# DATA SUMMARY

## LOCATION

| | |
|---|---|
| Date and time | **Friday, 1 June 2012; 16:45 local time[1]** |
| Site | **Benagéber Reservoir (Valencia, Spain)** |

## AIRCRAFT

| | |
|---|---|
| Registration | **EC-KRF** |
| Type and model | **AIR TRACTOR AT802A amphibious** |
| Operator | **Avialsa T-35, S.L.** |

### Engines

| | |
|---|---|
| Type and model | **PRATT & WHITNEY PT6A-67F** |
| Number | **1** |

## CREW

### Pilot in command

| | |
|---|---|
| Age | **47 years old** |
| Licence | **Commercial pilot license (aircraft)** |
| Total flight hours | **3,008 h** |
| Flight hours on the type | **350 h** |

## INJURIES

| INJURIES | Fatal | Serious | Minor/None |
|---|---|---|---|
| Crew | | | **1** |
| Passengers | | | |
| Third persons | | | |

## DAMAGE

| | |
|---|---|
| Aircraft | **Significant** |
| Third parties | **None** |

## FLIGHT DATA

| | |
|---|---|
| Operation | **Aerial work – Commercial – Firefighting** |
| Phase of flight | **Maneuvering** |

## REPORT

| | |
|---|---|
| Date of approval | **24 July 2013** |

[1] All times in this report are local.

# 1. FACTUAL INFORMATION

## 1.1. History of the flight

On Friday, 1 June 2012, an amphibious AT-802A aircraft, registration EC-KRF, capsized at approximately 16:45 in the Benagéber reservoir (Valencia) while in the process of taking on water because the landing gear was lowered.

The aircraft was based out of the Castellón Aerodrome, along with an AT802, and had been mobilized to help fight a fire that had broken out in the province of Valencia. After taking off at 16:00, it proceeded to the fire and made an initial drop, after which it headed to the Benagéber reservoir to take on water before returning to the fire. It was while reloading water that it suffered the accident.

After hitting the water the aircraft capsized, remaining in an inverted position. The pilot waited for the cockpit to flood and then left the aircraft under his own power. He was uninjured even though his life vest inflated unintentionally while he was still inside the aircraft. Once on the surface, he saw that the gear was lowered, and that that had been the cause of the accident.

The aircraft was towed to shore and lifted out with the help of a crane. It was placed upright on its landing gear. The gear was fully down and locked. There was significant damage to the aircraft, especially along its front section.

**Figure 1.** Condition of the aircraft after the accident

### 1.2. Personnel information

The pilot, a 47-year old Spanish national, had a valid medical certificate and a valid license at the time of the accident. Two months before the accident he had renewed his amphibious Air Tractor rating and a year before his agricultural rating, both of which were valid and in force at the time of the accident.

He had a total of 3,008 flight hours. In the previous month he had flown 2 h and 11 h in the previous three months. His last flight had been on 13 May with the accident aircraft.

In the last year he had flown mainly on the AT802A amphibious aircraft, and since 2008 he had worked exclusively on fighting fires. He was not a seasonal pilot, but rather flew this type of mission year-round.

As regards his training history, there is no record that he received training[2] on the procedure to follow in the event the cockpit floods. In a subsequent interview, the operator confirmed to this Commission its intention to hold courses for its crews in the underwater escape simulator at the Ministry of Infrastructure and Public Works´ Jovellanos Training Center.

### 1.3. Aircraft information

The aircraft had valid and in force registration and airworthiness certificates at the time of the accident. The aircraft and operator were authorized to carry out forest firefighting flights during the 2012 campaign.

There were 729 total hours on the aircraft and 334 on the engine at the time of the accident. The aircraft had last flown on 23 May.

In May 2008 the aircraft was converted into an amphibious configuration. The engine and propeller on the aircraft at the time of the accident were installed in January and March 2010, respectively. The aircraft and engine had last been inspected on 27 February 2012 (three months before the accident). A COMDES network terminal[3] was installed on 28 March 2012.

In the three months before the accident the aircraft had flown a total of 13 hours over 8 days.

[2] Such training is not required by regulations on aerial work.

