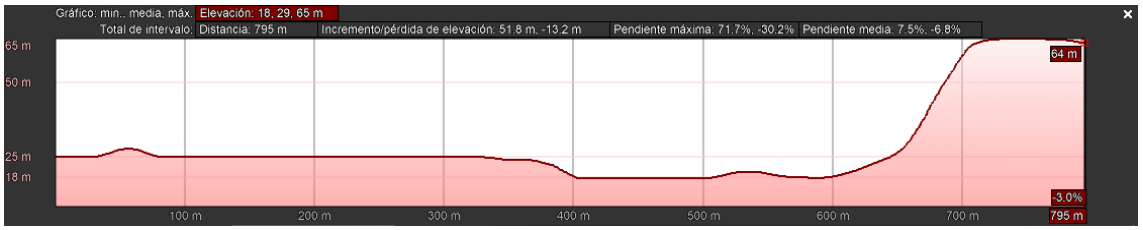

Fig. 3.15 Elevation profile of the blue path of Móra d'Ebre hospital [63]

Finally, the yellow path that follows an elevation profile and can be seen in **Fig. 3.16**. This path has a profile of about 40 metres during mostly all the paths. At its end it rises until 64 metres high. This path is also an alternative to arrive to the hospital, there is not any high building and the helicopter will arrive without any problems.

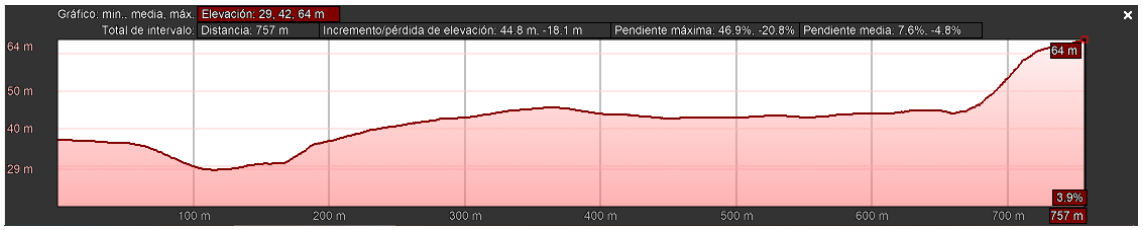

Fig. 3.16 Elevation profile of the yellow path of Móra d'Ebre hospital [63]

The heliport can be built in the Móra d'Ebre hospital because there is enough place to put it in the parking, in an annex building up of the hospital or in the surroundings of it. All the possible paths to arrive at the hospital allows the helicopter to safely operate, bringing the patient without any problem.

The best option will be to place the heliport in an annex to be built at the top of the hospital. The heliport could be connected directly to the elevator and the patient can just land and in a couple of minutes arrive at the urgencies.

The second-best option will be to locate the heliport in the parking. However, is not as directly as the other one because the patient will have to be moved from that zone next to the entrance inside the hospital. In addition, it would be more dangerous if there are people at the surroundings of the entrance of the heliport and all that zones will have to be closed in order of safety for having the heliport there.

Finally, the last option will be to put the heliport at the surroundings of the hospital in the agricultural fields, However, the patient will have to be transported by ambulance and it will take longer.

To summarize, the best option is to build a heliport at the top of the building connecting it directly with urgency by an elevator. The patient will arrive in less time than in the other cases and can have more possibilities to be saved.

3.2.1.3 Hospital de Palamós

The Hospital of Palamós is a general hospital with a regional scope that provides services in the Baix Empordà region. Based on SEM's feedback, there is a hyperbaric chamber in this hospital, and it would be convenient to have a heliport there to bring patients that can improve their health conditions by using the hyperbaric chamber. This technology helps patients with multiple disorders thanks to its oxygenation capacity.

However, the structure of the hospital itself does not allow a heliport there because it is located just in the middle of the village. There is no possible to build a heliport there as it can be seen in **Fig. 3.17**. So, one has to look for alternatives. For example, in a while they will build another hospital to move it because the currently hospital is not big enough for all the people in the surroundings.

Fig. 3.17 Top view of the surroundings and in yellow circled the hospital of Palamós [64]

There are studies stating that there will build a new hospital bigger to improve the service and allows them to assist all people in the region of Baix Empordà. However, the construction of the new hospital will take 10 years for being operative since they have just started. [65]

Fig. 3.18 Possible location of the new hospital of Palamós [65]

In the new hospital (**Fig. 3.18**), there will have to make a heliport there to transfer patients that need special hospital care. Though, in the studies does not appear a heliport in the new hospital of Palamós which is something very necessary for that hospital and for the hospitals in the future to transport all the critical patients fast and save more lives.

Therefore, when building the new hospital, they should consider the construction of a heliport at the top of the building or near it. The reader can realize that the best would be at the top of the building because the helicopter does not have to go down to the ground for landing. Additionally, the top of the building can be connected by an elevator to transport the patient directly on a stretcher to the emergency room for quicker treatment.

However, this new hospital would not be operative up to 10 years and in the currently one, it is not possible to build a heliport due to its located in the middle of the village. So, a possible alternative for the current hospital will be found.

First, it is impossible to put the heliport in the top of the hospital or just next to it due for the location that it has. The unique alternative is to build a heliport near the hospital. In this case, after landing the patient will have to be transported by an ambulance to the hospital. The possible places that the heliport could be located can be seen in **Fig. 3.19** and **Fig. 3.20** where one is located to the right side of the hospital and the other to the left side, in the same place that probably will be the new hospital of Palamós.

Fig. 3.19 Right side of the surroundings of the hospital of Palamós [64]

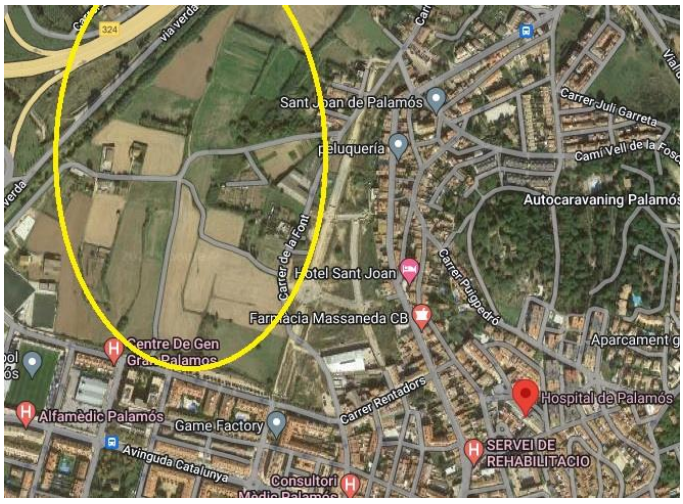

Fig. 3.20 Left side of the surroundings of the hospital of Palamós [64]

Having to build a heliport in the surroundings of the current hospital does not make sense in case of building another heliport in the new hospital and so, the current hospital and the heliport will become inoperative in a few years. If having a heliport is a need for the hospital, then the best option is to build it in the left side of the hospital (**Fig. 3.20**) because then the heliport could be used for the new hospital as it will be in the same plot of land.

If the heliport would be located in the left region of the hospital, where the new one will be built, 3 possible ways of arriving to it will be analysed, as it could be seen in **Fig. 3.21**.

Fig. 3.21 Possible ways of landing in the new heliport of Palamós [66]

As it can be seen in the **Fig. 3.21**, the different ways to arrive to the new possible heliport are very different between them. One of those has to cross the C-31 which is a very busy road. The other ways have to cross the city coming from the sea.

In the **Fig. 3.22,** it can be seen the elevation profile of the red path. There is a mountain at 1 kilometre before arriving to the heliport with an altitude of 84 metres high and then it decreases to a height of 4 metres. Finally, there is a very busy road (C-31) arriving to the heliport where the helicopters will have to pay attention when crossing it.

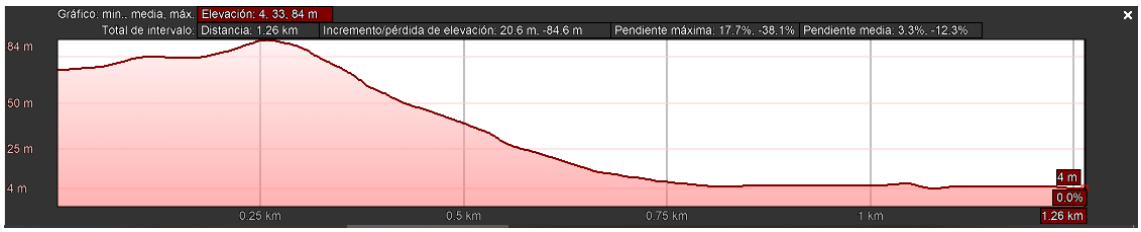

Fig. 3.22 Elevation profile of the red path [66]

In the **Fig. 3.23**, it can be seen the elevation profile of the yellow path. This path goes through the town of Palamós and the helicopters will have to be careful, especially when operating at night, not to disturb neighbours. The elevation profile has heights between 0 and 5 metres during the last kilometre.

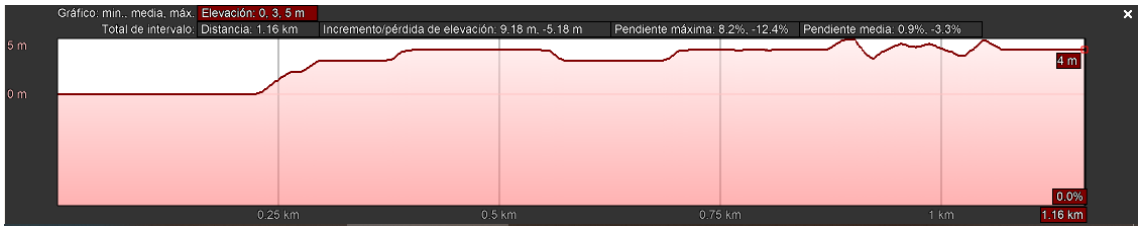

Fig. 3.23 Elevation profile of the yellow path [66]

Finally, the elevation profile of the blue path can be seen in **Fig. 3.24**. As in the previous case, the path goes through the town of Palamós and they will have to be careful to not disturb the neighbours at night. There is a mountain with an altitude of 36 metres high one kilometre before the heliport and then the elevation decreases to 4 metres high.

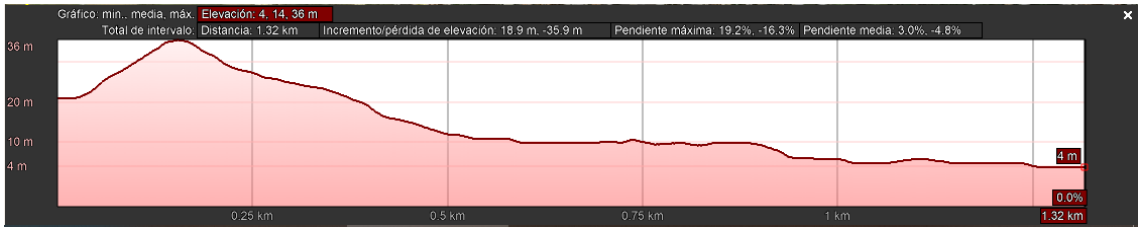

Fig. 3.24 Elevation profile of the blue path [66]

To sum up, the heliport can be built in the left side of the current hospital where they will build the new hospital in ten years, if there is an inmediate necessity for SEM and the people living in Palamós or surroundings. Building the heliport there is an advantage for the future that when the new one will be build the heliport will be already there. However, now the heliport is far from the current hospital where a top of the building heliport or near heliport to the hospital is impossible to build due to the zone where is located. So, the patients will have to arrive to the hospital by an ambulance.

In the near future, when the hospital will be built the heliport could be connected by a little tunnel to just transfer the patient inside urgencies and allow him/her to be assisted in the less possible time.

3.1.2 Proposals by GRAE

Currently, GRAE has 3 bases: one in Sabadell, which is permanent, and two near the Pyrenees in Andorra-La Seu d'Urgell and Tírvia. The first is a permanent base and the other is a temporal base for the days with a high influence of people in the Pyrenees. The proposals and needs that GRAE has are to establish a permanent base to cover the south of Catalonia establishing a base in Tarragona.
Actually, when an accident occurrs, the helicopter of Sabadell is the one that has to go to the South of Catalonia, so having a permanent base in Tarragona will benefit GRAE for arriving early to help people in the south of the region.

In this case, the most suitable will be searching for a specialized heliport located in Tarragona or near it. In Annex 3, there is a list of all the heliports of Catalonia. Searching in that list, it will be found the Heliport del Centre de Gestió d'Emergències 112 which is a specialized heliport located in Reus and whose operators are Centre d'Atenció i Gestió de Trucades d'Urgència 112 Catalunya, SEM and the Divisió de la Sala Central de Bombers.

For this reason, the best option for establishing a base in Tarragona will be in the specialized heliport of Reus. As is a specialized heliport, the firefighters can operate during the day and at night. This heliport can be seen in **Fig. 3.25**, and it is located three metres above street level to facilitate take-off and landing manoeuvres for up to three helicopters. [67]

Fig. 3.25 Heliport del Centre de Gestió d'Emergències 112 located in Reus [67]

CHAPTER 4. Analysis

As a summary, based on all the facts exposed so far, an analysis of the most important points will be made.

As it has been seen, Helicopter Emergency Medical Services (HEMS) are responsible for transporting the seriously injured person to hospital for treatment and providing appropriate treatment during the route. HEMS are an integral part of the health care system in developed countries, which aims at shortening the transport time and at the same time providing emergency medical services in remote areas.

In Catalonia, there are two existing services: SEM and GRAE. These services complement each other being able to cooperate together to provide the best possible services. SEM is responsible for transporting the patient to the hospital in case that needed. However, GRAE cannot transport the patient to the hospital due to strict regulation stipulated by Law 5/1994. Though, GRAE could only transfer the patient to hospital if the SEM doctor, who is part of the crew, considers it as really necessary and essential. Otherwise, they are only responsible of rescuing people who are in difficult situations. For example, if someone have an illness in mountains, skiing or climbing, they will rescue the patient from bad situations, and they will transfer him/her to SEM to transport to the hospital.

As the reader can realize, there is a well-coordinated service network in Catalonia that depending on the accident of the patient the central coordination which is 112 Emergencies will send to the place of the accident the respective service (SEM or GRAE).

As well as the crew that goes in the helicopter is a multi-disciplinary team that cooperate and help each other during the whole rescue process. They give the best of themselves to provide the best possible services and save as many patients as possible. Each crew of all the medical services is always formed at least by a pilot and a nurse or a doctor. In some cases, as in the case of SEM, it is also formed by a co-pilot and has both a doctor and a nurse. In others, as GRAE, it is also formed by two members of GRAE and a crane operator.

