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THE DESIGN OF AN AUTOMATIC BEACON EJECTING SYSTEM FOR AIRCRAFT

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Abstract

This paper investigates retrofitting a standard nautical EPIRB on existing aircraft commercial aircraft. The solution ejects the EPIRB automatically prior to an aircraft impacting water so that it falls clear of any debris. For the systems to be accepted by aircraft operators, the retrofit must be cost effective, reliable, as well as being easy to install and maintain. The selected location to install the system must not interfere with existing aircraft systems and the airframe so as to avoid extensive testing and re-certification. The EPIRB should be self-contained and will activate automatically through built in sensors measuring the rate of descent and altitude. Theoretically this will allow the successful deployment of the EPIRB even if the aircraft were to break apart during descent. Other areas investigated include analysis simulating post ejection trajectory to prevent the beacon striking the aircraft. Once the beacon is in the water the EPIRB will begin to transmit GPS coordinates so its position is able to be tracked as it drifts on ocean currents.

1 Introduction

Emergency Locator Transmitters (ELTs) are required to be carried by aircraft according to Federal Aviation Regulation 91.207 [1]. The ELT is fixed internally to the airframe of the aircraft and automatically activates in the event of the aircraft crashing. If an aircraft were to crash into water, then the performance capabilities of the ELT are diminished as it is unable to transmit once it becomes submerged. In addition to aircraft carrying ELTs, a potential solution is to install an Electronic Position Indicating Radio Beacon (EPIRB) which ejects automatically prior to an aircraft crashing into water. The major advantage that an EPIRB offers in comparison to an ELT in a maritime environment is that it is specifically designed to operate in water as it is buoyant with maritime authority's requiring surface vessels to carry them. Like ELTs, EPIRBs operate and transmit GPS coordinates at 406 MHz to the COSPAS/SARSAT [2] satellite system which relays information to ground stations prompting an emergency response. An EPIRB signal can be received in less than 5 minutes allowing a rapid response increasing the chance of survivability of possible crash survivors and assisting the air crash investigation process by providing an immediate known location of any aircraft wreckage. For this to work though the EPRIB must be ejected away from the aircraft prior to impact so that it does not become trapped in any wreckage and submerged meaning it would not be able to transmit effectively.

A system would need to be designed which is retrofitted within the aircraft structure which successfully ejects the beacon away from the aircraft prior to it impacting the water. As the proposed design solution is intended for existing aircraft to maximize its impact upon the aviation industry, the ejection system needs to be designed in a manner which will minimize its impact upon the pre-existing structure of the aircraft. Additionally, the costs associated with retrofitting such a system need to be considered. It is for these reasons that the ideal location to retrofit the ejection system would be aft of the rear pressure bulkhead in a pre-existing non-structural access hatch. Installing the system aft of the rear pressure bulkhead located in a non-pressurized section of the aircraft would mean that in the event of an explosive decompression the possibility of the beacon being ejected prior to the pre-programmed conditions is reduced. As well as this, retrofitting the system in a non-structural section of the aircraft means that complexity and cost is both reduced.

Additional to the design of the system mechanically, the conditions required for ejection activation are critical for the system to function in the desired manner. Considered parameters include GPS to ensure that the beacon will only eject over the water, altitude so that the beacon will not deploy at an unreasonable altitude and be located as close to the aircraft as possible after it has ejected, orientation of the aircraft i.e. if the aircraft is an uncontrolled spin or is it upside down and abnormal velocity and acceleration i.e. extremely high or low speeds. Utilizing the ideal combination of activation parameters will reduce the risk of accidental system activation and ensure that the system shall activate when required.

The rationale for the research into designing this system has been highlighted by two major recent aviation incidents. The first occurred on June 1 2009 when Air France flight 447 [3] crashed into the Atlantic Ocean off the coast of Brazil, there were no survivors from this crash and it took two days for search and rescue teams to locate any wreckage. Additionally, it took two years for air crash investigators to recover the black box. More recent Malaysian Airlines 370 [4,5] disappeared on March 8 2014 and is likely to have crashed somewhere in the Southern Indian Ocean with no evidence of any wreckage having been discovered to this date. Although there were no survivors from either of these incidents, there is a chance of survivability in a controlled crash into water but the chance of rescuing survivors significantly decreases over time. In the case of there being no survivors, being able to locate the wreckage expediently will improve the air crash investigation process allowing for any potential safety flaws to be addressed more rapidly.