[3] The COMDES network allows communication between aerial and ground units mobilizied on a forest fire, and with coordination centers which are responsible for its mobilization, assignation to a forest fire and supervision.
Among other characteristics, these devices have GPS and allow the supervision by the coordination centers. It is possible to send status messages from the aircraft (en route, in service, arrival to the base, withdraw or standby) and can issue emergency calls.

### 1.3.1. *Landing gear indication*

The amphibious AT802A had been operating in Spain since 2004. To convert a AT802 model into an amphibious one two floats are installed on it. Each float houses a nose wheel and the main gear, which features a dual wheel. The train is hydraulically actuated, powered by two electrical motors. The gear is locked mechanically.

The gear is not visible from the cockpit, so the aircraft has the following visual and aural gear position indication systems (Figure 2):

- Down and to the left, on a flat panel parallel to the floor, a set of 10 position lights next to the gear lever (1 in Figure 2):
  - 4 blue lights that are on when the gear is up and locked,
  - 2 red lights that are on when the pumps are on, meaning the gear is in transit, and
  - 4 green lights that are on when the gear is down and locked.
- An acoustic gear advisory every 3.5 seconds that, when the airplane's speed drops below a certain value set by the operator above a certain minimum, informs the pilot on the position of the gear:
  - If the gear is up and locked, the message "GEAR IS UP FOR WATER LANDING" is sounded using a female voice.
  - If the gear is down and locked, the message "GEAR IS DOWN FOR RUNWAY LANDING" is sounded using a male voice.
- Up and to the left is an amber GEAR ADVISORY light (2 in Figure 2) that turns on along with the preceding acoustic advisories. If the pilot flips this switch, the acoustic message stops.


Figure 2. Location of visual gear indications in the cockpit of the AT802A

### 1.4. Communications

The aircraft was tuned in to three frequencies in order to carry out its firefighting duties:

- The ATC frequency of the Castellón Aerodrome, where it was based. Once in the vicinity of the fire, this frequency was changed to that of the company.
- The frequency of the coordinating helicopter belonging to the aerial coordination unit charged with managing the other aerial resources dispatched to the fire. The coordination frequency for aerial resources is the same throughout the region of Valencia, meaning it does not change from province to province, and it was 130.500 MHz.
- The COMDES working group, which is specific for each fire. Aerial and ground resources allocated in a fire communicate using a COMDES working group. The working group is designated by the Coordination Center. In case of large fires, they are sectored and each sector is assigned a COMDES working group.

### 1.5. Survival aspects

In the accident the aircraft capsized and the cockpit started filling up with water. After the impact, the pilot was in an upside down position restrained by his safety harness. When he tried to unbuckle to turn right side up, the pull cord that protrudes from the vest and that is used to inflate it got caught and the vest inadvertently inflated.

The pilot was wearing a LIVEMAR life vest (Figure 3). It has two parts: an internal yellow part that inflates, and covering this part a red portion with harnesses used to fit the vest to the body. The vest is manually inflated by pulling on a tab that hangs some 5 centimeters below the bottom edge of the vest. The vest's specifications are as follows: "150N, Inflatable lifejacket ISO 12402-3" for the inflatable part and "Deck safety


**Figure 3.** Life vest used by the pilot in this accident

Harness Conforms to ISO 12401" for the harness. The vest does not make any reference to any certification standard for aviation vests (TSO or ESTO).

## 1.6. Tests and research

### 1.6.1. *Pilot's statement*

The pilot arrived at the base in Castellón the day before the accident at around 20:40. He had dinner at about 21:30 and went to bed at midnight. He woke up on the day of the accident at around 08:00. He was well rested. After breakfast, he started to prepare for the flight. He made the pre-flight inspection of the aircraft and completed the load and balance sheet. He also checked the weather forecast and the fire risk forecast, as well as the fire alert levels for the region of Valencia. He had lunch at 13:40.

At 15:45, while he was in his room, they were notified of a fire and told to dispatch the amphibious airplane. They were only told about the location of the fire and noticed that it practically coincided with that of the Benagéber reservoir. He checked the weather once more. He telephoned his company's operations manager to inform him of his departure, and the manager told him of the possibility that the reservoir would have a low water level, in which case he was to take on water at the Siete Aguas base. It was approximately 16:00 when he climbed into the cockpit. He was wearing a jumpsuit, kneeboard, helmet and life vest. After filling up with water he proceeded to the runway threshold. The helicopter that was carrying the firefighters to the fire site had just taken off.