In terms of the number of helicopters in Catalonia, as seen before, SEM has 4 helicopters and GRAE has 4 helicopters more for the entire region of Catalonia. In case that the helicopter could not go where the accident took place, they will send an ambulance. This number of helicopters is enough for the region of Catalonia and all people are well covered with these 8 helicopters.

However, the service done by SEM and GRAE is not the same. As mentioned before, GRAE is not allowed to transport the patients to the hospital unless the doctor of SEM considers it as really necessary. SEM is the responsible of making this transport. The helicopters of SEM are better equipped as they act like an ICU, whereas those of the GRAE are only equipped with medical material.

In the previous chapter, the SEM and GRAE services were compared with Rega. This service with a much amount of territory was as well-covered as Catalonia during the day. But at night, Rega had more helicopters operating and as a consequence, is better covered than Catalonia. In addition, the SEM and GRAE services were compared with SASEMAR. In the comparison that was made before, in terms of the number of helicopters, number of people and territory were not covering as well as the unique region of Catalonia. Based on the figures, one could claim that Catalonia has enough helicopters to give attendance to all the people that live in the region. However, at night, probably more than just one helicopter will have to be operating for the whole region, t improve the network.

All the helicopters are distributed across the whole region of Catalonia. SEM has a perfectly distributed network consisting of 4 bases, each of them being located in a different province: Barcelona, Tarragona, Lleida and Girona. However, GRAE has two bases in the Pyrenees and one in Sabadell. This service is focused on mountains and for this reason, there are two bases in the Pyrenees, one of which is the permanent one located at the Pyrenees in Andorra-La Seu d'Urgell. However, to have a better well-distributed area, they need another base located in Tarragona serving the region of Tarragona and the south of Catalonia. This is a real need of GRAE that Xavi Toledo, the officer in charge of the firefighters' air media group, suggested during the interview. Based on his feedback, the thesis analyzed the possibility of having a heliport there in Tarragona. After analysing all the possibilities, the best option would be to have a base in the heliport of Reus. This heliport is already built it and GRAE can operate there because it is the Emergency Management Center Heliport of 112. From the personal perspective, the best option would be to have the GRAE base of Tarragona in the specialized heliport located in the centre of 112, in Reus. It is already built and located in a place that can cover the south and all the province of Tarragona.

In the case of SEM, the permanent bases are already well-distributed around all the territory of Catalonia. However, there are also some needs of SEM to improve the heliport hospital network as stated during the interview with Merche Vals, the head of the SEM Air Media Unit. Most of the hospitals should have a heliport for transporting critical patients. So, it has been done an analysis of some hospitals where SEM would like to operate that needs heliports. These hospitals are Hospital Arnau de Vilanova, Hospital Móra d'Ebre and Hospital de Palamós. At the end of each analysis there is a conclusion on the best option for all these hospitals, according to the possibilities of each of them.

The first hospital, Hospital Arnau de Vilanova has already a project to expand the current hospital and build a heliport there in the following years. In this case, as the heliport will be built in couple of years, it does not make any sense to build another heliport right now because there is one located in the nearest fire station where the helicopter can land, and the patient could be transported by an ambulance to the hospital Arnau de Vilanova. However, after making the analysis, the new heliport that will be built at the top of the building would have a perfect location with respect to its environment, the space needed and the elevation profile of the surroundings.

The second hospital, Hospital Móra d'Ebre has enough space to locate the heliport at either the top of the building connected with an elevator or in the parking connected with a tunnel to enter the patient into the hospital. Both are good options to locate the heliport next to the hospital. However, it seems that for the helicopter, it would be better to land in a platform at the top of the building than to land just in the ground where has to go down more. In case of building the platform at the top of the building, the best way would be to connect the platform with an elevator to make a fast transfer and assisting before the patient.

Finally, the last hospital is Hospital of Palamós. This is a hospital that does not have enough space to build the heliport near there because it is located in the centre of the town and the helicopters cannot land there. This hospital is not big enough for the population that live there. For this reason, there are studies to expand the hospital building a new one in a land field next to the road C-31. The solution can be to build the heliport in the field of land where there will be the new hospital and take advantage of that. The importance of this heliport is because there is a hyperbaric chamber that serves to assist injured divers. In addition, that technology helps patients with multiple disorders thanks to its oxygenation capacity. Therefore, it is of high importance to have a heliport next to that hospital, so the patients could recover from their illness thanks to this hyperbaric chamber. Though, now the heliport would not be located next to the current hospital and the patients will have to be transferred by ambulance. In a few years, when the hospital is expected to be built, it can be connected by a tunnel to enable the patient to enter the hospital. So, the heliport could be built now to facilitate the transport of critical patients into the current hospital. This heliport will improve the living standard of the surrounding population. Then, the same heliport will be near the future new hospital where the patients will be directly entering to the hospital by a tunnel after landing the helicopter.

On the other hand, the type of helicopter that the emergency medical services use is usually an H135 in both services (SEM and GRAE). GRAE also has a BELL429 which is a bit bigger than the other one. All these helicopters can operate in a Performance Class 1 which is an essential characteristic that all helicopters of medical services should have. Without this characteristic, helicopters could not land in a hospital in case of transporting a patient.

Both helicopters, H135 and BELL429, are twin engine helicopters and have maximum speeds of more than 250 kilometres per hour. These speeds enable to reach the patient as quickly as possible. Other important characteristic is having a big range for flying to reach any location and transport the patient to the hospital. These helicopters can fly for 633 km (H135) or 722 km (BELL429) without stop over and transporting the patient until the hospital. At the same time, the endurance of both helicopters goes between 3,5 hours to 4,5 hours with a full tank of fuel that allows them to fly a long distance as well as the range. As these helicopters can fly stationary, the flying time is also important for them.

These helicopters are equipped with the last technologies and the equipment that the patient needs onboard. However, SEM helicopters are better equipped

than GRAE, with respect to medical assistance. SEM helicopters are prepared to bring someone who requires intensive care caused by serious health condition as an ICU. GRAE helicopters are only equipped with a defibrillator and a bag with some medicines. This is because they rescue people that are in a difficult situation, but they do not treat the people. SEM is the service responsible of transporting and medically assisting the patient. However, both helicopters are equipped with medicines and a stretcher for lifting the patient and transporting him/her to hospital or to a safe place.

These services preferred to lease the helicopter from a provider company. They ensure that if a helicopter fails, they will always have a replacement to perform the services and therefore they will never lack the shortage in helicopters. In the case of SEM, all four helicopters are leased. Though, in the case of GRAE there is one H135 which is owned by them, whereas the others H135 and BELL429 are leased. If the helicopters are leased, they always have the latest existing model and with the newest improvements and technologies.

4.1 Possible improvements and criteria to design a service as HEMS

In this section, the possible improvements and the criteria to design a HEMS service will be identified. Explaining the possible improvements, the number of helicopters stablished and the functionality of the services in respect to the current services in Catalonia.

Considering the existing services that operate in Catalonia, 4 helicopters of SEM and 4 of GRAE operate from sunrise to sunset. Therefore, during the day, Catalonia is well-covered considering the population and the amount of territory. Nevertheless, at night there is only one helicopter for the whole region. As it can be seen, at night Catalonia is not as covered as it should be. All the helicopters, at least those of SEM, should operate at night to attend emergencies when the patient needs to be transported to the hospital for special treatment and cares. In case that all the 4 helicopters of SEM could operate at night, it would be a perfect well-covered network for the region. In addition, at least two helicopters of GRAE could have to operate at night. Otherwise, if a patient needs a rescue and they can only arrive to him/her by helicopter, it will have to wait until the sunrise to be rescued.

Now, the helicopters that operate during the day, they only operate until the sun goes down. In winter, the sun goes down at 17 or 18 hours. For this reason, there is a need that all the helicopters of SEM and two of GRAE could operate for 24 hours a day. The only thing that is needed for operating for 24 hours a day is that all the heliports have to be certified to do this type of operations. Additionally, the heliport must be a specialized heliport with all the necessary equipment for operating in IFR conditions such as beacons and radio aids. So, helicopters can land at night without any problems and bring patients to be attended there. Additionally, the helicopter must be equipped to operate in IFR conditions and also the pilot has to be certified to fly in IFR. All the newest H135

are equipped with the last avionics technology. As these services have 7 helicopters leased, they will have all the necessary equipment in the cabin for operating in IFR.

Another point to bear in mind is that with the helicopters operating at night, there will also be a higher cost of operations, maintenance and personnel. As all the helicopters are operating for 24 hours, more personnel are needed to assist patients and the cost of operation will be higher. However, the increase in public taxes to cover these additional costs will be an improvement to have a better health care network for all the inhabitants of Catalonia having medical helicopter assistance at any time of the day.

Another possible improvement which will benefit the whole region of Catalonia is that GRAE could have the competence to land in hospitals. Though, this would only be feasible by changing the current legislation (Law 5/1994). HEMS try to reduce the transport time that with ambulance would be larger. However, if GRAE rescues somebody that needs immediate hospital care and needs it as fast as can be, it does not make sense that GRAE has to make a transfer to the helicopter of SEM for transporting him/her to the hospital. If GRAE could have the competence to transport the patient to the hospital, they will reduce time of transfer and subsequently reduce the cost of operations, and the patient could be attended before. GRAE inside their helicopters have one doctor or nurse who belongs to SEM and knows how to treat the patient, so the reader can realize that they should be allowed to land at hospitals and reduce the time of transfer between both services.

On the other hand, the services in Catalonia will improve if the helicopters of GRAE could make the same service as SEM. As for example Rega, that makes rescues but also transports the illness patient to the hospital or assists patients that had injured. Rega makes both services of SEM and GRAE at the same time, so it would be an improvement. Actually, depending on the type of accident, 112 send SEM, GRAE or both in case that the patient needs hospital attention. A possible improvement will be that if GRAE is the chosen service to go there, GRAE can rescue the patient and then, if necessary, transport him/her to the hospital, without the need of SEM. On board the crew of GRAE, there is already a SEM doctor that has the competence to know how to act. In this case, as GRAE is the responsible of transporting the patient to the hospital, the different SEM ground and air vehicles could make another assistance.

Finally, another point will be that all the hospitals should have a heliport to allow transporting the patient there, or at least all the hospitals that are building from now on considering the necessity of having a heliport from critical serious illness patients that need a rapid transfer.

In summary, if the author of this thesis were to design a HEMS, she would consider the following criteria.

• My ideally HEMS will have both services (SEM and GRAE) emerged in one service, as for example Rega. That service will be allowed to make all the operations that now make SEM and GRAE. Additionally, that service will be able to land and operate in hospitals.

• The establishment of 8 helicopters operating during the day (from sunrise to sunset) as the same as the current services, and 4 of those operating for 24 hours. This seems to be the best option because helicopters daily operate from sunrise to sunset. Having this number of helicopters allows to have a well-covered network for all Catalonia, as the currently one. However, 4 of those helicopters will operate also at night, improving the current network that is already at night now.

• All helicopters must have the latest technological advances to ensure greater safety in this type of service. It must also be able to operate in IFR conditions to be able to operate at night. Finally, it must be able to operate in Performance Class 1 to be able to land in hospitals and fly over inter-urban areas.

• All hospitals or at least one for each province need a heliport at the top of the building connected by an elevator. This heliport should be certified for operating also at the night with the respective beacons and IFR conditions. When building a new hospital, consider the fact of having a heliport where this service can operate to transport critical patients.

CONCLUSIONS

As a conclusion, the reader can conclude that the Helicopter Emergency Medical Service network is well-distributed and well-organized in Catalonia, covering all the territory efficiently. All the number of helicopters that SEM and GRAE have, to assist us and improve our standard of living in case of having some illness or accident cover to all the population living in the region of Catalonia. Once, they have been compared with other services such as Rega that assist people in Switzerland and Liechtenstein, the author of this thesis first thought that they will be better covered for the number of helicopters that they have (18) but their territory is bigger and more mountainous than Catalonia, so after analysing, Catalonia is as well-cover as Switzerland.

The only improvement that can help to safe more people that have serious illness is to improve the network of heliports building some certified heliports in hospitals to operate during night. Hospital Arnau de Vilanova, Hospital de Móra d'Ebre and Hospital de Palamós are examples that have been analysed during this thesis considering the elevation of the buildings near there. If the helicopters can fly during both day and night, they will save more lives transporting people to the hospital at night and so, reducing the time of the ambulance. The cost of operations and personnel will be increased due to having the helicopters operating during all day and night, and as a consequence, being a public service, public taxes will be increased.

On the other hand, the helicopters used by both services are suitable for this type of service, having a suitable maximum speed, range and endurance, giving capacity to all the crew and the ill patient and the most important, being able to land in a certified heliport with Performance Class 1.

Helicopter medical emergency services are an improvement for the society where the patient is being transported to the hospital in a couple of minutes. For this reason, these types of services have to be considered when building a new hospital. In lots of expanding hospital, for example Hospital Arnau de Vilanova, the study to expand the hospital do not include the construction of a heliport for reducing the transport time and save more lives. This is a very important need that is not properly considered, and they should consider it to improve the living standard from now to the near future.

As it can be seen, without this type of services, the people that have serious illness and need a fast transfer to the hospital, most part of them will not safe it because they will take much time transferring the patient by an ambulance. So, the good management and the service that SEM and GRAE provide to all the inhabitants of Catalonia have to be acknowledged, reducing the time transporting them by helicopters in case of needed. Furthermore, it must be prepared for the future by having a good network as it is now but adding some heliports to guarantee a perfect and prompt action during all day and all night.

ACKNOLEDGEMENT

In this section I would like to acknowledge Jordi Prats, my TFG director, for the follow-up and for guaranteeing me the required help during the whole work. As well, my co-director of the TFG, Jovana Kuljanin, for reviewing it and giving me her point of view to improve it.

In addition, I would like to acknowledge Merche Val who is the head of the SEM Air Media Unit for giving me all the information that I need and solve all my doubts. Finally, I would also like to acknowledge Xavi Toledo who is the officer in charge of the firefighters' air media group for giving me all the information, solve my doubts and also allow Jordi Prats and me to visit the hangar of the firefighters in Aeroport de Sabadell. Both, give me part of the information that I need, solve my doubts and I contrast with them the information that I have searched before.

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ANNEXES

ANNEX 1. OTHER EXISTING SERVICES

1.1 Maritime Rescue and Safety Society (SASEMAR)

The Maritime Rescue and Safety Society is a public business entity in charge of maritime safety in Spanish waters. It is directly dependent on the Ministry of Transport, Mobility and Urban Agenda through the General Directorate of the Merchant Marine. [30]

1.1.1 Fleet and material inside the helicopter

The Maritime Rescue and Safety Society (SASEMAR) has 11 helicopters: 9 AugustaWestland AW139 and 2 Eurocopter EC225 Super Puma. However, in Reus where is the base of SASEMAR in Catalonia there is one AW139 which operate in the region of Catalonia.