As the system is designed to be retrofitted using an internationally accredited pre-existing technology in the EPIRB which is low cost and operates on an established satellite system specifically used for search rescue the feasibility of the project is high and is intended to be a viable solution to be adopted by the aviation industry.

This paper discusses the design of the ejection system. Details of the design process discussed include dynamic simulations determined the necessary ejection force required through flight path optimization. As well as this the sensors and the conditions required to eject the beacon at the optimal time prior to impact are discussed. Further information on how the ejection system shall be installed into specific aircraft including the Boeing 787-8 and the Airbus A320-200 shall be detailed with the differences between installation in aircraft with traditional materials such as in the A320-200 and composite materials located in the 787-8 having been researched. The final major area of discussion in this paper will concern the experimental testing of the ejection system where the system shall be raised to a specific height over a body of water and activated to evaluate whether the EPIRB has ejected the desired distance away from the aircraft.

Using a nautical technology such as an EPIRB has the potential to assist the aeronautical community by providing a solution which will allow for search and rescue teams to rapidly locate aircraft which have crashed into water. This paper provides a detailed solution as to how this technology can be applied to the aviation industry.

2 The Selected EPIRB

The maritime authority requires the carriage of an Emergency Position Indicating Radio Beacon (EPIRB) on surface vessels. EPIRBs are designed to float and transmit GPS coordinates at 406 MHz to the COSPAS/SARSAT satellite system that beams the information back to ground stations to prompt an emergency response. This is the same system which ELTs use. An EPIRB signal can be received in less than 5 minutes, allowing a rapid response with an increased chance of saving lives. An EPIRB that is built into an aircraft is potentially a cost-effective means to locate and track aircraft in water. Although EPIRBs are designed to operate in a maritime environment, it is critical that they are not trapped within aircraft in the event of an accident over water as they will not be able to function effectively and cannot transmit through water if the aircraft wreckage were to become submerged.

The EPIRB selected for this project is the Kannad Marine SPORTPRO+. The specifications for this EPRIB can be seen in table 1. This particular EPIRB contains small lithium metal batteries and the EPIRB has been approved to be taken on board passenger aircraft as a personal item in carry-on hand baggage. This is because the overall low level of lithium content of the EPIRB and is classified as "non-restricted" as air cargo under IATA packing instruction – PI 970. Additional to this registration of 406MHz satellite EPIRBs with the EPIRB Registration Section of the national authority is mandatory, due to the global alerting nature of the Cospas-Sarsat system.

Table 1: Kannad Marine EPIRB Sport+ specifications [6]

EPIRB Type	Kannad Marine Sport, Sport+	Class 3, Non float free
Operation	Manual activation	Switch, protected by anti-tamper seal.
	Self test button	Checks transmitters, battery and high intensity LED
406 MHz Transmitter	Operating frequency	406.040 MHz ± 1 kHz
	Power output	5 W typical
	Modulation	Phase (16K0GID)
121.5 MHz Homer	Operating frequency	121.5 MHz ±3.5 kHz
	Power output	50 mW radiated typical
	Modulation	Swept tone AM (3K20A3X)
GPS Receiver (Sport+ version only)	Centre frequency	1.57542GHz
High intensity LED	Type	High intensity LEDs
	Light output	0.75 cd minimum
Antenna	Vertical	Whip
Battery	Type	Lithium metal
	Operating life	48 hours minimum
	Storage	7 years
	Replacement	By service centre
	Use	Logged by microcontroller
Environment	Operating temperature	-20 °C to +55 °C
	Storage temperature	-30 °C to +70 °C
	Waterproof	Immersion to 10m
	Buoyancy	Floats
	Exterior Finish	High visibility yellow
Physical	Weight	Without GPS 609g With GPS 615g
	Height of body	21 cm
	Length of antenna	18 cm
	Overall	39 cm
	Lanyard	5.5m, 40Kg breaking strain
Fixing	Two part Bulkhead bracket	Removable Carrysafe collar
Standards applied	Satellite system	Cospas-Sarsat T.001/T.007
	EPIRB	IEC 61097-2, AS/NZS 4280.1