While climbing after takeoff, the firefighter coordination center called the base to report the COMDES working group for the fire. The pilot then received a call from the base to inform him of this change, at which point he changed the group. This change involves several steps and, according to the pilot, is not easy as it requires a lot of attention, especially when flying solo. He was tuned in to the fire frequency[4], which generates a lot of noise in the cockpit, and he was communicating on the aerodrome's ATC frequency to report his position. When he reached a sufficient altitude, he reduced power and propeller pitch and raised the flaps, leaving the gear down. He was flying behind the helicopter that had taken off ahead of him.

When he reached the fire he contacted the coordination helicopter, which informed him he was number 5 and last in the sequence. At that time, the remaining air resources from the Siete Aguas and Enguera bases also arrived on the scene. He was the last to drop water and reported that he was going to the reservoir to scoop. Two other helicopters also went to the reservoir. The land resources went to a base.

[4] The fire frequency refers to the COMDES working group.

He performed the procedures and reconnoitered the reservoir to make sure he could scoop there. He did the final checklist, which includes checking the gear lights. When he did so, he thought he saw four blue lights, though the amount of smoke from the fire, the proximity of the green lights to the blue ones and the similarity of the colors could have confused him. The pilot described the scooping operation as one with a high workload due to the constant radio chatter on the frequencies he was tuned into, the constant monitoring of the other firefighting aircraft that were taking on water at the reservoir and the rising smoke that blocked the sun.

#### Impact and exiting from the airplane

He completed the checklist and approached the water. He immediately felt a strong impact and found himself upside down with the airplane stopped. He heard a whistling sound and turned off the power. He turned right side up inside the cockpit and just then his life vest caught on something and inflated. This produced him a lot of anxiety due to the oppression in his neck between the helmet and the vest. He removed his helmet and life vest and waited for the cockpit to fill with water. He took the emergency latches off the doors and tried to open them but could not due to the external water pressure. He grabbed the air bottle, tested it and tried to relax. When the cockpit was almost completely full, he kicked against on one of the doors while pushing with his back against the other side and managed to open it. The cockpit finished filling up, he put on the bottle and exited the airplane, at which point he saw the gear was extended. He climbed onto the float and waited to be rescued. He estimates it took one minute for the cockpit to fill up.

The pilot stated that the procedure to follow in the event the cockpit flooded had been explained to him. He had also heard a pilot say how breaking the window could be dangerous due to the risk of being cut by the glass, and also that there was not too much room to pass through.

### 1.6.2. *Prior events involving gear problems in amphibious airplanes and pilot evaluations of gear warnings*

Since its first operational use in Spain in 2004, a total of 39 events have been reported, of which 17 have been investigated by the CIAIAC. Of these 17, five were caused by the gear being incorrectly positioned for landing[5].

In the opinion of some pilots of both this operator and others that use this type of airplane in Spain, the design of the gear indication system is ineffective for two reasons.

[5] References CIAIAC: IN-035/2004, A-026/2005, A-050/2006, A-023/2011 and A-019/2012.

With regard to the position of the gear lights, they believe that by being situated on the left of the cockpit, they are not within the pilot's normal field of vision during operations. In addition, the horizontal plane in which they are located leads to confusion with respect to the forward-top aft-down association. What is more, the gear advisory system (light and aural notification) is not active just during landings; rather, since it depends on the speed, there are times during a flight when the speed is low enough that it activates. As a result they are "relatively used to" receiving this advisory several times during a flight and turning it off automatically or, on other aircraft, to receiving it too late.

### 1.6.3. *Information on life vest*

The use of a life vest for this type of operation is required by Spain's Air Traffic Regulations (RCA), which establish the need for every person onboard all airplanes flying over water to wear a life vest or an equivalent individual flotation device (RCA, Book 7, 7.2.5.3.1.a). The operator's Operations Manual also requires it and the Aircraft Flight Manual recommends it.