SASEMAR helicopters are not medicalized units. In case of an emergency that requires medical assistance, the SASEMAR is always taking the action in coordination with the corresponding health services according to the region where is the intervention. In the case of Catalonia, it will be the SEM.

1.1.2 Type of vehicles

The AugustaWestland AW139 is a medium-sized twin engine helicopter which was manufactured in Italy. Each engine has a power of 1531 horsepower. The helicopter has a capacity for a pilot, a co-pilot and 15 people inside it. It has a rotor diameter of 13.8 metres and a helicopter longitude and high of 13.77 metres and 3.72 metres respectively.
A five-blade articulated rotor with a four-blade canted tail rotor provides high tail rotor ground clearance. The heavy-duty nosewheel tricycle landing gear is retractable for increased speed. [32]

On the other hand, the Eurocopter EC225 Super Puma, which is now the Airbus Helicopter H225, is a long supply passenger transport helicopter which is developed by Eurocopter. It is a twin-engine helicopter that can carry up to 24 passengers including a pilot, a co-pilot and a cabin crew. The helicopter is commercialized for the support of structures located near the sea, passenger transport and public services. [33]

1.1.3 Geographical ambit and their bases

The Maritime Rescue and Safety Society operate in all the country of Spain, but they basically operate in the maritime zones. They control more than 127 million square kilometres of maritime area monitored per year. However, the responsibility area in savage is about 1 million and a half square kilometres, which is three times the Spanish national territory as it can be seen in **Fig A.1.1**. This total area is subdivided in 4 zones: the Atlantic zone, the Strait of Gibraltar zone, the Mediterranean zone and the Canary Islands zone. However, Maritime Rescue maintains close cooperation and coordination relations with the rescue services of the neighbouring countries.

Fig A.1.1. Responsibility area in savage [35]

They have 11 helicopters bases situated around all the maritime regions for maritime search and rescue tasks. These bases are located in Jerez, Gijón, Las Palmas de Gran Canaria, Tenerife, Valencia, Reus, Almería, Santander, Palma de Mallorca, Santiago and A Coruña, as it can be seen in the black circles **Fig. A.1.2**.
The helicopters are activated to provide a rapid response to emergencies that require immediate action due to serious conditions, survival or medical evacuations, in which lives are in danger. [31]

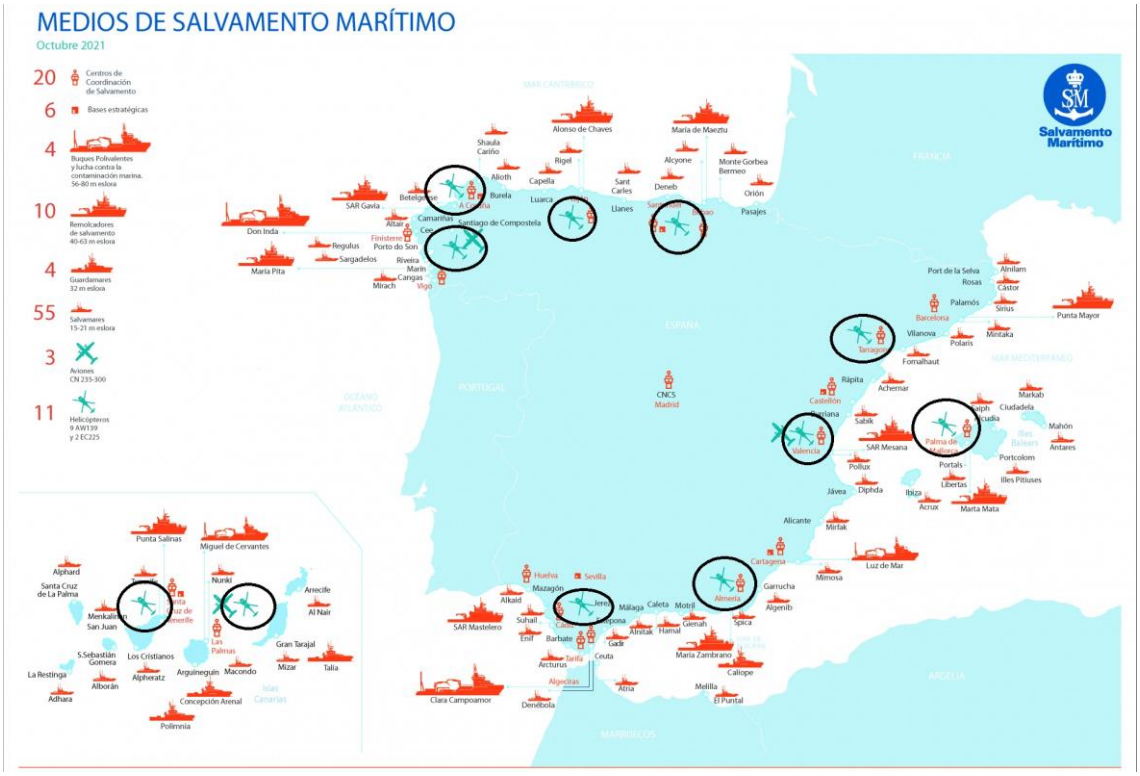

Fig. A.1.2 Maritime Rescue and Safety Society helicopters' bases [23]

1.1.4 Operations

Their operations are diverse from the rescue of human life at sea, prevention and flight against pollution of the marine environment, provision of maritime traffic monitoring and assistance, maritime safety and navigation services, towing and auxiliary vessels or those complementary to the above. [35]

The purpose of all the services that SASEMAR does is the protection of human life at sea, and also the protection of marine animals and plant life. So, definitely the objective of SASEMAR is to protect life at sea.

The most frequent types of emergencies that they face with are drifting vessels, recreational accidents, stranding, irregular immigration, people falling into the water from land or accidents during underwater activities. [36]

1.2 Rega

Rega is a private non-profit air rescue service that provides emergency medical assistance in Switzerland and Liechtenstein. Rega does not receive financial assistance from any government. The majority of their costs are paid through the annual fees of their members who represents the 38% of the population there, and they do not have to pay the costs in case of search, rescue or repatriation.
Rega is an air rescue service that mainly assists in mountain rescues but also operate in other terrains in life-threatening emergencies. It also provides a repatriation for those members who experience a medical emergency while they are abroad and local treatment is not available.

1.2.1 Fleet and material inside the helicopter

Rega has 18 rescue helicopters which are distributed in 12 bases in all the region of Switzerland which means that even the most remote areas can be reached within minutes.

All Rega helicopters carry a crew of three people, formed by a pilot, an emergency physician and a paramedic.
The pilot is responsible for the aircraft and ensures that the mission is carried out safely and precisely. At the accident site he/she assists the two colleagues in taking care of the patient and communicates with the operations centre.
The paramedic is trained to assist the pilot for radio communication, navigation, radio, terrain/object avoidance and operating the rescue hoist, if the helicopter is not able to land. In the ground, he/she also helps the flight physician to administer first aid.
Finally, the emergency flight physician has the medical responsibility for the patient. He/She checks and stabilises their vital functions and determined which is the best hospital for the patient depending on their situation. It is also assisted by the paramedic.

Rega is formed by hundreds of employees that work each day for rescue people and save lives. In November 2021, there were more than 300 full and part-time employees. [16]

In case of operations such as evacuating someone of a cableway or retrieving injured climbers from a rock face, the crew is also formed by a specialist trained by the Swiss Alpine Club.

The helicopter fleet is formed by 7 Airbus Helicopters H145 stationed in the bases of Zurich, Basel, Berne, Lausanne and St. Gallen, 11 AugustaWestland Da Vinci which are located in the mountain bases of Untervaz, Locarno, Erstfeld, Samedan, Wilderswil, Mollis, Zweisimmen and Sion. It also has a helicopter for training purposes which is an Airbus Helicopters H125.

On the other hand, Rega has three ambulance jets Challenger 650 from Bombardier which are in service in all the world.

1.2.2 Type of vehicles

Rega has different types of helicopters depending on the region they are going to operate and the difficulties that may be encountered.

Airbus Helicopter H145 (in **Fig A.1.3**) is a twin engine of 894 horsepower each. It is equipped with an ultramodern glass cockpit with the newest developed avionics and navigation. During the flight, all the data information for the pilot and the paramedic is clearly display on three monitors. It is equipped with a four-axis autopilot that allows to control the flight in the three axis and also the performance. In addition, it can also perform satellite-based approach in extreme situations.
The helicopter has a length of 13.64 meters, a height of 3.95 meters and a rotor diameter of 11 meters. It also has an enclosed tail rotor to reduce noise emissions. It has a flying speed of 230 kilometres per hour and it can arrive at an operational altitude of 5,000 metres above the sea level.
Rega has 7 Airbus Helicopter H145 stationed at the lowland bases of Switzerland.

Fig. A.1.3 Rega's Airbus Helicopter H145 [19]

The operational range of these helicopters goes from traffic accidents to acute diseases, and they also perform interhospital transport of patients from one hospital to another. For this reason, the cabin of the H145 offers a high level of flexibility. It is designed for the transport of special intensive care patients, and it contains machines such as a heart-lung machine and a mobile incubator for premature babies.

In the next figure, **Fig. A.1.4**, there is an interior view of the helicopter where it is possible to see the distribution of each element and the crew.

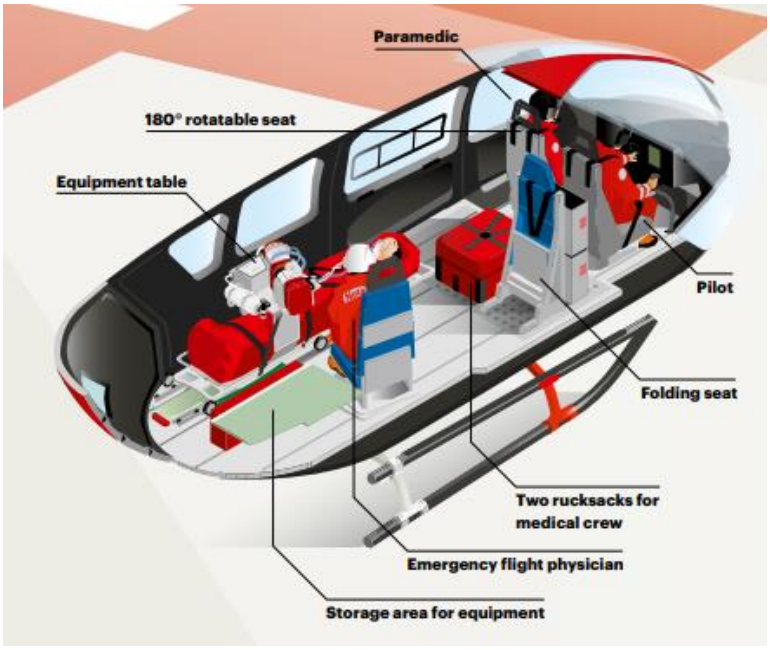

Fig. A.1.4 Interior view of the Airbus Helicopter H145 [19]

AugustaWestland Da Vinci (in **Fig. A.1.5**) is a helicopter manufactured by the Italian AugustaWestland according to the specifications of Rega. This rescue helicopter is being used in all the mountain bases of Switzerland. They have 11 helicopters distributed in all these mountain bases. It optimally fulfils the high demands placed on it in terms of flight characteristics, emergency medical equipment and maintenance.

Fig. A.1.5 AugustaWestland Da Vinci in an extreme rescue [20]

It is a twin-engine, with a 778 horsepower each and a maximum flying speed of 235 kilometres per hour. The helicopter has a length of 12.96 meters, a height of 3.40 meters and a rotor diameter of 10.83 meters. It can arrive at an operational altitude of 5,000 above sea level, the same as the Airbus Helicopter H145.

Airbus Helicopter H125 (in **Fig. A.1.6**) is a helicopter for training purposes. The up-and-coming Rega pilots are trained in performing mountain and load flights.

It is a single engine, with 860 horsepower and a maximum flying speed of 220 kilometres per hour. The helicopter has a length of 12.94 meters, a height of 3.34 meters and a rotor diameter of 10.69 meters.

The cockpit of the Airbus Helicopter H125 (**Fig. A.1.7**) is similar to the one that has the Da Vinci Mountain Helicopter (**Fig. A.1.8**), so they train with the Airbus Helicopter H125 to fly the mountain helicopter in the future. Rega only has one Airbus Helicopter H125.

Fig. A.1.6 Airbus Helicopter H125 [21]

Fig. A.1.7 Cockpit of the Airbus Helicopter H125 [20]

Fig. A.1.8 Cockpit of the Da Vinci Mountain Helicopter [21]

1.2.3 Geographical ambit and their bases

Rega's helicopters operate in the region of Switzerland and Liechtenstein, which corresponds to 4 million hectares of territory, and they can succour up to 8 and a half million people. Their principal objective is helping skiers, hikers in difficult terrain and mountain areas.

The 18 helicopters that belongs to Rega are distributed around the whole territory in 13 helicopter bases, a partner base and a training base, as it can be seen in **Fig. A.1.9**.