As seen in table 1, there are a number of parameters which make this EPRIB suitable for the project. The operating life of 48 hours provides a significant amount of time for search and rescue teams to co-ordinate and pinpoint a location. The storage life of the battery is 7 years meaning that costs associated with maintenance required is reduced because of the long battery life. The operating temperature means that the EPIRB will be able to function effectively in any marine environment and in conjunction with this the storage temperature which the EPIRB is able to withstand means that it is able to be stored aft of the rear pressure bulkhead without the need for additional insulation. The operational parameters of the EPRIB are suitable for this project, however there are numerous aftermarket EPRIBs which offer comparable performance. However, the size of the Kannad Marine Sport+ adds to its adaptability as its packaging footprint is reduced which then influences the size of the ejection system. A detailed drawing of the EPRIB can be seen in Fig 1.

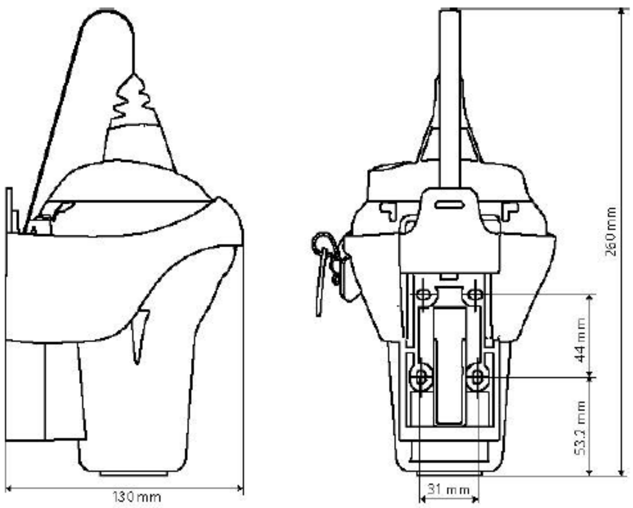

Fig 1: Kannad Marine Sport+ EPIRB dimensions [6]

From Fig 1 it can be seen that the EPRIB is designed to be stored with the antenna folded. In the event of ejection, the antenna would "whip" out and be in its intended position for functionality. Another feature which can be seen in Fig 1 is the bracket which is used for mounting. This bracket has been designed by Kannad to mount the EPRIB in an appropriate location on a maritime vehicle. An advantage of the bracket is that it could be used via modification to assist in the insertion process of the EPRIB into the ejection system as the unconventional shape of the EPIRB could prove to be challenging.

The conditions which activate an aircraft ELT are different to those which activate an

EPIRB as an EPIRB is not designed to be placed under high g loading that an aircraft may experience in a crash. However, the major challenge faced is not being able to install an EPIRB in an aircraft or activating the EPIRB as it can function as intended after an aircraft crashes into water but actually being able to eject the EPIRB away from the aircraft prior to it impacting the water. A number of conditions must be met for an EPIRB to be adapted for aviation purposes. These include:

1. Must withstand high impact loads.
2. Must be stored at low pressure and sub-zero temperatures while at cruise altitude.
3. Must be ejected automatically clear from the aircraft to avoid being trapped by the wreckage.
4. Must be fitted on the aircraft with minimal impact on the original structure.
5. Must be reliable and economically viable.

There have been studies which have evaluated the performances of both ELTs and EPIRBs.

In 2013 the Australian Transport Safety Bureau (ATSB) [7] evaluated the effectiveness of emergency locator transmitters in aviation accidents. The study primarily focused on ELTs used for general aviation but the findings are applicable to EPRIBs and this project. Data from the ATSB showed that ELTs functioned as intended between 40 and 60 per cent of accidents in which activation should have occurred.

The Australian Maritime Safety Authority's Search and Rescue (SAR) records show that search and rescue personnel were alerted to aviation emergencies in a number of ways including radio calls, phone calls and ELT activations accounted for first notification in approximately 15 per cent of incidents. However, it was found that ELT activations were directly responsible for saving an average of four lives each year.