The aircraft's regulatory certification is FAR23, which in §23.1415b, Ditching Equipment, specifies the requirements that the life vest be approved[6].

The rules for certifying life vests are laid out in the certification standards. The American standard, TSO-C13f[7], is also used by the European standard ETSO-72c[8]. The design requirements for the inflation mechanism on the vest are listed in point 4.1.4.3.2[9] of the standard, which requires that the pull cord be visible and extend 3.8 to 7.6 cm below the edge of the vest. Each cord must end in a ring or red pull knob with rounded edges.

Vests certified as per TSO-C13f and having a design similar to the one worn by the accident pilot are shown in Figure 4. The orange vest on the left, for example, is used by another operator of this type of aircraft. The inflation mechanism is identical to that on the vest worn by the accident pilot (see Figure 3). The blue vest on the right has a different inflation system and is also TSO-C13f certified.

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[6] 23.1415.b) Each raft and each life preserver must be approved.
The equivalent to FAR23 in Europe is CD23, which has the same requirement (CS 23.1415b) for life vests as the equivalent requirement in the FAR23.

[7] Life preservers.

[8] Individual flotation devices.

[9] TSO-C13f. 4.1.4.3.2. Pull Cord Assembly: the mechanical inflation means must have a pull cord assembly for each gas reservoir. The pull cords must be identical in length, clearly visible, and extend between 1 1/2 to 3 inches below de edge of the life preserver. The end of each pull cord assembly must be attached to a red pull knob or tab having rounded edges.


**Figure 4.** Other models of TSO-C13f certified life vests

## 1.7. Organizational and management information

### 1.7.1. *Information on the operator Avialsa T-35*

Part A of the Operations Manual, Aerial Work, Firefighting[10], defines the process of mobilizing an airplane, it describes the dispatch process and communications on the scene. The following texts of relevance to this accident are taken from it:

- The mobilization order is conveyed to the pilot along with all the known information of relevance to the operation, such as: location of the fire, geographical coordinates, aerial resources involved, ground and air frequencies in use, means of aerial coordination, and others.
- One designated unit at the fire will be tasked with coordinating the aerial resources fighting the fire. This will normally be an air unit (helicopter or airplane circling above the fire area), though it can be a ground unit.
- Prior to arriving at the scene, the aerial resources will contact this coordination unit. Prior to taking off, all aerial resources shall know what the air coordination frequency is.

With regard to the landing gear, the operator, in Part b of its Operations Manual, specifies that the normal procedures to be used are those contained in the Aircraft Flight Manual. In these procedures, the position of the gear lever after takeoff and prior to reloading water is checked 5 times (landing gear UP-4 BLUE LIGHTS). The checklists are done from memory according to the operator.

The Aircraft Flight Manual contains several cautions and warnings regarding the prohibition of landing on the water with the landing gear partially or fully extended.

[10] Sections 14.3.3.7 and 14.3.3.8.

### 1.7.2. *Information on the Region of Valencia's Special Plan against the Risk of Forest Fires*

At the time of the accident, Valencia's regional government had in effect a Special Plan against the Risk of Forest Fires (PEIF), which defined the protocol and organization in the event of a forest fire. Appendices V (Directive for aircraft coordination) and VI (Directive for Communications) refer to the regulations for coordinating and communicating among firefighting aircraft, respectively. These include the following aspects of relevance to this accident:

- Coordination aircraft: this shall be a helicopter and shall provide support in the task of overseeing the firefighting efforts. The presence of the coordination aircraft depends on the number of resources mobilized which, in general, shall be four units, though this is not required. The coordination aircraft controls the movement of air resources in the fire area and responds to the instructions of the Fire Manager. It provides operating and holding instructions and establishes the order in which the aircraft conduct water drops.
- The working frequency (2.6 in Appendix V) in the Region of Valencia shall be 130.500 MHz. Aircraft responding to a forest fire shall report to the coordination aircraft on this frequency.
- If the resources assigned to a province are insufficient, the mobilization of additional air units in other provinces may be requested from the region or even from other autonomous regions (3.2 in Appendix V).
- The coordination directives shall be distributed to the companies awarded air resource contracts by the regional government to defend against forest fires (5 in Appendix V).
- Air resources shall communicate with the air resource coordinator on air band in direct mode (Appendix VI).
- The regional government requests that the TETRA working group be kept tuned in as it provides a redundant safety system.
- COMDES network objective is to allow communications of the emergency and security services in the Region of Valencia. Aerial units of the Region of Valencia are users of the COMDES network (3.3. in Appendix VI).