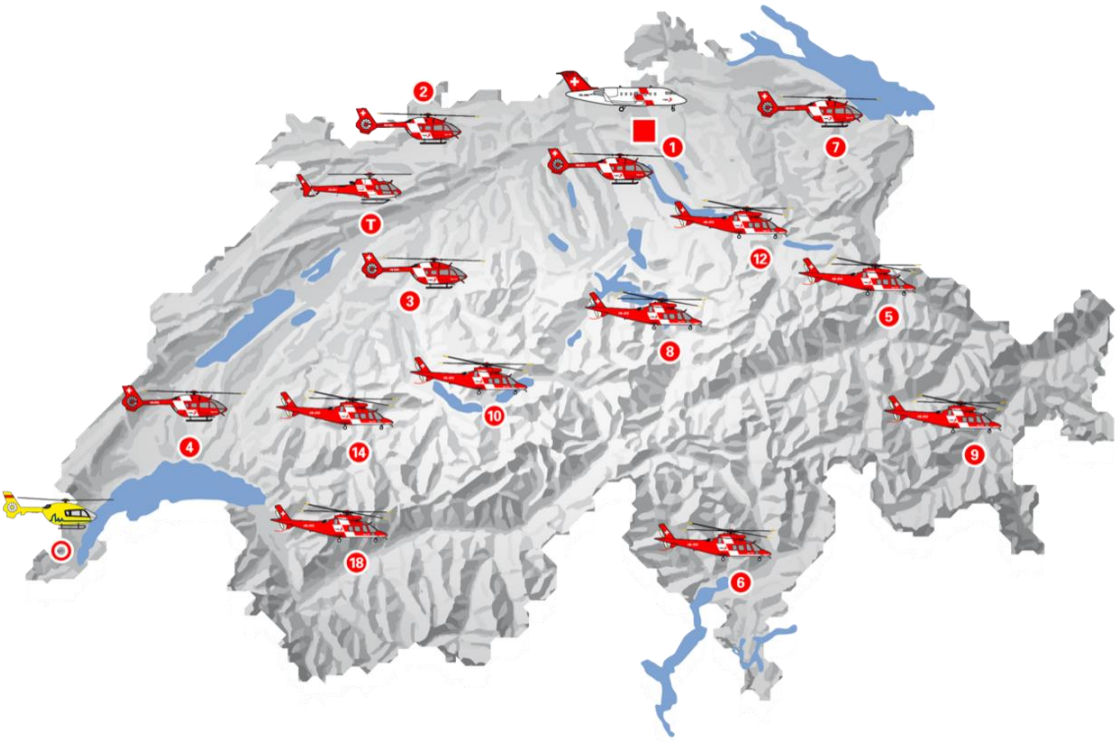

Fig. A.1.9 Rega helicopters' bases [23]

There is the Rega Centre which is represented in the figure before as a red square. This is the Rega's headquarters where all the missions are coordinated from there, and it is located at the north-east of Zurich-Kloten Airport. It has directly access to the runways of the airport. It also has a maintenance centre for the helicopters.
In addition, there are the Zurich Base which is the oldest Rega base (base 1 in the figure), Basel base which is characteristic for being located on French soil but a swiss flag flies on the helicopter base (base 2), Berne base which is located in Belpmoos (base 3), Lausanne base in French-speaking Switzerland (base 4), Untervaz base in the north of Graubünden (base 5), Locarno base in Italian-speaking Switzerland (base 6), St. Gallen base which is situated in Eastern Switzerland (base 7), Erstfeld base which is located in the region where Switzerland was founded (base 8), Samedan base which is located in Engadin (base 9), Wilderswil base in the Bernese Oberland (base 10), Mollis base situated in Glarus (base 12), Zweisimmen base in the west of the Bernese Oberland (base 14), Partner base in Geneva (base 15), Sion base (base 18) and finally there is a Training base in Grenchen where Rega pilots have been taking off on training flights. [23]

1.2.4 Operations

Rega is ready to operate 24 hours a day, 365 days a year in case of having an injury or illness in Switzerland and Liechtenstein with their helicopters and abroad with their jets.

The most frequent operations that Rega rescue helicopters make are operations for patient with illness, to deal with winter sports, road, occupational and alpine accidents. Almost one quarter of all Rega helicopter missions take place at night which is a challenging task for their crews.

Rega is also for their members when they are abroad and depending on the severity of the medical emergency, the medical consultants will assist the patient by phone helping him/her or they will come the patient back home with their jets or in a conventional flight with a Rega's medical staff.

ANNEX 2. OTHER HELICOPTERS

In this section, it will be explained other helicopters that are used by SASEMAR and Rega, but this thesis is not focusing on. In addition, it will be explained other configurations of the helicopters H135 and BELL429 that are used by the Catalan services (SEM and GRAE) and have been explained before in terms of HEMS.

2.1 Airbus H125

The Airbus H125, which was also called Eurocopter AS350 B3e, as it can be seen in **Fig. A.2.1**. It is the best single-engine helicopter in terms of performance, versatility and low maintenance and acquisition costs. [34]

This helicopter has broken world record during its career as for example in 2005, the Eurocopter AS350 B3 broke the world record for the highest altitude landing and take-off, performed on Mount Everest at 8,848 metres. A title which still held today and in 2013 the same helicopter model, AS350 B3, performed the world's highest long-line rescue operation on Lhotse, the world's fourth-highest mountain, located in the Himalayas, at 7,800 metres. [34]

Fig. A.2.1. Airbus H125 which also was named as AS350 B3 [34]

The H125 has a wide, unobstructed cabin, fast cruise speed and long range, and has a capacity for six passengers. The helicopter offers easy cabin access

through two wide sliding doors, forward-facing seats and three baggage compartments.

2.1.1 Specifications

The H125 is equipped with a Safran Helicopter Engines Arriel 2D turboshaft engine with a dual-channel full authority digital engine control (FADEC) unit plus a third independent and automatic back-up channel and an automatic start-up. In addition, the engine is fitted with an engine data recorder.

The helicopter has a built-in manoeuvrability, excellent visibility and low vibration levels in the cabin. This helicopter has earned its reputation as a true multi-mission aircraft, becoming a common sight at heliports, hospital landing pads, police department operations centres and airports around the world. [34]

The cabin of the H125 has a flat floor that can be reconfigured for different missions as aerial work, firefighting, law enforcement, rescue and passenger transport.

The H125 offers pilots enhanced safety and reduced workload thanks to the glass touchscreen cockpit instrument panel with Garmin G500H TXi and Vehicle & Engine Multifunction Display (VEMD) which allows pilots to check the main vehicle and engine parameters with just a glance. [34]

2.1.2 Missions

The helicopter H125 can be configured to operate in different missions with a wide range of optional equipment to get the job done, whatever the environment and mission requirement.
The type of missions includes air crane operations, firefighting, power line inspection, crop spraying, parachuting, news gathering, geological and wildlife survey or farming and fishing activities.

The H125 is up to the most rigorous high and hot missions and can transport its own empty weight with an impressive sling capacity of 1,400kg. Its best performance in high and hot environments has been certified to improve hover ceiling out of ground effect at a maximum take-off weight up to 12,600 ft.

It is fast, agile and simple to use, and it is operated by police forces in some 30 countries around the world and is the reference for airborne law enforcement in the United States. [37]

The H125 is well adapted for multi-role law enforcement missions including surveillance, command and control, search and pursuit, rescue, special operations, escort and border patrol in high and hot conditions.

2.1.3 Equipment

The H125 can be equipped with a “lean” instrument panel and maximum pilot view kit or additional dual roof windows that increase visibility. A first limit indicator (FLI) remote display supplemental type certificate (STC) developed by AKV provides flight limitations at a glance on tablets via Bluetooth to simplify pilot workload during external load operations.

A variety of equipment has been developed for police missions, such as law enforcement instrument panels, search lights, electro-optical system (EOS), operator consoles, night vision goggle (NVG)-compatible light sourcing and instruments, wire strike protection, loudspeakers, downlink, rappelling, etc.

2.1.4 Configurations

There are different kinds of configurations depending on the mission and the equipment that is required.

2.1.4.1 Four passenger’s configuration:

A pilot and/or a co-pilot and four passenger configuration is the best option for VIP or private and business aviation. It has forward-facing seats and a spacious cabin where passengers can make the most of their time in the air as it can be seen in **Fig. A.2.2**.

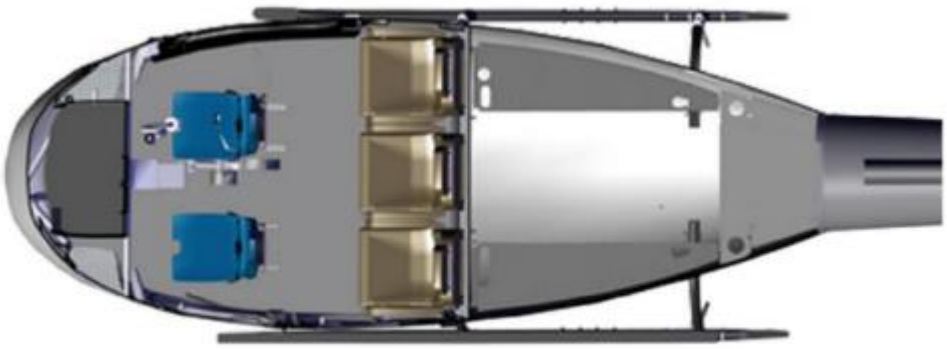

Fig. A.2.2. Four passenger’s configuration in H125 [38]

2.1.4.2 Five passenger’s configuration:

The H125’s standard seating configuration of one pilot with/or not a co-pilot and five passengers complement commercial transport operations. The passengers

will benefit from ample legroom and a comfortable ride. In **Fig. A.2.3,** there is the five passenger's configuration.

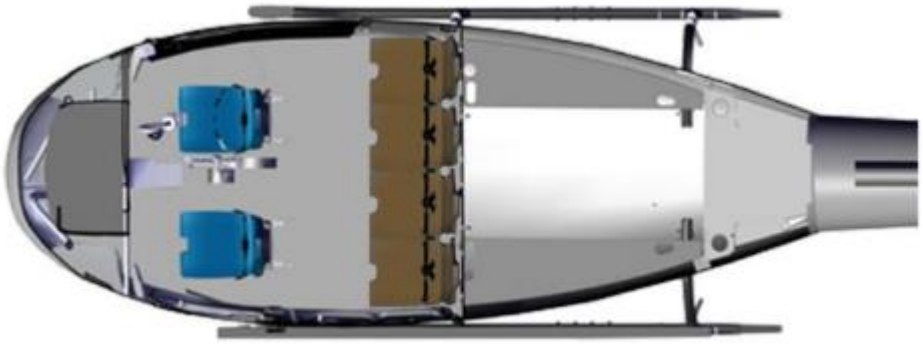

Fig. A.2.3. Five passenger's configuration in H125 [38]

2.1.4.3 Six passenger's configuration:

The six-passenger configuration is used by tourism and sightseeing operators. The H125's compact cabin means every passenger has the opportunity for breath-taking views. In **Fig. A.2.4**, it can be seen the six-passenger configuration.

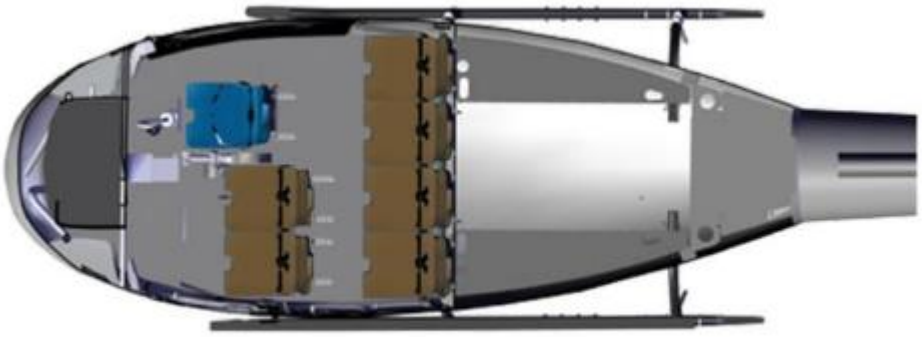

Fig. A.2.4. Six passenger's configuration in H125 [38]

2.2 Airbus H135

The Airbus H135 is a helicopter which is used by SEM and GRAE that has been explained before. However, there are other configurations of this helicopter that will be seen here below.

2.2.1 Other configurations of the H135

The other configurations that can have the H135:

2.2.1.1 Five seats for passenger transport configuration

In this configuration there are two pilots and five passengers which is well suited for passenger transport operations, as it can be seen in **Fig. A.2.5**. A combination of rear-facing and forward-facing seating create an environment conducive to conversation or work. Another configuration of high-density seating is also available and can accommodate up to 6/7 passengers.

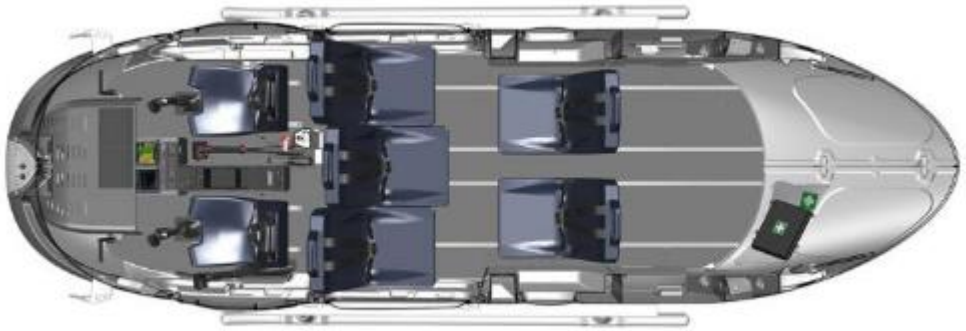

Fig. A.2.5 Five seats configuration of the Airbus H135 [41]

2.2.1.2 Police surveillance configuration

There are different possible kind of configurations for public service and surveillance operations. A typical layout of two pilots and an onboard operator at the console of an electro-optical system, as it can be seen in **Fig. A.2.6**, leaves cabin space free for cargo or additional equipment.

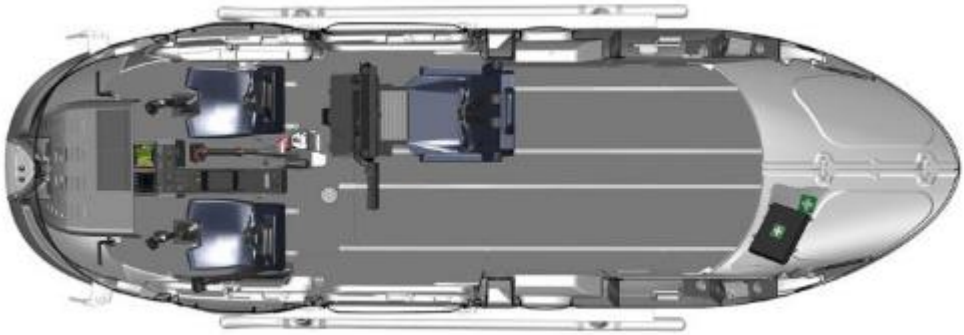

Fig. A.2.6 Police surveillance configuration of the Airbus H135 [41]

2.2.1.3 Training configuration

Finally, theere is the two-pilot and three-passenger layout of a sample training configuration lends itself to easy in-flight instruction, as it can be seen in **Fig. A.2.7**. Three forward-facing seats just behind the pilots give students or observers an up-close view of the cockpit environment.

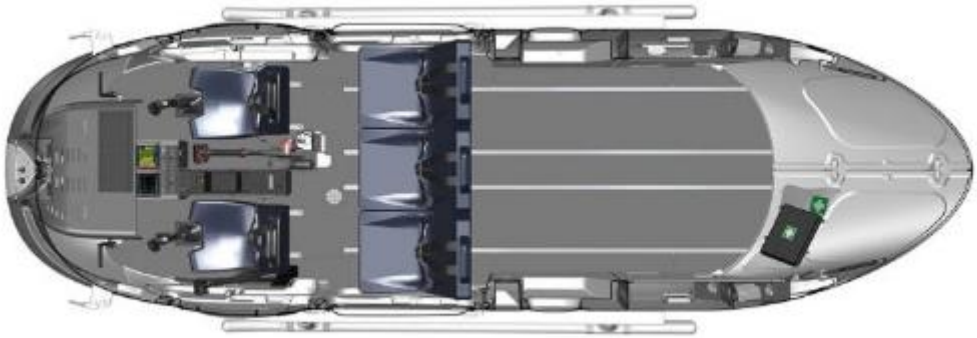

Fig. A.2.7 Training configuration of the Airbus H135 [41]

2.3 Airbus H145

The Airbus H145 is designed to deliver excellent performance throughout the flight envelope, and it is the latest member of the company's four-tonne-class twin-engine rotorcraft. It is designed with a mission capability and flexibility to operate especially in high and hot operating conditions.