It was found in accidents where ELTs did not function as intended, performance could have been influenced by the following factors:

- Not selecting the ELT activation to be armed prior to flight.
- Incorrect installation.
- Flat batteries.
- Lack of water proofing.
- Lack of fire protection.
- Disconnection of the co-axial antenna cable from the unit during impact.
- Damage and/or removal of the antenna during impact.
- An aircraft coming to rest inverted after impact.

The report summarized a number of ways in which better use, carriage, fitment, and design could improve their effectiveness in an accident:

- GPS equipped ELTs significantly increase the accuracy of positional resolution from approximately 5 km (non-GPS) to approximately 120 m for GPS enabled ELTs.
- Newer ELTs incorporating 3-axis g switches improve the likelihood of activation upon impact. Single-axis units are only able to activate correctly if there is a significant impact force in the direction that the ELT is mounted.
- Installing ELTs as far aft in the fuselage as possible improve post-crash survivability.
- Australian Search and Rescue (AusSAR) advise that if a pilot is attempting a forced landing, is experiencing serious control difficulties or dangerous weather conditions, proactively activating an ELT could significantly increase the likelihood of the search and rescue coordination centre knowing the exact position of the aircraft. If the emergency is alleviated, turn off and notify AusSAR as soon as possible.

Additional to this, data reviewed by the Australian Maritime Safety Authority (AMSA) shows that of the 442 search and rescues relating to aircraft emergencies between June 1999 and December 2012, 68 of the incidents benefitted from the detection of a search and rescue beacon which resulted in 52 lives being saved during this period.

Although the study conducted by the ATSB related to ELTs, some of the findings from the study can used to ensure reliability of the system performance. Key relevant points to ensure the EPIRB functions as intended concern the EPIRB activating, incorrect installation, flat batteries and the antenna disconnecting from the unit during impact.

EPIRBs, ELTs and PLBs require the use of the COSPAS-SARSAT system to be able to be tracked. The COSPAS-SARSAT system provides Low Earth Orbiting Search and Rescue (LEOSAR) service which is used by first generation EPIRBs and the Geostationary Orbiting Search and Rescue (GEOSAR) service. The Kannad SPORTPRO+ EPIRB selected for this project is a second generation EPIRB. A study by the Global Area Wireless Technology Research Group ETRI [6] investigates the development and performance of second generation 406 MHz EPIRBs.

Second generation 406 MHz search and rescue beacons including EPIRBs allow for the encoding of position data in the transmitted 406 MHz message, which provides quasi-real time alerts and position information through the GEOSAR service. The beacon transmits a 5 watt half-second burst approximately every 50 seconds. The carrier frequency is phase modulated with a digital message. The low duty cycle provides a multiple-access capability of more than 90 beacons operating simultaneously in view of a polar orbiting satellite. An image of the way in which the COSPAS SARSAT system operates can be seen in Fig 2.

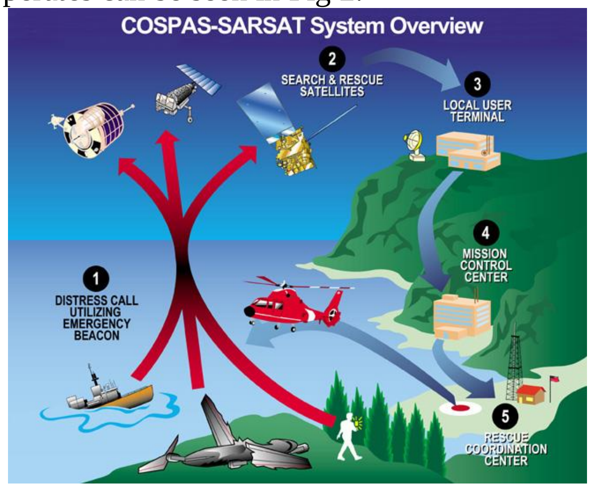

Fig 2: Overview of the operational procedure when an activated beacon uses COSPAS SARSAT [2]

3 Selecting a Suitable Location to Install the System

The design of the EPIRB ejection system is constrained by the location in which it is possible to install the system. The most effective method to establish a suitable location to install the ejection system is to physically inspect the aircraft. To ensure the system functions as intended and to remove the risk of the system experiencing an explosive decompression the system shall be installed in a non-pressurized section of the aircraft. To minimize costs and to prevent a major re-design of the internal aircraft structure a non-structural access hatch shall be used as a location to install the system. Jetstar Airways facilitated an inspection of a Boeing 787-8 and an Airbus A320-200 at the Qantas maintenance hangar at Tullamarine airport.