## 2. ANALYSIS

A firefighting operation is made highly complex by the short amount of time and information available to plan it, by the constant changes in the site where the flight is taking place, by the interaction with and awareness of other aircraft in the same environment, by the very nature of the water dropping and reloading activity, by the constant interactions with and interruptions from elements external to the flight and by the constant changes in priorities. It is a highly stressful situation that requires a lot of coordination with the other units involved, a great deal of attention to the environment and very precise maneuvering.

It is within this context that the following aspects of interest in this accident are considered:

- The supply of information to aircraft that, due to the very nature of the operation, is required to be done during the course of the flight.
- The need to prioritize flight activities during certain phases of the flight while delaying fire related activities to avoid interruptions.
- The constant communications in the cockpit due to being tuned in to the firefighters' frequency (COMDES working group).
- The efficiency of the landing gear system, in terms of its location and design, so as to alert the pilot to dangerous configurations.
- The need for pilot training or awareness on procedures in the event the cockpit floods.
- The design of the life vest inflation mechanism, due to the ease with which it can get caught in confined cockpits, like the one in this aircraft.

### 2.1. Supply of information to aircraft during fires

The mobilization of aircraft EC-KRF, an air resource in the province of Castellón, to help combat the fire that had broken out in the province of Valencia was considered in the Special Forest Fire Plan of Valencia's regional government.

Since this aircraft was mobilized in the initial stages of the fire, its pilot received information on two separate occasions. In the first, only the coordinates were given, and in the second, the COMDES working group for the fire. Although ideally all of this information would be available prior to dispatch so that it can be incorporated prior to takeoff, this is not always possible, especially in the initial phases of a fire. It is normal for this information to be supplied gradually. It is also not realistic to delay the takeoff until all of the necessary dispatch information is available, meaning a tradeoff is necessary between the rapid response of the aircraft and the safety of the operation.

In this case, due to each fire has a specific COMDES working group, the pilot should have been aware of the need to do this change, at some point during the flight.

Given the impossibility of fully planning the flight before taking off, since an inherent feature of these operations seems to be the constant receipt of information during the flight, it is essential that pilots prioritize flight over firefighting tasks during certain critical phases. When operating with amphibious airplanes, the takeoff and initial climb are regarded as a critical phase due to the operation of the landing gear.

### 2.2. Prioritizing flight activities to avoid interruptions

Aircraft EC-KRF received a call during the takeoff and initial climb to supply information on the fire. Due to this interruption, the checklist, including the item to raise the landing gear, was not completed. The pilot prioritized the call and interrupted a checklist that he did not resume. This interruption took place during a critical phase of flight, especially for an amphibious aircraft, on which the position of the gear is critical to safety.

While it is true that the lists include the check of the gear position five times before taking on water, and that the position should have been detected by the pilot had the lists been performed properly, the nature of the operation must be considered. When flying an amphibious aircraft, the gear is retracted immediately after takeoff and is not operated again until the aircraft returns to base, meaning this component is ignored during the operation. The constant coordination, the calls on the radio, the awareness of the position of the other aircraft and of the fire or the operation of the water loading and dumping systems are the priorities on these operations, and not the landing gear after takeoff. This is one of the reasons why, even though the check of the gear is on the list and the pilot performs it, as the accident pilot stated having doing, the attention paid to this item will not be the same as for the water scoops, for example, which are important at that point in the operation and the pilot assumes the gear is up, because it always is. In other words, the pilot will execute the list but he will expect to find everything in its expected position, making the check ineffective, as happened in this accident.