The H145's compact footprint, unobstructed cabin, and flat floor from nose to tail lend themselves to a full range of applications, being able to accommodate:

one or two pilots and up to 8 passengers (standard configuration) or up to 10 passengers (higher-density configuration).

2.3.1 Specifications

The H145 is the only rotorcraft of its range to take off and land at 20,000 ft. A distinction which was confirmed in September 2019 with a flight over Aconcagua in the Andes Mountain range (22,840 ft), where the H145 demonstrated its incomparable power reserve at high altitude.

Twin-engine reliability is complemented by a fully separated fuel supply system, a duplex hydraulic system, dual electrical system and redundant lubrication for the main transmission. In addition, a key safety aspect of the H145 is its inherent crashworthiness with the energy-absorbing fuselage and seats, as well as crash-resistant fuel cells. [42]

The H145 incorporates the latest technologies, such as the advanced cockpit design with the most modern human machine interface (HMI), state-of-the-art Helionix avionics suite and a Fenestron antitorque-device as the tail rotor.

The simplified rotor system and airframe components, together with an enhanced main gear box, enable low maintenance costs and high in-service-time. The engines also significantly contribute to the reduced maintenance costs through high TBO (Time Between Overhauls) and an evolved maintenance concept with usage monitoring, which increases engine availability. [42]

2.3.2 Missions

The combination of speed and performance of the H145 with its large cabin and rear-loading clamshell doors make this helicopter a choice for a variety of civil missions worldwide.

The H145 is capable of being equipped with a mission management system for law enforcement operations. It includes different roles as patrol, surveillance, and rescue missions, supported by the roomy, flexible cabin, and installation of forward-looking infrared (FLIR) and daylight cameras. These cameras are controlled by an operator who also handles communications and data exchange with ground-based police resources. [43]

It is also capable for emergency medical services due to its spacious and unobstructed cabin is perfect for transport patients in primary, secondary or intensive care transport. It is also meeting all the requirements set by national medical regulatory agencies.

On the other hand, it operates in the transport of onshore and offshore oil and gas passenger transportation and cargo missions. The helicopter H145 can operate in Performance Class 1 conditions, while its compact airframe enables manoeuvring in complex environments, such as oil and gas helidecks.

Another type of mission that H145 does is the offshore wind energy for wind park operations and maintenance. Its cabin can accommodate two teams of three technicians including their equipment, while the rotorcraft's outstanding hover and with one engine inoperative performance enables safe and efficient hoisting operations.

It is also used for private and business aviation. It is the most flexible cabin and can be configured with more than eight different layouts.

Finally, the H145 it is a choice for civil missions due to its large cabin and flat floor, designed-in modularity, and a large choice of optional mission equipment. It can be reconfigured quickly and easily for various roles in multi-mission operators. [43]

2.3.3 Equipment

The H145 is equipped with a wide range of rapidly and easily interchangeable optional equipment, such as emergency floats, rescue hoist, searchlight, and cargo hook. Together with its inherently versatile cabin layout, this multi-purpose rotorcraft is tailored for emergency medical services and law enforcement duties, along with aerial work and passenger transport, including private and business aviation as well as offshore operations.

The latest version of the Airbus H145 launched in 2020, is equipped with a five-bladed main rotor. It also has 150 kg useful load, leading to the best useful load to maximum take-off weight ratio for a light twin helicopter.

Additionally, the H145 is equipped with an advanced dual-duplex, 4-axis autopilot specially designed for helicopters which offers a high flight stability and precision, unique flight envelope, over-limit protection, automated take-off and fully coupled approaches to hover.

On the other hand, the offshore wind energy equipment list includes an external hoist on both sides, weather radar in colour, an emergency floatation system, life rafts, helicopter emergency egress lighting (HEEL), and an automatic deployable emergency locator transmitter. [43]

2.3.4 Configurations

There are different kinds of configurations depending on the mission and the equipment that is required.

2.3.4.1 Eight seats for passenger transport configuration

The configuration with one or two pilots and eight passengers, as it can be seen in **Fig. A.2.8**, is perfect for transport or for offshore airlift operations. The H145 has a large cabin where it can be an additional 1.31 m^3 of cargo.

Fig. A.2.8. Eight seats for passenger transport configuration of the Airbus H145 [44]

2.3.4.2 10 passenger's configuration

The H145's high-density can accommodates one or two pilots and ten passengers as it can be seen in **Fig. A.2.9**. This is ideal for travelled routes because the spacious cabin gives an impression of comfort even when is fully occupied.

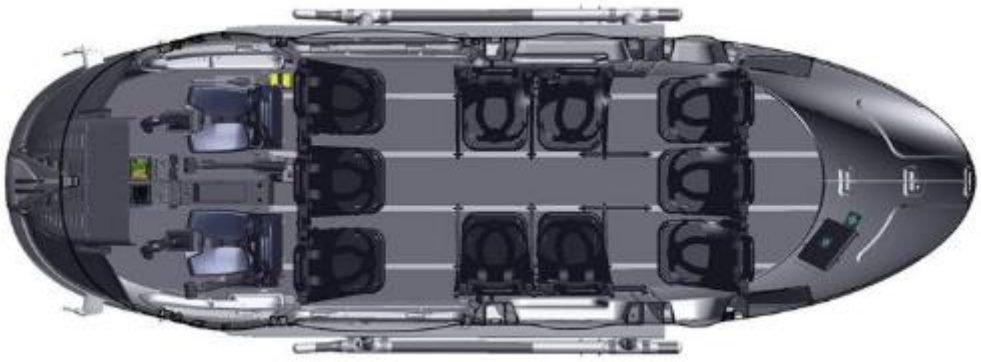

Fig. A.2.9. 10 passenger's configuration of the Airbus H145 [44]

2.3.4.2 Law enforcement configuration

Airbus' H145 offers multiple seating arrangements for law enforcement operations. It includes a two-pilot configuration and space for four passengers or five police officers or nine SWAT members or 10 troops. In **Fig. A.2.10**, it can be seen an example of configuration.

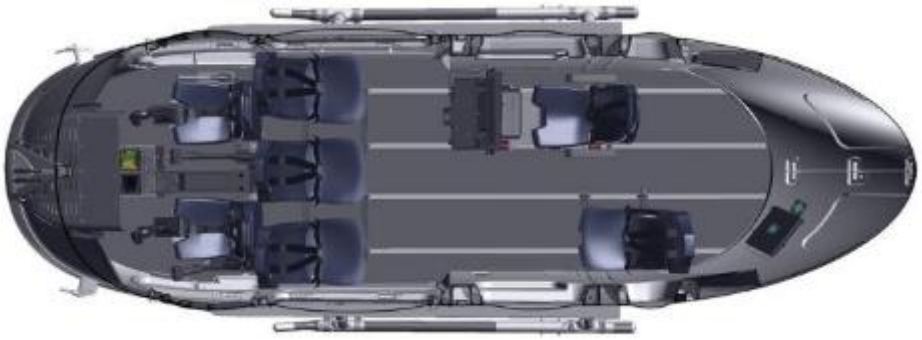

Fig. A.2.10. Law enforcement configuration of Airbus H145 [44]

2.3.4.3 Emergency medical services configuration

In the case of emergency medical services, it include one or two pilots, up to two stretchers and three HEMS crew members, as it can be seen in **Fig. A.2.11**. Efficient loading of stretchers through side sliding doors or rear clamshell doors facilitate patient comfort and safety.

Fig. A.2.11. Emergency medical services configuration of Airbus H145 [44]

2.4 BELL 429

BELL 429 is a helicopter used by GRAE for rescuing people who are in a difficult situation and have a difficult access. This helicopter as it has been said before, is based on the airport of Andorra-La Seu d'Urgell. However, now there will be explained other configurations of that helicopter when the mission is other different as HEMS.

2.4.1 Other configurations of the BELL 429

The BELL 429 is usually used in the executive or private transport due its spacious cabin and has plenty of storage. It gives you the calm and uncomplicated journey you need for the executive activities like meetings with a more refined style as it can be seen in **Fig. A.2.12**. The configuration for these types of missions will be 2 crew and 6 people in the cabin which is the maximum capacity in the cabin.

Fig. A.2.12 BELL 429 configured for executive and private missions [51]

The BELL429 is also prepared for public safety missions because it arrives on the scene quickly and is ready to act as it can be seen in **Fig. A.2.13**. The ample cabin space, large doors and adjustable components accommodate your equipment and keep the crew comfortable. The configuration in these types of missions will be the pilot and 7 more people, one of them near the pilot because the cabin can only have capacity for 6 people.

Fig. A.2.13 BELL 429 for public safety missions [51]

Finally, it can be also used for offshore missions where it is reliable and stable (**Fig. A.2.14**). It can carry out the mission with confidence due to the built-in flotation system and the twin engine platform. In these types of configurations there will be the pilot and 7 more people, one of them near the pilot because the cabin can only have capacity for 6 people.

Fig. A.2.14 BELL 429 for offshore missions [51]

2.5 AW 139

The AW139 is a multi-mission twin-engine helicopter that has more than 1000 units in service worldwide. It has a fantastic performance, advanced safety design features and state-of-the art avionics. It can carry up to 15 passengers in its spacious cabin. It is part of the AWFamily of advanced rotorcraft which all the helicopters have similar design, philosophy, safety features and high-performance flight characteristics.

2.5.1 Specifications

A five-bladed fully articulated main rotor with four-bladed canted tail rotor gives high tail rotor ground clearance, heavy-duty nose-wheel tricycle landing gear is retractable for higher speed. Full crashworthy systems and seats are standard while an icing protection system is optional. Low noise signature, high-speed refuelling is possible from either side. [48]

It is powered by two Pratt & Whitney PT6C-67C turboshaft engines with full authority digital engine control (FADEC). The engines have a maximum continuous power of 1,531 horsepower each. Due to the power reserve of the engines, a safe flight is ensured with one engine inoperative (OEI) at maximum take-off weight.

The AW139 exceeds the most rigorous regulatory standards, and it has the newest technology in avionics and mission systems, minimising pilot workload and optimising operational efficiency with safety built into the design.

The AW139's integrated avionics system enables operators to gain the maximum benefit from the sensors and comprehensive communications suite required for the law enforcement role, while the best-in-class power reserve provides excellent Category A Performance Class 1 to operate safely in a wide range of conditions. [45]

2.5.2 Missions

The AW139 is usually used in the executive and private transport due to it offers a unique blend of safety, comfort, cabin flexibility and speed. The AW139 provides exceptional levels of comfort due to the incredibly low levels of noise and vibration. The passengers benefit from the largest cabin in its class and the wide hinged doors which allows an easy access for the passengers. Finally, the baggage compartment provides plenty of space for luggage.

It is also used for Emergency Medical Services and Search and Rescue missions. In this type of missions, the helicopter combines advanced technology, safety design features and superior performance. The AW139 has

Category A with Performance Class 1 certification which allows it to operate safety.

On the other hand, it does missions of security services. The helicopter has a rapid response, effective search and surveillance capabilities which are vital for operators across law enforcement, maritime/border patrol and security missions. Operators need a helicopter that can adapt to multiple missions. The AW139 provides the flexibility to perform a wide range of security operations in confined or congested areas and is easily adapted for disaster relief, humanitarian missions and parapublic missions. [45]

Finally, the AW139 is used for offshore mission which is one of the most demanding for any helicopter operator. This helicopter is perfect for the offshore role, to support oil and windfarm operators, combining superior payload, range, speed and single-engine performance.

2.5.3 Equipment and configurations

The cabin of the AW139 is large, brightly and versatile, and can be adapted into a variety of layouts to suit SAR operations. It provides abundant space to work including accommodation for fully integrated of the mission, medical treatment and casualty evacuation interiors. A separate baggage compartment, optionally accessible from the cabin, can be used to save the stretchers or SAR equipment.

On the other hand, for HEMS operations is very important the space that can be in the cabin, so it can accommodate up to five medical attendants and four stretchers with the most advanced life support equipment. There is a complete access to put the patient inside the helicopter due to the large sliding doors on each side that allows an easy entry.

ANNEX 3. CLASSIFICATION OF HELIPORTS

Helicopters are often used to transport injured persons from the scene of an accident to a hospital and to transfer patients from one hospital to another. A hospital heliport accommodates helicopters used by Emergency Medical Services. On heliports there is an H indicating the location and the orientation that allows the pilot to know the axis of the preferred approach/departure path, as it can be seen in **Fig. A.3.1**.

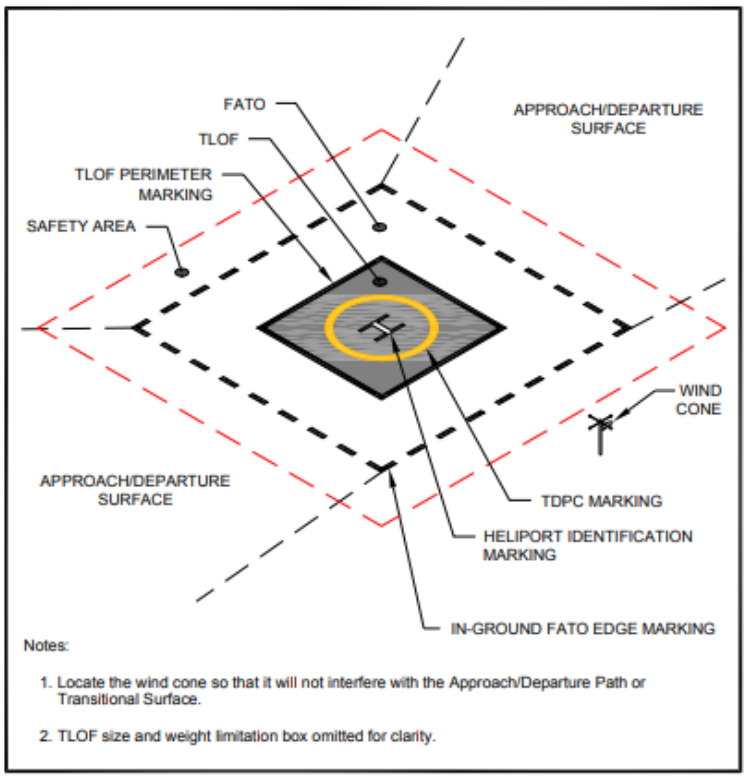

Fig. A.3.1 Essential Features of a Heliport [74]

When designing the heliport, it always must take into account the most critical helicopter that will operate there and the environmental conditions. This helicopter will determine the length of the different elements of the heliport. Heliports must be located in a site with easy access to surface transportation and parking. No high-voltage power lines are allowed near the heliport as they would make landing and take-off impossible. As in the case of airports, in the runway of the heliport must not be any permanent, mobile or provisional obstacle when the helicopter is operating.