After inspecting both the 787-8 and A320-200 a suitable location was found in both aircraft which were in relatively similar positions. This position is an access hatch which is located aft of the rear pressure bulkhead in both aircraft. In both aircraft the access hatch is used for maintenance on the screw-jack for the elevator trim. The differences between the two aircraft concern the side of the aircraft which the access hatch is located on, with the access hatch located on the port side in the 787-8 and on the starboard side in the A320-200. The location of the access hatch on the 787-8 can be seen in Fig 3.

Fig 3: Location of access hatch on 787-8 aft of the rear pressure bulkhead

Fig 3 shows the location of the non-structural access hatch relative to the rear of the aircraft. It can be seen that the hatch opens towards the front of the aircraft at approximately 90°. The size of the hatch which is approximately 400mm x 400mm is suitable to design the system around. However, consideration must be taken into how the ejection system is mounted to the access hatch considering the carbon fibre which the hatch is made from as well as the maximum distance which the hatch is able to open. This location is ideal though as after ejection the chance of the beacon being struck by the aircraft is minimized. Fig 4 shows the same access hatch on the A320-200.

Figure 4: Location of access hatch on A320-200 aft of the rear pressure bulkhead

Fig 4 shows the location of the access hatch used for maintenance on the elevator-trim screw jack It can be seen that the hatch opens differently when compared to the 787-8 and at a greater angle when compared to the 787-8. The size of the access hatch is approximatelt 370mm x 370mm which is slightly smaller when compared to the 787-8 but is stil a suitable size for the system. If the system were to be designed for multi-aircraft compatability using both the 787-8 and A320-200 to determine constraints then dimensions of the A320-200 access hatch and the maximum angle that the access hatch of the 787-8 opens shall be used. The elevator trim screw jacks for both the 787-8 and A320-200 can be seen in Fig 5.

Fig 5: Elevator trim screw jack. Left 787-8. Right A320-200

In Fig 5 it can be seen that layout of the elevator trim screw jacks in both the 787-8 and A320-200 is almost the same. Because of the similarity between the two screw jacks across both the aircraft this simplifies the challenges associated with designing the ejection system for when maintenance work is required. Scheduled maintenance checks on the screw jack is designated as a B check meaning the check is conducted approximately once every six months. This means that the ejection system needs to be designed in a manner which takes this into consideration.

4 Ejection System Design

The method to eject the beacon will involve a spring loaded system. The reason for this is that it removes a significant degree of complexity in regards to both regulations and functionality. Other methods such as explosives i.e. such as in an airbag will present a number of regulation problems and the use of systems such containing hydraulics or pneumatics will present a significant challenge in being able to operate independently of all other aircraft systems.

Unlike aircraft ELTs, EPIRBs are not designed to withstand high impact loads. To address this the EPIRB shall be contained within a capsule which will provide protection for the EPIRB and will automatically open after it enters the water. A preliminary design of the capsule can be seen in Fig 6.

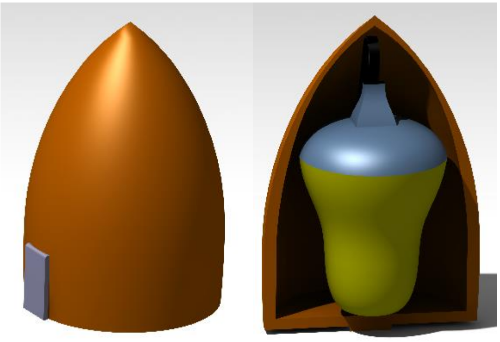

Fig 6: EPIRB capsule

The design seen in Fig 6, is ballistic in nature. The design is intended to minimize the impact which the EPIRB experiences when it enters the water. It can be also see that the capsule is hollow, however a shock absorbent material shall be included within the design which will surround the EPIRB to minimize the translational forces experienced by the EPRIB when the capsule enters the water. The motion to automatically open the capsule shall be mechanically driven by being spring loaded and will activate once the capsule experiences a pressure which corresponds to a depth of 1 meter within the water. This depth also protects the EPIRB as a depth of 10 meters will damage the EPIRB. The EPIRB will then be able to float the surface and activate undamaged. The capsule will also allow for a greater force to be applied for ejection thus improving overall functionality of the system.