In addition, single-pilot cockpits lack the dual checks made in dual-pilot cockpits, meaning that both oversights and unchecked items go undetected. Furthermore, the lists are executed from memory and are not checked by reading the list. That is why, regardless of the design of the gear system, the measures taken should address improving or ingraining procedures and tools so that pilots can avoid situations like the one that took place in this accident and, if possible, to detect and correct said situations. With this goal in mind, safety recommendations are issued to the operator so that it take the measures needed to ensure that its pilots restart checklists from the beginning when they are interrupted, and so that it specify those moments during an operation, such as the takeoff and initial climb or when scooping, when the pilot can only perform flight-related actions to ensure they are completed.

The pilot, who was highly experienced on both this type of operation and aircraft, was rested, meaning that neither fatigue nor a lack of experience on the model are considered to have had any effect on the accident.

### 2.3. Excessive communications in the cockpit

The need for the pilot to be tuned in to the COMDES working group communications, in addition to the coordination frequency for aerial units and ATC frequency, warrants consideration in this accident.

From the aircraft operation point of view, references on the operator's Operations Manual and Valencian regional government PEIF are explicit. The aerial resources coordination unit is the sole intermediary for the aircraft and communications should take place using the coordination frequency (in this case on 130.500 MHz).

Clearly COMDES network has benefits in relation with management and safety aspects for all units involved in the fire, but in the case of aerial units and specifically in this case, those benefits are not as clear. This practice could make sense at times during a fire, such as when no organizational structure is defined for the fire and there is only one fire truck and one aerial resource and the firefighters on the ground do not have an air band radio. But in those situations where a coordination unit is assigned, the dual channel is redundant since, by definition, the coordination unit (be it air- or ground-based) is supposed to act as the sole intermediary for the aircraft and any instruction or directive to an air resource must be issued by this coordination unit, which also knows the location and status of the other resources.

Being tuning in on to a frequency of firefighters, in addition to the coordination and ATC or company frequencies, can make the pilots feel fatigued and tiresome, which should be taken into account.

When the size of the fire makes it necessary to call in air resources from another region, these logically will not have the COMDES network system onboard, since each region specifies its own protocols and requirements. In these cases, the non-use of a working group is not an impediment to the participation of these resources in firefighting activities, which are coordinated on an air band frequency.

As a result, a safety recommendation is issued to the regional government of Valencia to evaluate the benefit of indiscriminately using these dual communications channels (COMDES working group and the regional coordination frequency) at all times.

## 2.4. Design of the landing gear

The landing gear is critical on this aircraft due to the safety risk posed should this component be improperly positioned. Of the two possibilities, landing on the ground with the gear up or landing on the water with the gear down, the first does not pose a safety risk to the pilot because the damage is limited to the floats. Landing on the water with the gear down, however, is a very dangerous situation. The immediate consequence is capsizing in areas where the water can be made turbid by mud, for example. For this reason, this situation must be avoided using any means possible.

The technical resources on the aircraft and the procedures in the cockpit are the only barriers in place to detect an improper configuration, beyond possibly being alerted by other airplanes, which is not always possible.

As concerns the technical resources, the gear actuating and indicating system, as shown in Figure 2, is located in an area that is outside the pilot's field of view during firefighting activities. The pilot is looking outside, since firefighting operations are completely visual, and at the scoops panel during scooping operations. But the gear, situated below and to the left, will be outside his normal field of view.

In addition, the panel is oriented horizontally, that is, parallel to the floor. This layout is different from that in other retractable-gear aircraft in which the panel is oriented vertically and the gear is retracted or extended by raising or lowering the gear. In other words, there is a direct cognitive associative relationship between lever up-gear up and lever down-gear down. This is not the case on the amphibious AT802, however, since this relationship is lever forward-gear up and lever back-gear down. This association is neither direct nor intuitive. Feeling the position of the lever with the hand does not let the pilot quickly check the incorrect position of the gear, especially in a high stress situation such as firefighting.

The blue and green light colors are intended to associate green with the ground and blue with the water, which is intuitive. But the lights are also located outside the pilot's normal field of view.