On the other hand, large buildings nearby the heliport can be cause of whirlwinds and turbulence which can affect negatively to the aircraft. At the same time, the heat which is generated by the fireplaces nearby the helicopters' trajectory can influence negatively to make the landing operations or during the ascend before the take-off. In terms of the wind effects, the helicopters must

avoid downwind operations and they should reduce to minim side wind operations. Finally, it is important to pay attention to the noise that the helicopters do, especially near hospitals or schools.

3.1 Classification of heliports according to their location

Depending on the type of installation, heliports can be classified in surface heliports, elevated heliports, maritime heliports and heliports on ships, as mentioned before. In our case, the focus will be on the heliports located in all the territory of Catalonia, so it will be surface heliports and elevated heliports.

3.1.1 Surface heliports

Surface heliports are built in the ground, at the surface level and they have to meet specific requirements:

3.1.1.1 Final approach and take-off areas

The surface heliports will have a minimum of FATO (Final Approach and Take-off Area) which has to be clear of obstacle. The dimensions of the FATO will depend on the performance category of the helicopter, but the helicopters that operates making medical services, will be Performance Class 1. So, the dimensions of the FATO will be more than the dimension (D) of the larger helicopter that could operate there. The average slope will be not more than 3% and for Performance Class 1, the heliports will have a slope which shall not exceed the 5%.
The surface of the FATO will be resistant to the effects of rotor downdraft, will be free of irregularities that may adversely affect helicopter take-off or landing and will have sufficient strength to permit interrupted take-off of helicopters operating in Performance Class 1.

The FATO should not be located near taxiway intersections or waiting points where the jet engine jet is likely to cause severe turbulence, or near areas where aircraft wake vortex is likely to be generated.

The obstacle clearance in the final approach and take-off phase is determined by a height of 200 ft (61 m) at a distance of 5000 ft (1524 m) from the FATO, as it can be seen in **Fig A.3.2**.

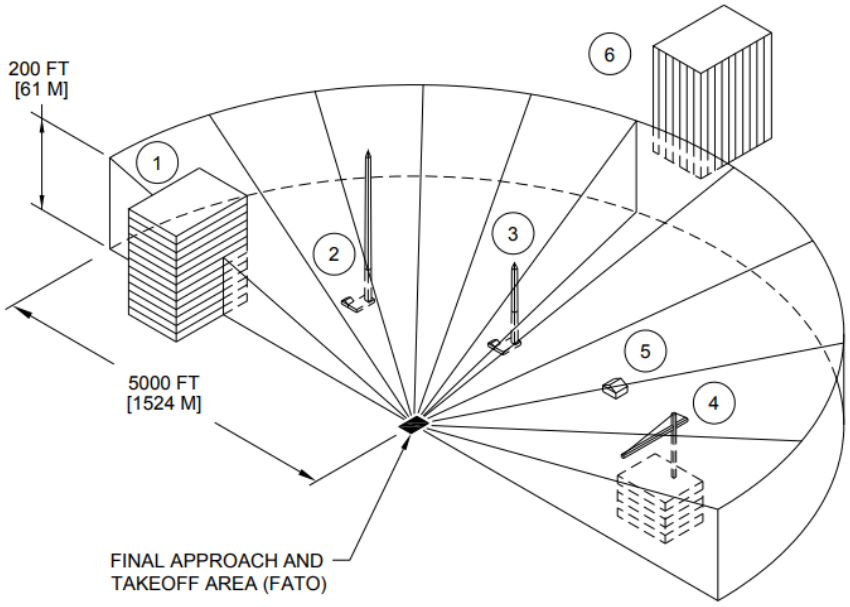

Fig. A.3.2 Final Approach and Take-off Area [74]

3.1.1.2 Helicopter obstacle clearance zone

The helicopter obstacle clearance zone will be situated beyond the end of the FATO. This area will not be less than the operational safety area and as it can be seen in **Fig. A.3.3**, the operational safety area will have a longitude for each side of minimum 3 metres or 0.25 x D, where D is the dimension of the bigger helicopter that can operate there. Finally, the FATO plus the operational safety area will be a minimum of 2D.

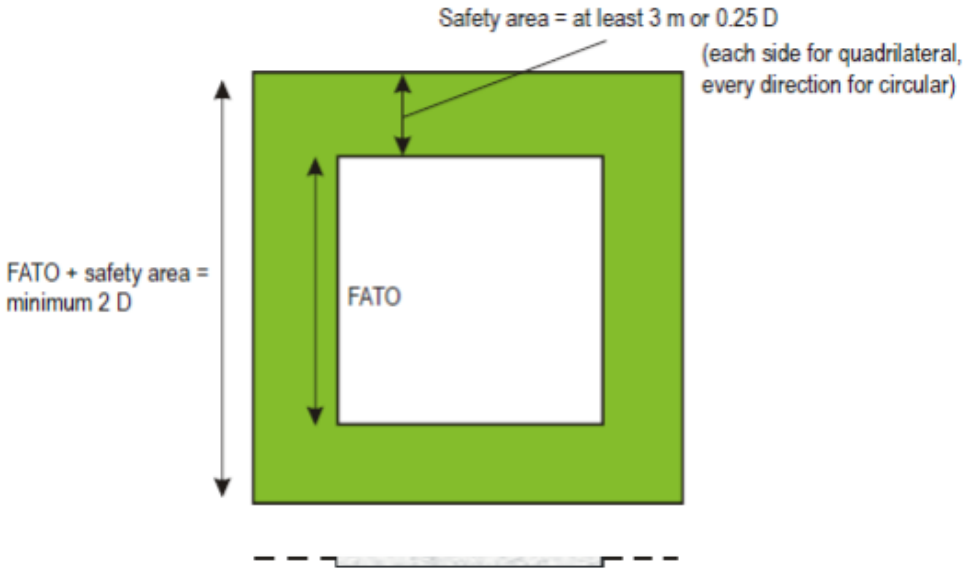

Fig. A.3.3 FATO and operational safety area [60]

The terrain in a helicopter obstacle clearance zone should not exceed a 3% upward slope plane, the lower limit of which is a horizontal line on the periphery of the FATO. On the other hand, any object in the obstacle clearance zone, which could endanger helicopters in flight, should be considered as an obstacle and removed.

3.1.1.3 Contact and initial elevation areas

In heliports, shall be provided at least a TLOF which will be inside of the FATO. The TLOF shall be of such extent as to comprise a circle whose diameter is at least 0.83 x D of the largest helicopter for which the area is intended. The slopes of the TLOF shall not exceed 2% in any direction.

3.1.1.4 Operational Safety Area

The operational safety area will have a longitude for each side of minimum 3 metres or 0.25 x D, where D is the dimension of the bigger helicopter that can operate there. Each external side will be at least of 2 x D on case that the FATO is a quadrilateral or circular.

There shall be a protected side slope rising at 45° from the edge of the safety area to a distance of 10 metres, the surface of which shall not be penetrated by obstacles. There won't be any object above the operational safety area and in case of having to be there, if the distance to the centre is less than 0.75 x D, they will not extend above a plane at a height of 5 cm above the plane of the FATO and if the distance to the centre is 0.75 x D or more, they will not extend above a plane at a height of 25 centimetres above the plane of the FATO.

3.1.1.5 Ground taxiways for helicopters

The width of the taxiways will be at least 1.5 x maximum landing gear width of the bigger helicopter, as it can be seen in **Fig. A.3.4**. In addition, the slope of the taxiways will not exceed 3% and the taxiway will always be symmetrical of a minimum of 0.75 x maximum landing gear width.

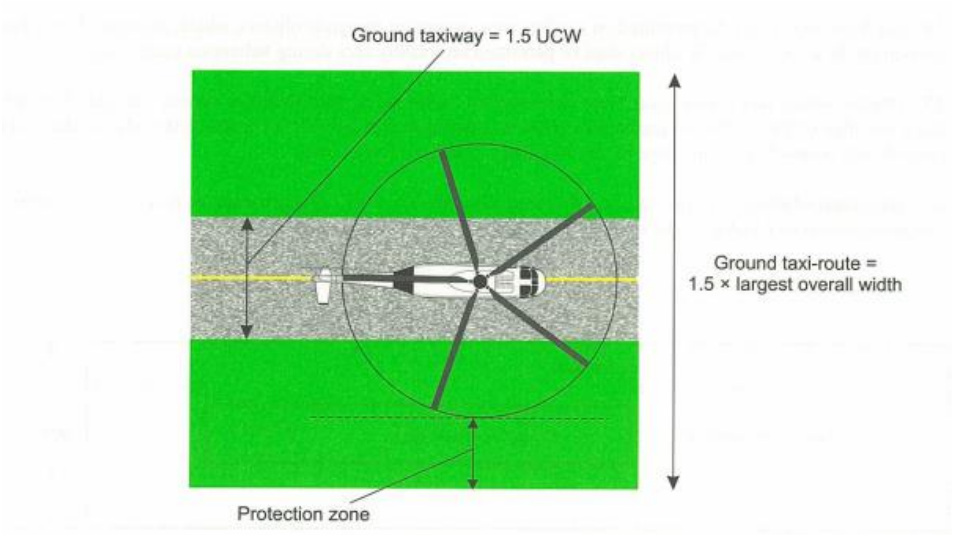

Fig. A.3.4 Ground taxiway for helicopters [60]

The objects which are necessarily to be in the taxiway will not be at a distance lower than 50 centimetres of the edge of the taxiway and they will not extend above a plane at a height of 25 centimetres above the plane containing the taxiway.

3.1.1.6 Aerial taxiways for helicopters

The width of aerial taxiways shall be at least twice the maximum width of the landing gear and the slopes should not exceed 10 % (transverse slope) and 7% (longitudinal slope).

As the ground taxiways, the aerial taxiways will be symmetrically and with a minimum distance equal to the total width of the biggest helicopter for which they are intended. Each symmetrical side of the taxiway will have a distance of 0.5 x maximum total width of the helicopters for which they are intended, as it can be seen in **Fig. A.3.5**.

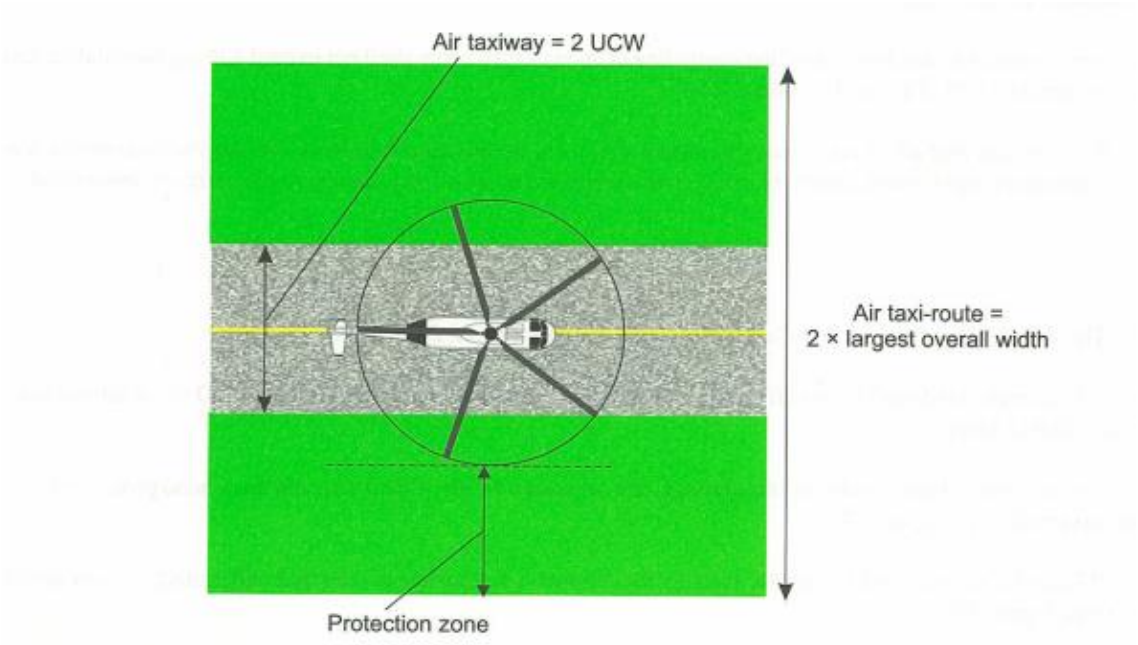

Fig. A.3.5 Ground taxiway for helicopters [60]

No fixed object shall be permitted above the surface of the ground on aerial taxiways, except for frangible objects which, by their function, must be located there. The objects above the ground which have to be necessarily there, have to be located at a distance of less than 1 metre from the edge of the helicopter taxiway and exceed a plane whose origin is at a height of 25 centimetres above the plane of the aerial taxiway for helicopters, at a distance of 1 metre from the edge of the helicopter taxiway, and whose outward and upward slope is 5%.

3.1.1.7 Helicopter parking stands

The dimension of a helicopter parking stand intended for use for stationary turns shall be such that it can contain a circle with a diameter of at least 1.2 x D of the largest helicopter for which it is used, as it can be seen in **Fig. A.3.6**.

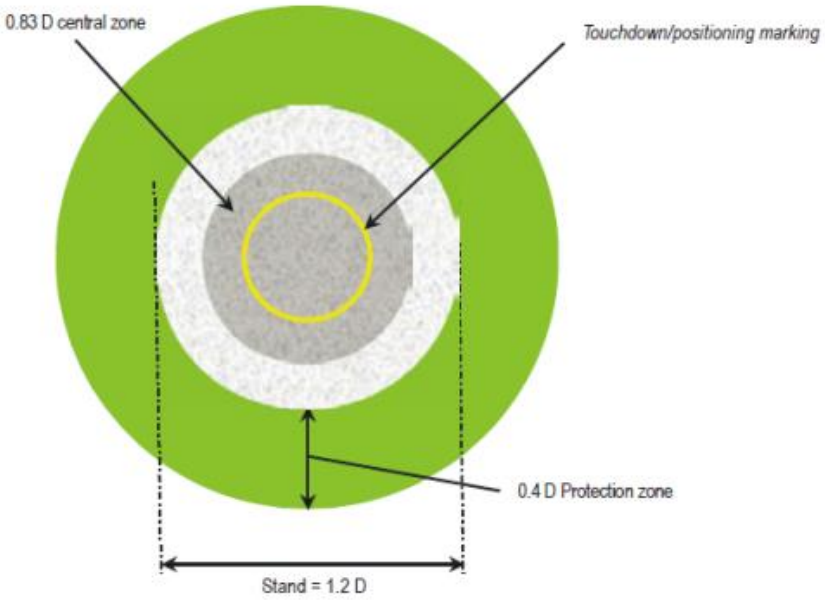

Fig. A.3.6 Helicopter parking position and the protection area [60]

If the helicopter parking stand is intended to be used for taxiing and the helicopter which is using it is not required to turn, the minimum width of the stand and associated protection area shall be equal to that of the taxiway. Whereas if it is intended to be used for turn-around manoeuvres, its minimum dimension with the protected area shall not be less than 2 x D. Finally, if it is intended to be used for turning, the helicopter parking stands shall be surrounded by a protective area extending a distance of 0,4 D or less.