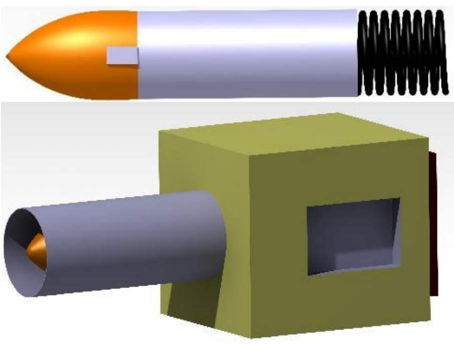

Fig 7: Overview of the ejection system

Fig 7 shows the preliminary design of the ejection system. It can be seen that the casing sits on shaft which is connected to the spring. This is then contained within a unit which is designed in a manner to contain all other hardware required and to simplify the installation of the system within aircraft. After reviewing the initial design, a number of components were modified. The reason for this was to primarily reduce weight and further simplify the system. The next iteration can be seen in Fig 8.

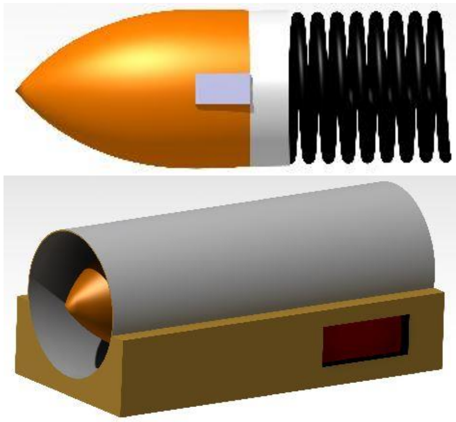

Fig 8: Overview of the redesigned ejection system

From Fig 8 it can be seen that the overall size of the system has been significantly reduced with the original systems total length being 1050mm compared to 560mm for the new design which also has a width of 270mm compared to 450mm. The spring is the key component to the EPIRB casing being able to eject away from the aircraft. This means that the design of the spring is critical to the system functioning as intended. The spring will experience a wide temperature range at both altitude and on a tarmac in the summer due to the fact that the system is located aft of the rear pressure bulkhead meaning that there is no environmental conditioning. Two nickel-based alloys, Iconnel 600 and Ni-Span C are two possible materials which the spring could be manufactured out of. Both materials have high elastic and shear modulus' and can function over a wide temperature range. The density of these materials coupled with their other properties will determine the material used for the spring.
Additional to this, using a spring which meets the force requirements to eject the EPIRB casing the desired distance is important. To determine this initial conditions needed to be established. If the aircraft were diving nose first, then the EPIRB needs to be able to clear half of the horizontal stabilizer span. The horizontal stabilizer semi-span of both the Boeing 747 and Airbus A380 is approximately 22m, so the initial ejection

distance required has been set to 13m. Additionally the EPIRB casing needs to be able to cover this distance in a specific time to minimize the risk of it being struck by the horizontal stabilizer. The initial times range from 0.05s to 0.2s. As the EPIRB weighs approximately 0.6kg, the total mass of the casing plus shock absorption material has been set from 0.9kg to 1.1kg. The forces required to be generated by the spring to meet these requirements can be seen in table 2.

Table 2: Ejection force requirements.

Mass	**0.9kg**	**1kg**	**1.1kg**
Time (s)	**Force Required (N)**	**Force Required (N)**	**Force Required (N)**
0.05	9360	10400	11440
0.1	2340	2600	2860
0.15	1040	1155	1271
0.2	585	650	715

Table 2 shows that the force requirements for the capsule to reach 13m in 0.05s is significantly higher than 0.2 seconds. Designing the spring to generate this force is ideal, although the mass required for a spring design that can generate this force may be unfeasible especially considering the ejection system is located a large distance rearwards of the center of gravity.