In addition to the gear position indication system, the manufacturer installed a Gear Advisory system that provides visual and aural notifications. This system uses a female voice and a male voice, a system that is regarded as effective for distinguishing between different situations. In other words, the mere fact that a female voice is used, even if the content is not understood as it is in English, lets the pilot know without a shadow of a doubt that he is approaching the water, meaning that the gear is up. The only drawback to this system is that it does not always activate properly, as this depends on the speed setting which, if too high, can cause the notification to be sounded too often, causing the system to lose its intended alerting function. If, on the other hand, the speed is set too low, the warning could be received when the airplane is about to make contact and the lead time would be insufficient. In this regard, then, it is the operators who must ensure that the Gear Advisory system is properly calibrated and adjusted to the same speed on every aircraft so that pilots can expect the system to behave the same in all aircraft and can rely on the system to function properly in the event the gear is incorrectly configured.

Therefore, as concerns the aircraft's technical systems and improper gear configurations, the design of the gear actuation and indication system is regarded as providing a counterintuitive indication of the gear's position. It is also in a part of the cockpit that is not visible. The Gear Advisory system is regarded as employing elements that are easily discernible (male-female voice) that should be effective as long as the activation speed is properly set.

These considerations, then, lead to the issuing of a safety recommendation to the manufacturer to improve the design of the landing gear actuation, indication and/or advisory system. A safety recommendation is also issued to the operator to ensure it is cognizant of the effect the activation speed setting has on the proper operation of the Gear Advisory system.

### 2.5. Pilot training on cockpit flooding

At the time of the accident, the aircraft's landing gear was down and locked since its position had not been altered after takeoff. Once it was recovered from the reservoir, the aircraft was perfectly supported by the gear, which confirms it was fully locked and rules out the possibility that it was transitioning to another position. The pilot admitted his surprise when, on making it to the surface, he saw that the gear was down. There were therefore no problems with the operation of the gear in this accident.

The reaction of the aircraft in terms of capsizing upon making contact with the water with the landing gear down is normal. Experience from previous accidents has shown that this is the expected outcome. The pervasive warnings in the flight manual against making a water landing with the gear down is indicative of the danger posed by this situation.

Once in the water, the aircraft remained afloat thanks to the floats. As a result the cockpit is not deep under water but it is, nonetheless, completely submerged.

This situation is one of the most dangerous and operating with amphibious aircraft implies a greater risk that it will occur. Scooping maneuvers on this type of aircraft result in a constant exposure to this type of situation. Experience has shown that, even after eight years of operations in Spain, accidents continue to occur involving improper gear configurations and highly experienced pilots who are specialists on this type of aircraft and operation, as was the accident pilot.

Current aerial work regulations do not require any training on what to do in the event an airplane capsizes, and the operator did not specifically train its pilots on this situation. The pilot, however, was able to rely on his knowledge of another pilot's experience when making his decisions. He recalled the other pilot's experience and ruled out the option of trying to break a window. The pilot's reaction in this case was quite correct because he remained calm and proceeded to test the air bottle first. He positioned himself vertically and waited for the cockpit to flood, regaining his composure after the incident with the life vest.

In this situation, it is useful for pilots who fly this type of aircraft to know both the behavior of the aircraft and the time available until the cockpit is completely flooded, as well as the procedures and recommended and counterproductive actions in this situation. A safety recommendation is issued in this regard.

### 2.6. Design of the life vest inflation mechanism

The situation confronting a pilot who suddenly finds himself upside down in the water is one of high stress. Since this is an unexpected situation, the pilot must first determine what is happening, then take actions while upside down, release his harness, turn around, unlatch the doors, take the air bottle and wait for the cockpit to flood before attempting to exit. And he must do all of this very quickly, in around a minute, while keeping calm.

The accident pilot was not only faced with all of this, he also had to deal with the life vest unexpectedly inflating. The force exerted by the life vest with it inflated upwards against his helmet made him feel anguished, as he himself stated. He felt a large amount of pressure on his neck, which prompted him to remove both the vest and the helmet. This decision is regarded as correct as it allowed him to move and exit the aircraft. Another individual who may not have remained calm, and who thus would have been unable to complete all these actions, would probably have found it impossible to exit the aircraft with the life vest inflated. This is why inflating it is prohibited inside aircraft, as it impedes the exit of the person wearing it.

The fact that the cockpit of this aircraft, which is designed for one pilot, is very small in size and does not allow for much maneuverability, had a deleterious effect on this process.