It is not considered a good practice to place helicopter parking stands underneath a flight path.
The helicopter parking stand will provide rapid drainage, but the slope in any direction will not exceed 2%.

For simultaneous operations, the protection areas of helicopter parking stands and their associated taxiways shall not overlap as it can be seen in **Fig. A.3.7**.

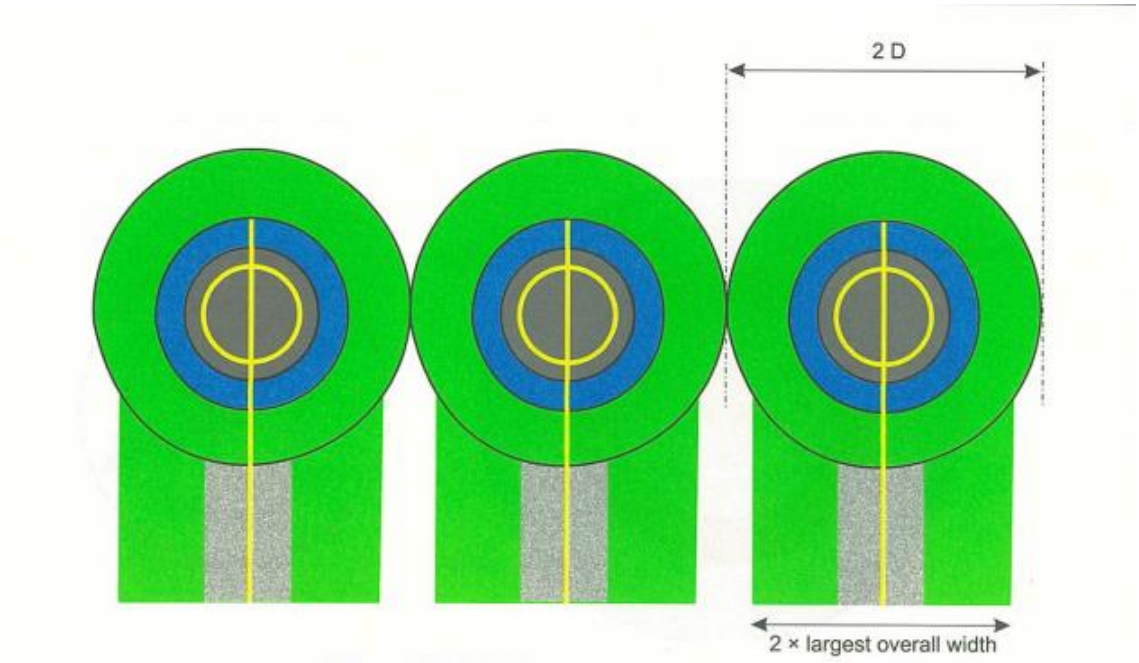

Fig. A.3.7 Simultaneous operations [60]

On the other hand, for non-simultaneous operations, the protection areas of helicopter parking and their associated taxiways may overlap as it can be seen in **Fig. A.3.8**.

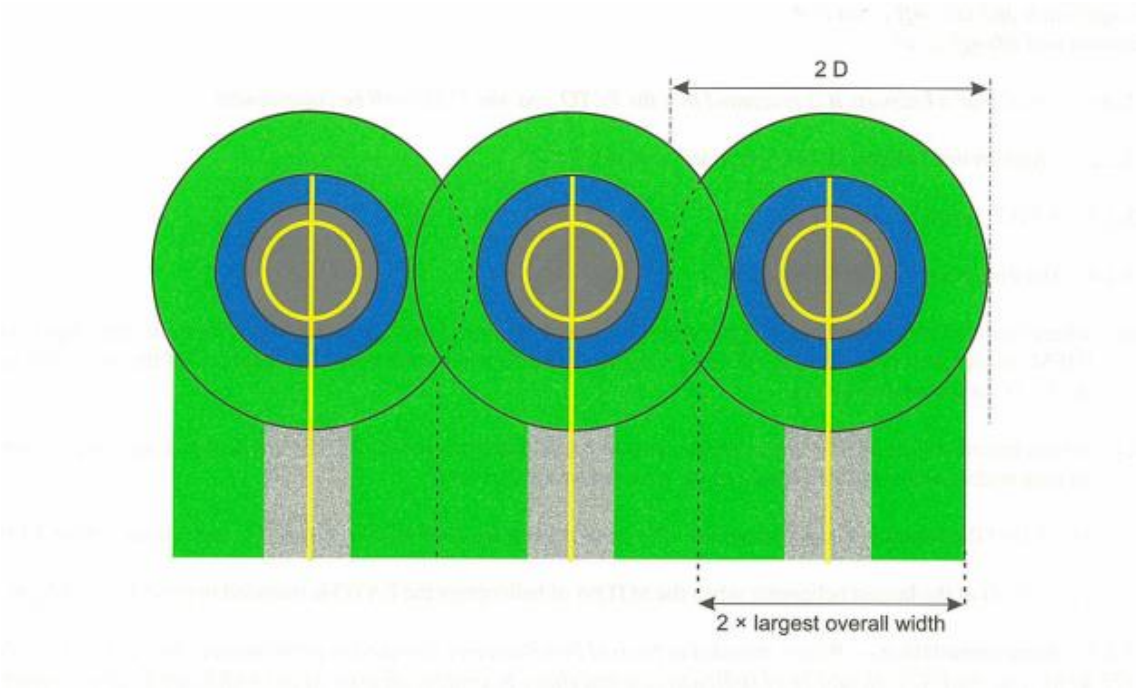

Fig. A.3.8 Non-simultaneous operations [60]

Fixed objects are not allowed to be in the helicopter parking position nor in the protection area around it. The mobiles objects that necessarily have to be there, if they are at a distance of less than 0.75 x D of the centre helicopter parking position, they will not project from a plane at a height of 5 cm above the plane of the central zone and if they are at a distance of 0.75 x D or more of the centre helicopter parking position, they will not project from a plane at a height of 25 centimetres above the plane of the central zone and with an upward and outward slope of 5%. Finally, the centre area of a helicopter parking stand shall have a diameter of not less than 0,83 x D of the largest helicopter for which it is intended.

3.1.2 Elevated heliports

Elevated heliports are those heliports where the FATO is slightly elevated in relation to the surrounding land. As it can be seen in **Fig. A.3.9**. They have to meet some specific requirements:

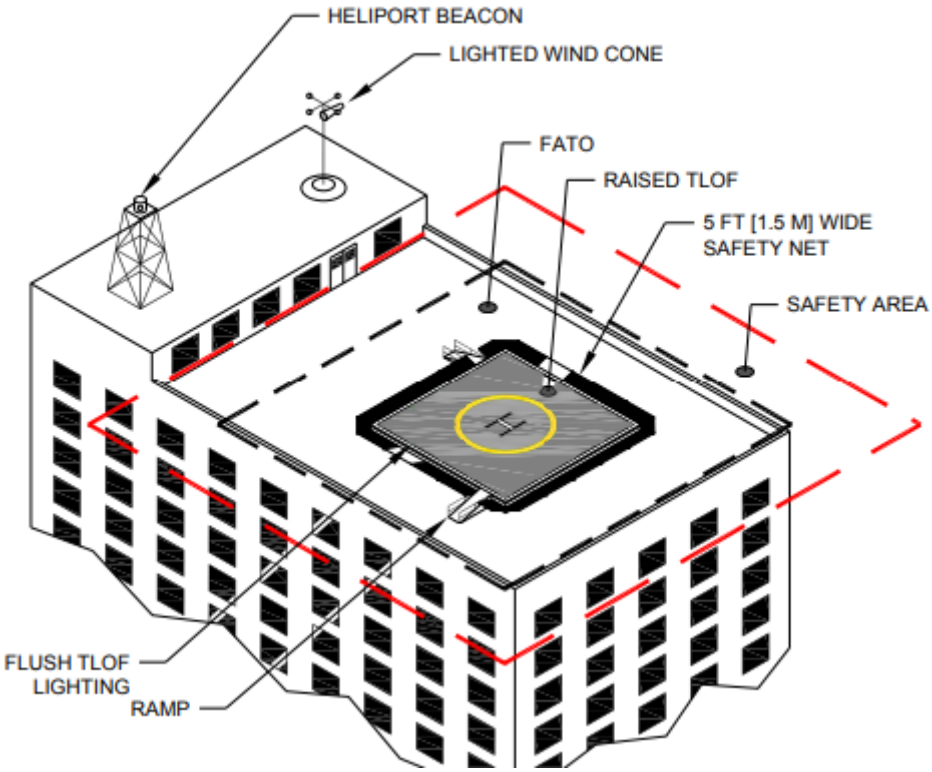

Fig. A.3.9 Elevated heliport with their different parts [74]

3.1.2.1 Final approach and take-off areas

In the case of elevated heliports, the FATO will coincide with the TLOF. The FATO dimensions for helicopters of Performance Class 1, will be of a width of at least D of the biggest helicopter that operates there, and it slopes will not exceed 2% in any direction and this will be enough to prevent water accumulation.

3.1.2.2 Helicopter obstacle clearance zone

The helicopter obstacle clearance zone shall be located beyond the end of the interrupted take-off area and the width of it should not be less than the security area near it. As for the surface heliports, in the case of elevated heliports it is the same and if there is an object in the helicopter obstacle clearance zone that could endanger helicopters in flight should be considered as an obstacle and removed.

3.1.2.3 Contact and initial elevation areas

The TLOF will coincide exactly with the FATO and their dimensions and characteristics are the same for both. As the TLOF can be located near additional helicopter stands, in this case the TLOF shall contain a circle whose diameter be at least of 0.83 x D of the largest helicopter that can operate. The slopes of the TLOF shall not exceed 2% in any direction, as in the surface heliports.

3.1.2.4 Operational Safety Area

The operational safety area surrounding the FATO for helicopters of Performance Class 1 in visual flight conditions shall extend outward at least 3 metres or 0.25 x D of the largest helicopter, depending on what is the biggest option. Each external side will of the safety area will be at least of 2 x D when FATO is a circle or a quadrilateral. There shall be a lateral slope corresponding to 45º from de safety area to a distance of 10 metres and it will not be any obstacles there.

Fixed objects shall not be allowed in the safety area, except for frangible objects which, by their function, must be located in the security area. Mobile objects are neither allowed during helicopters' operation. When the FATO has a diameter slower than D, the maximum height for the objects, that have to be there for necessity, will not exceed 5 centimetres.

3.1.2.5 Ground taxiways for helicopters

The width of the ground taxiways for helicopters will be at least twice the maximum width of the largest helicopter which operate there. The slope of the ground taxiways shall not exceed 3% (longitudinal slope) and 2% (transversal slope).

The ground taxiways will be symmetrical from one side to the other side, at a distance at least of the total width for the helicopters for which is allowed. Any object will be allowed instead of frangible objects that have the need to be there.

3.1.2.6 Aerial taxiways for helicopters

An aerial taxiway for helicopters is intended for the movement of a helicopter overhead at a height normally associated with ground effect and at ground speeds of less than 37 km/h (20 kt). The width of the aerial taxiway will be at least three times the maximum width of the landing gear for the largest helicopter. The slope for the aerial taxiways shall not exceed 2% (transversal slope) and 7 % (longitudinal slope).

The aerial taxiways, as the ground taxiways, will be symmetrical from one side to the other side, at a distance at least equal to the total width for the helicopters for which is allowed. Any object will be allowed instead of frangible objects that have the need to be there.

3.1.2.7 Helicopter parking stands on platforms

Helicopter stands shall be of sufficient size to contain a circle with a diameter of at least 1,2 x D of the largest helicopter for which they are intended. The slope in any direction will not exceed 2%. Fixed objects will not be allowed in helicopter parking stand or in the protection area.

If a helicopter parking stand is used for taxiing, the minimum width of the parking stand and associated protection area shall be equal to that of the taxiway. O3n the other hand, if a helicopter parking stand is used for turns, the minimum dimension of the helicopter stands, and the protection area shall be of 2 x D. For simultaneous and non-simultaneous operations will be the same as for a surface heliport. In the case of simultaneous operations, the protection area of helicopter parking stands and their associated taxiways shall not overlap. Otherwise, in non-simultaneous operations, the protection area of helicopter parking stands and related taxiways may overlap.

3.2 Classification of heliports according to their facilities

Depending on their facilities, heliports can be classified in different types such as: Transport heliport, Helipad and Helistations

3.2.1 Transport heliports

Transport heliports are facilities planned and designed to accommodate different types of helicopters and a growing number of operations.
These types of heliports typically provide for a minimum of 3 parking spaces on the platform, a terminal, fuel supply services, a beacon system, and clearly defined entry and exit routes. [61]

3.2.2 Helipad

The Helipad is limited to the physical space and the signalling for a single helicopter, parked in the centre of the same TLOF-FATO. It does not usually have any kind of installation other than those strictly required for its use (fire protection systems, lighting, etc.). It is not usually a helicopter base but, as its name suggests, the point of a simple mission stop to pick up passengers, cargo or the sick. [61]

3.2.3 Helistations

The Helistation is an intermediate facility between the helipad and the transport heliport. A helistation provides one or two parking positions in addition to a TLOF-FATO. [61]

3.3 Classifications of heliports according to their temporary nature

Depending on their temporary nature, heliports can be classified as permanent or eventual.

3.3.1 Permanent

A permanent heliport is an aerodrome or area defined on an artificial surface or elevated structure, for the exclusivity use of arrivals, departures, or surface

movements of helicopters, which may have fixed buildings, equipment and service facilities. [81]

3.3.2 Eventual

Eventual heliports are designated areas with a minimum conditioning that are only activated occasionally for aerial work campaigns, forest fires or specific events. These heliports cannot be activated for more than one year, planned to be used for more than 3 days a week and no more than 10 operations per day. [61] [80]

3.4 Classifications of heliports according to their use regime

According to their use regime the heliports can be classified as private or restricted use and public.

3.4.1 Private or restricted use heliports

These are facilities that are not generally accessible, intended to serve business corporations, hotels, golf courses, helicopter operators, hospitals, public services, fire stations or police stations which are used by the developer or specially authorised operators. [61]

3.4.2 Public use heliports

Public use heliports are civil aerodromes where commercial passenger, cargo and mail transport operations, including air taxis, may be carried out. [84]
These are facilities with general access, with an established system of operation and services, and information on the system of declared and public use as opening hours, services, or fees. [61]

3.5 Certification of heliports

A certified heliport is a heliport whose operator has been granted an aerodrome certification.