Due to the unpredictable nature of aviation accidents, a number of different scenarios were considered. To ensure reliability, a combination of sensors and a number of different parameters are used to determine system activation. The conditions are described as follows:

- Altitude: The beacon must deploy at an altitude that results in it being located as close to the aircraft as possible. If the beacon deploys at too high an altitude, it may come to rest too far from the wreckage to be effective. If it deploys too low, it may become trapped in the wreckage and sink.
- Rate of descent: In the event of an uncontrolled crash landing, the rate of descent will be outside an acceptable range. Additionally, in the event of a controlled crash landing (i.e. engine failure) the rate of descent will vary from that when compared to a conventional runway landing.

To measure these parameters, the following sensors and hardware are required:

- Absolute pressure sensor: This sensor will measure the pressure relative to a perfect vacuum. It could be used to determine the sudden drop in pressure relative to a sudden decrease in altitude. A range of pressure values could be programmed to indicate that the aircraft is about to crash into the water.
- Differential pressure sensor: This sensor measures the difference between two pressures. Differential pressure sensors are able to measure sudden drops in pressure which will be able to indicate a sudden decrease in altitude.
- Control board: The control board will be used to analyse inputs from the sensors and assess when the system is required to activate for ejection. The conditions are met for activation the control board will provide an output to activate the ejection system.
- Battery: The battery is used to provide power to the system. The selected battery will be required to meet the power requirements of the system and be able to operate under a variety of environmental conditions.

Seen in Fig 9 is two different sensors which can be integrated within the ejection system.

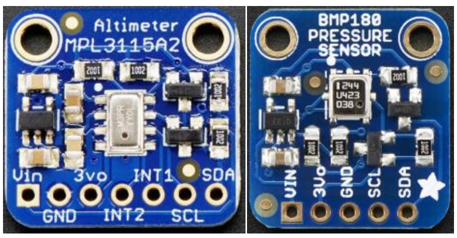

Fig 9: MPL3115A2 altimeter [16] (left), BMP180 pressure sensor [17] (right)

In Fig 9, the MPL3115A2 on the left and the BMP180 are both barometric pressure, altitude, and temperature sensors. Both these sensors can be used to determine the altitude and the rate of descent which is being experienced by the system. The selection of the most suitable sensor depends primarily on power consumption and performance over a wide range of conditions. Both these systems are able to operate over a temperature range of -40°C to 85°C and have an accuracy of 3 pascals within 0.3 meters. The dimensions of the MPL3115A2 are 18mm x 19mm x 2mm and the dimensions of the BMP180 are 3.6mm x 3.8mm x 0.93mm. The size of these sensors mean that packaging them within the ejection system shall not be difficult.

To maximize the effectiveness of the ejection system, it is critical that the system is 100% independent of all other aircraft systems and is able to effectively function no matter what the condition of the aircraft is and it is for this reason that hydraulics and pneumatics were not considered to power the ejection mechanism.

4 Store Release

A key area of research to be investigated which is critical to the EPIRB capsule ejecting as desired, concerns store release. To accomplish this initially Computational Fluid Dynamics (CFD) will be used to provide a viable solution which provides accurate and both cost and time effective solutions.

An investigation by A. Cenko [14] discusses lessons learned over the past 30 years of store separation testing. Primarily for store separation testing the three approaches that have been used are Wind Tunnel Testing, CFD analyses and Flight Testing with significant advances having been made in all three areas in the past 30 years. The US Navy primarily relies on wind tunnel testing for new aircraft/store integration programs. Ideally for this project a CFD investigation will be conducted and depending on the feasibility of it, a wind tunnel testing will be conducted. For a full evaluation of the store separation testing an approach developed by the US Navy which is an Integrated Test and Evaluation (T&E) approach to store separation which uses CFD and Modelling and Simulation (M & S) to design the wind tunnel test which is then used to design the flight test matrix. This process continuously improves as the wind tunnel test results are used to validate the CFD predictions and the flight test results are used to both check the wind tunnel test data in addition to the original CFD predictions.

These studies analyze shapes which are more complicated than the EPIRB capsule and the analysis required for the EPIRB capsule is simplified as the primary concern for the EPIRB capsule is to determine its aerodynamic coefficients to provide the necessary information to predict the ejection process of the capsule a simplified dynamic analysis.

5 Sea Drift

The EPIRB is designed to transmit for 48 hours, and during this time it will provide a location to search and rescue teams while it is active. Ideally search and rescue teams will arrive at the wreckage of the aircraft as fast as possible so as to maximize the chances or recusing any survivors. As the beacon and the aircraft wreckage are both in the water, over time they will begin to experience leeway drift caused by ocean currents. As the time after beacon deployment increases, the beacon may have travelled a significant distance away from the wreckage of the aircraft.

In 2014 [11] there was a study which determined the leeway drift characteristics of tropical Pacific island craft. The paper determined the downwind and crosswind coefficients for three small craft common to Pacific communities. The results from the finding have been implemented into search and rescue models which have been used by several SAR organizations globally. The results have shown that the findings have the potential to not only increase the likelihood of finding persons adrift at sea alive but also reduce the search and rescue costs through more effective drift prediction and efficient search area formulation.

Being able to apply these findings to this study is a challenge, and this is due to the fact that upon impact with the water it is almost impossible to predict the condition of the aircraft and therefore the drift leeway characteristics of the aircraft wreckage. If the drift characteristics of the EPIRB are able to be understood, then search and rescue teams will be able to predict where the wreckage of the aircraft is relative to how far the beacon has drifted if there has been a significant amount of time since the beacon activated.

A study on the leeway field method [12] discusses the methods used to establish the drift properties of small objects. If necessary, the methods discussed in this study can be applied to determine the drift properties of the EPIRB.

6 Testing

Testing of the ejection system will be a complicated aspect of the project. The reason for this is because attempting to replicate test conditions so as to simulate the conditions an aircraft is experiencing prior to crashing into water will be difficult. Based on initial proposals it is intended that the beacon will be ejected approximately 100 meters above the water. Finding a suitable location where the ejection system can be raised to 100 meters and a body of water where the experiment can be conducted safely and legally further add complexity to testing of the system. A possible solution is to use a multirotor which is powerful enough to lift the system to a height of 100 meters and deploy the beacon over a lake where testing has been approved by the appropriate regulatory body. A number of factors will be able to be determined from a successful experiment. The performance of the ejection system at the height which the system is intended to activate in real life scenario is able to be evaluated. As well as this the performance of the EPIRB after it has deployed is also able to be evaluated. Successful experimental results would provide enough validation so as to move the next step of retrofitting the system into aircraft.

7 Conclusion

The feasibility of this project succeeding is considerable, as two key components critical to the operation of the system being the EPIRB and the COSPAS SARSAT satellite system are internationally accredited with their performance capabilities well established. In this study the following conclusions are made with respect to the design of an ejection system which allows for an existing nautical technology to be adapted for aviation purposes.

- The location in which the ejection system is retrofitted to is critical to minimize the impact which it has upon the aircraft structural integrity. The access hatch selected aft of the rear pressure bulkhead reduces the risk of the EPIRB being struck by a part of the aircraft after ejection. As well as this using a non-structural component simplifies the certification process and means that a costly major re-design of that area is not required.
- The selected EPIRP for the project will be able to function as intended and not be negatively impacted by the changes in temperature which an aircraft experiences during flight. The relatively small size of the unit makes it an ideal choice as to not only reduce the size of the ejection system but to minimize its weight contribution.
- Studies on store release have shown that the aerodynamic characteristics of a store upon release can be accurately predicted. This is useful as it reduces the cost of the project as costly wind tunnel testing is not required.
- Being able to accurately predict the sea drift characteristics of the EPIRB will provide additional information which will assist in the search and rescue process.

Based on the findings in this paper, adapting a nautical EPIRB for aviation purposes to address a search and rescue shortcoming is feasible as long as costs associated with the system are kept to a minimum and do not impact upon the performance of an aircraft.

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