Aerodrome certification has been a requirement by ICAO since 2001. It is an effective way of ensuring safe and efficient aerodrome operations, through a defined different process which examines various components of the

aerodrome, with the objective of verifying their compliance with international Standards and Recommended Practices (SARPs). [82]

During the certification process, aerodrome regulators and operators verify that the aerodrome's facilities, design, equipment and operational procedures comply with relevant SARPs. With this verification they are ensuring safe operations and supporting optimization of aerodrome capacity and efficiency.

It starts with a submission, by the aerodrome operator, of a formal application to the national authority responsible for civil aviation. This submission includes basic information on the aerodrome operator, the aerodrome itself and its facilities, and the intended operations. It continues with a thorough review by the authority of the aerodrome manual, the key document submitted by the aerodrome operator, which details the day-to-day procedures for the operation of the aerodrome, as well as information belonging to its planning and design.

The process is followed by technical inspections and on-site verification by the authority of the aerodrome facilities and operational procedures. It includes its safety management system, in order to complete the analysis and ensure compliance with applicable provisions, as well as the appropriateness of operating procedures. The process ends with the granting of the aerodrome certification, which may include details of specific features or limitations related to the operations arising from the certification process, information on the main facilities, and the validity of the certificate. [82]

For grant the aerodrome certificate must be submitted the following documents: [81]

•Document of compliance with the technical standard for the design and operation of aerodromes for public use, according to the model developed by EASA. In this document all the compliances and non-compliances should be adequately justified.

•Accreditation of compliance with the technical standard, signed by the Airport Manager or competent professional. In that document is specified that the airport, its facilities, systems, equipment, services, and procedures comply with the provisions of the Certification Regulation for airports under State jurisdiction.

•Technical documentation, justifying the decision, which will include:

-Study of existing obstacles both inside and outside the airport site, including Technical Report, obstacle sheets and obstacle plans for each of the SLOs (Obstacle Limitations Surfaces).

-Drawings report, including the following list of verifications that should be in the aerodrome or heliport:

•Airfield and platform configuration.

•Latest topographic survey of the airfield and platform, including minimum contour lines every metre, longitudinal profiles and transverse profiles.

•Drainage system.

• Obstacle map.

• Vertical and horizontal signals.

• Beaconing.

-Supporting documents for the document of compliance of technical standards.

All these previous characteristics such as airfield and platform configuration, latest topographic survey of the airfield and platform, drainage system, obstacle map, vertical and horizontal signals or beacons must be in the heliport for being grant it. As well as the heliport should present all the information and documents specified before. Otherwise, it would not be a certified heliport.

3.6 Verification of heliports

Verified heliports are those civil infrastructures, for public use, whose manager has obtained a favourable verification resolution in accordance with the provisions of Royal Decree 862/2009 [83], of 14 May, approving the technical standards for the design and operation of aerodromes for public use and the Regulation on the certification and verification of airports and other aerodromes for public use. Those public use heliports that do not comply with the certification requirements or have an exemption from compliance should be verified. [84]

To obtain the verification resolution, the aerodrome manager must pass a supervision process in which AESA will carry out different necessary checks to verify compliance with the standards established for the infrastructure, equipment and services, in accordance with the technical design and operation standards for aerodromes for public use, as well as verifying the manager's ability to manage air transport operations.

If the verification resolution is granted to a newly constructed infrastructure will not be valid for more than 36 months. After this period of time, it will be another supervision and the verification will be renovated, this time for an indefinite period of time. [85]

ANNEX 4. LIST OF THE HELIPORTS IN CATALONIA

In this section, there is a list of all the heliports of Catalonia, divided by those where can operate SEM, Firefighters and other heliports.

3.1 Heliports operated by SEM

The heliports located in hospitals that are in the region of Catalonia and SEM can operate in all of them to transport patients that have had an accident or illness are:

1. Heliport de l'Hospital General de Catalunya is a heliport specialized in the sanitary sector which is located in Sant Cugat del Vallès whose operator is Eliance coordinated with SEM.

2. Heliport de l'Hospital General de Manresa is a heliport specialized in the sanitary sector in Manresa whose operator is Next Generation Airport Solutions coordinated with SEM.

3. Heliport de l'Hospital Germans Trias i Pujol is a heliport specialized in the sanitary sector located in Badalona whose operator is the hospital itself coordinated with SEM.

4. Heliport de l'Hospital Josep Trueta is a heliport specialized in the sanitary sector in Girona and that its operator is the hospital itself coordinated with SEM.

5. Heliport de l'Hospital Sant Joan de Reus is a heliport specialized in the sanitary sector located in Reus and that its operator is Grup Sagessa in coordination with SEM.

6. Heliport de l'Hospital Teknon is a heliport specialized in the sanitary sector in Barcelona whose operator is the hospital itself coordinated with the SEM.

7. Heliport de l'Hospital Universitari Joan XXIII is a heliport specialized in the sanitary sector located in Tarragona whose operator is the hospital itself coordinated with SEM.

8. Heliport de l'Hospital Universitari de Bellvitge is a heliport specialized in the sanitary sector located in L'Hospitalet de Llobregat whose operator is Next Generation Airport Solutions in coordination with the SEM.

9. Heliport de l'Hospital Verge de la Cinta is a heliport specialized in the sanitary sector located in Tortosa whose operator is the hospital itself in coordination with SEM.

10. Heliport de l'Hospital d'Igualada is a heliport specialized in the sanitary sector located in Igualada whose operators is Consorci Sanitari de l'Anoia in coordination with SEM.

11. Heliport de l'Hospital de Sant Joan de Déu is a heliport specialized in the sanitary sector that is located in Esplugues de Llobregat and the operator is the hospital itself coordinated with SEM.

12. Heliport de l'Hospital de la Cerdanya is a heliport specialized in the sanitary sector, located in Puigcerdà and operated by the Agrupació Europea de Cooperació Territorial of this hospital in coordination with SEM.

13. Heliport de l'Hospital de la Santa Creu i Sant Pau is a heliport specialized in the sanitary sector which is located in Barcelona and its operator is the hospital itself in coordination with the SEM.

14. Heliport de l'Hospital de la Vall d'Hebron is a heliport specialized in the sanitary sector which is located in Barcelona and its operator is Airtech Levante coordinated with SEM.

15. Heliport de la Corporació Sanitària Parc Taulí is a heliport specialized in the sanitary sector located in Sabadell and it operator is the hospital itself coordinated with SEM.

16. Heliport del Nou Hospital de Mataró is a heliport specialized in the sanitary sector located in Mataró and that its operator is the hospital itself in coordination with SEM.

17. Heliport de Campdevànol is an eventual heliport located in Campdevànol whose operator is SEM.

18. Heliport de Tremp is a specialized heliport locaed in Tremp and it is operated by SEM.

19. Heliport de Vilaller is a specialized heliport located in Vilaller and whose operator is SEM.

20. Heliport del Centre de Gestió d'Emergències 112 is a specialized heliport located in Reus and whose operators are Centre d'Atenció i Gestió de Trucades d'Urgència 112 Catalunya, SEM and the Divisió de la Sala Central de Bombers

3.2 Heliports operated by Firefighters

The heliports located in Fire Stations in the region of Barcelona whose operator is the Divisió de la Sala Central de Bombers are:

20. Heliport del Centre de Gestió d'Emergències 112 is a specialized heliport located in Reus and whose operators are Centre d'Atenció i Gestió de Trucades

d'Urgència 112 Catalunya, SEM and the Divisió de la Sala Central de Bombers. (Same heliport as before because it can be operated by SEM and GRAE)

21. Heliport del Parc de Bombers d'Horta de Sant Joan is an eventual heliport which is located in the locality of Horta de Sant Joan and whose operator is the Divisió de la Sala Central de Bombers.

22. Heliport del Parc de Bombers d'Olot is a specialized heliport which is located in Olot and whose operator is the Divisió de la Sala Central de Bombers.

23. Heliport del Parc de Bombers d'Orriols is an eventual heliport which is located in Bàscara and whose operator is the Divisió de la Sala Central de Bombers.

24. Heliport del Parc de Bombers de Balaguer is an eventual heliport that is located in Balaguer and whose operator is the Divisió de la Sala Central de Bombers.

25. Heliport del Parc de Bombers de Calaf is a specialized heliport which is located in Calaf and whose operator is the Divisió de la Sala Central de Bombers.

26. Heliport del Parc de Bombers de Cambrils is an eventual heliport that is located in Cambrils and whose operator is the Divisió de la Sala Central de Bombers.

27. Heliport del Parc de Bombers de Camprodon is a specialized heliport located in Camprodon and whose operator is the Divisió de la Sala Central de Bombers.

28. Heliport del Parc de Bombers de Cardona is an eventual heliport that is located in Cardona and whose operator is the Divisió de la Sala Central de Bombers.

29. Heliport del Parc de Bombers de Cerdanyola del Vallès is an eventual heliport located in Cerdanyola del Vallès and whose operator is the Divisió de la Sala Central de Bombers.

30. Heliport del Parc de Bombers de Dosrius is an eventual heliport that is located in Dosrius and whose operator is the Divisió de la Sala Central de Bombers.

31. Heliport del Parc de Bombers de Garraf is an eventual heliport located in Sitges and whose operator is the Divisió de la Sala Central de Bombers.

32. Heliport del Parc de Bombers de Girona is an eventual heliport which is located in Girona and whose operator is the Divisió de la Sala Central de Bombers.

33. Heliport del Parc de Bombers de Manresa is an eventual heliport which is located in Manresa and whose operator is the Divisió de la Sala Central de Bombers.

34. Heliport del Parc de Bombers de Maçanet de la Selva is an eventual heliport which is located in Maçanet de la Selva and whose operator is the Divisió de la Sala Central de Bombers.

35. Heliport del Parc de Bombers de Montblanc is an eventual heliport which is located in Montblanc and whose operator is the Divisió de la Sala Central de Bombers.

36. Heliport del Parc de Bombers de Montmell is an eventual heliport which is located in the locality of El Montmell and whose operator is the Divisió de la Sala Central de Bombers.

37. Heliport del Parc de Bombers de Móra d'Ebre is an eventual heliport located in Móra d'Ebre and whose operator is the Divisió de la Sala Central de Bombers and SEM.

38. Heliport del Parc de Bombers de Prades is an eventual heliport located in Prades and whose operator is the Divisió de la Sala Central de Bombers.

39. Heliport del Parc de Bombers de Valls is a specialized heliport located in Valls and whose operator is the Divisió de la Sala Central de Bombers.

40. Heliport Antic CECAT is an eventual heliport located in Reus and whose operator is the Divisió de la Sala Central de Bombers.

41. Heliport de Berga is a specialized heliport located in Berga whose operator is the Divisió de la Sala Central de Bombers.

42. Heliport de Boí i Taüll is an eventual heliport located in La Vall de Boí whose operator is the Divisió de la Sala Central de Bombers.

43. Heliport de La Torre de Capdella is an eventual heliport in La Torre de Capdella whose operator is the Divisió de la Sala Central de Bombers.

44. Heliport de Tírvia is a specialized heliport located in Tírvia and whose operator is the Divisió de la Sala Central de Bombers.

45. Heliport de Vallter 2000 is an eventual heliport located in Setcases and whose operator is the Divisió de la Sala Central de Bombers.

46. Heliport de la Molina is an eventual heliport located in Alp and whose operator is the Divisió de la Sala Central de Bombers.

3.3 Other heliports located in Catalonia

47. Heliport de l'Hotel Juan Carlos I is a private heliport located in the Juan Carlos I hotel in Barcelona and whose operator is Barcelona Project's, SA.

48. Heliport Fortalesa de Sant Julià de Ramis is a specialized heliport located in Sant Julià de Ramis and whose operator is Lutecaf, SA.

49. Heliport d'Amposta is a specialized heliport in Amposta whose operator is Heliswiss Ibérica S.A.

50. Heliport d'Ullastrell - Teresa Vila is a specialized heliport in Ullastrell whose operator is Helipistes, SL.

51. Heliport de Boca Sud – Vielha is an eventual heliport located in Vielha e Mijaran whose operator is Pompièrs Emergéncies.

52. Heliport de Can Bonastre is a specialized heliport in Masquefa and whose operator is Hotel Can Bonastre Wine Resort.

53. Heliport de Costa Brava Centre is a specialized heliport located in Castell-Platja d'Aro and whose operator is Turisvol, SL.

54. Heliport de Lles is an eventual heliport located in Lles de Cerdanya whose operator is the Direcció General dels Agents Rurals.

55. Heliport de Port del Comte is an eventual heliport located in Port del Compte.

56. Heliport de Portaventura is a private heliport located in Vila-seca and whose operator is Port Aventura Entertainment S.A.U.

57. Heliport de Sant Martí Sescorts is a private heliport located in L'Esquirol whose operator is Enginyeria de Construccions Rovira,SL.

58. Heliport de Vielha is a specialized heliport located in Vielha e Mijaran and whose operator is Eliance.

59. Heliport de l'Aeròdrom de la Cerdanya is an eventual heliport located in Das and whose operator is Gestió Aeroportuaria Ceretana SL (GAC).

60. Heliport de l'Autoritat Portuària de Barcelona is a specialized heliport located in Barcelona and whose operator is Cathelicopters SL.

61. Heliport de l'Hotel Mas Passamaner is a specialized heliport located in La Selva del Camp and whose operator is Mas Passamaner, SL.

62. Heliport de la Fira M2 de l'Hospitalet is a specialized heliport located in l'Hospitalet de Llobregat and whose operator is Eliance.

63. Heliport de la Pobla de Segur is an eventual heliport located in La Pobla de Segur and whose operator is the Ajuntament de La Pobla de Segur.

64. Heliport de la Roca Village is a specialized heliport located in La Roca del Vallès and whose operator is Bigas Group SL.

65. Heliport del Complex Egara is a specialized heliport located in Sabadell and whose operators are the Direcció General de la Policia and Cap de la Unitat de Mitjans Aeris.

66. Heliport del Port de Tarragona is a specialized heliport located in Tarragona and whose operator is Autoritat Portuària de Tarragona.

67. Heliport del Reial Automòbil Club de Catalunya is a specialized heliport located in Barcelona and whose operator is the same foundation of RACC itself.

68. Heliport dels Serveis Generals del Circuit de Catalunya is a public and specialized heliport located in Montmeló and whose operator is Bigas Grup Helicopters Slu (BG Helicopters).

69. Heliport dels Serveis d'Evacuació del Circuit de Catalunya is a specialized heliport located in Granollers and whose operator is Circuits De Catalunya,SL..