The life vest inflated inside the cockpit because the inflation system, which in this case consists of a cord and a red pull tab hanging approximately 5 cm below the vest, was actuated. In such a small cockpit where the pilot is restrained upside down by the safety harness and in which the pilot is forced to move, it is relatively easy for this tab to get hooked on something, probably with the pilot's own safety harness.

The life vest is required by both the operator and by Spain's Air Traffic Regulations (RCA). The certification standard specifies that it must be an approved vest. The one worn by the pilot was not approved by any aviation certification standard and is the one used in maritime operations.

When the vest worn by the pilot was compared with vests certified by aviation standards, however, it was noted that some models have the same vest inflation mechanism. This means that even if the pilot had been wearing a TSO-C13F or ETSO-72c certified vest that relied on the same inflation mechanism, he would have had the same problem and the vest would have inflated.

This design for the activation mechanism in certified vests is logical when considering the standard as having to be applicable in a wide range of aviation scenarios. In this sense, the design of the vest with the cord and the red pull tab hanging down may be perfectly suitable for use as a life preserver by passengers in a large aircraft who do not have the training necessary to identify and actuate the inflation mechanism.

Other designs for this mechanism exist, however, that comply with the same certification standard (Figure 4 right) but that do not have a cord or other component that is susceptible to hooking on anything. From a safety standpoint, this design seems more appropriate for use in small spaces as it is less likely to be inadvertently actuated.

Thus due to the gravity of the situation that resulted, a safety recommendation is issued so that in aircraft with small cockpits, like the one in the accident airplane, life vests are used whose actuation mechanism is not susceptible to getting hooked and inadvertently actuating.

Lastly, this accident has demonstrated the efficacy of the helmet and safety harness, which kept the pilot from being injured during the impact, leaving him in a condition that enabled him to evacuate the aircraft.

## 3. CONCLUSIONS

### 3.1. Findings

- The operator, pilot and aircraft had the proper licenses, authorizations and permits to engage in the activity.
- The aircraft was mobilized to help combat a fire that had broken out in another province.
- The frequency for coordinating air resources is unique to the region of Valencia. In addition, the region of Valencia uses the COMDES network for the communications between aerial and ground resources allocated on a fire.
- The pilot was experienced in both the activity and aircraft. He was not an occasional pilot, devoting himself to firefighting exclusively.
- The pilot had rested before the flight.
- The pilot was wearing a life vest and helmet and was restrained by the safety harness.
- The pilot reacted properly, remaining calm when the cockpit flooded.
- The life vest inflated inside the cockpit when the inflation mechanism that hangs down some 5 cm got caught.
- The pilot properly handled the unexpected inflation of the vest inside the cockpit, taking it off so as to be able to exit the aircraft.
- The pilot attempted to scoop water with the landing gear down and locked.
- The landing gear was not retracted after takeoff and remained extended throughout the flight.
- The after takeoff checklist was interrupted and never completed, leaving the landing gear down.
- The interruption occurred to inform the pilot of a COMDES working group.
- The procedures have the pilot check the gear five times between takeoff and the water refill.
- The landing gear panel is situated in a part of the cockpit that is outside the pilot's normal field of view during operations.
- The positions of the gear lever are not cognitively easy to associate with the gear's actual position.

- The Gear Advisory system did not serve its warning function due to the mistrust generated by the fact that it often activates too frequently or too late.
- The activation speed of the Gear Advisory system is set by each operator on its aircraft, there being a minimum speed below which it cannot be set.
- There crews were not trained on gear flooding scenarios as such training is not required.
- The checklists are performed from memory.
- The operator was using life vests that were not certified as per the aviation standard.
- The life vests used by the operator had the same inflation mechanism as those certified as per the aviation standard. This inflation mechanism is at high risk of getting caught and inflating inadvertently.

### 3.2. Causes

The accident of aircraft EC-KRF occurred because the landing gear was down during the water refilling operation on the Benagéber reservoir. The gear had not been raised after takeoff because the relevant checklist was interrupted and not resumed. This gear-down configuration was not detected and corrected during the rest of the flight.

The following factors are regarded as having potentially contributed to the accident:

- The location in the cockpit of the landing gear panel beyond the field of view of the pilot during normal operations.
- The horizontal configuration of the landing gear panel which impedes associating the position of the gear lever with the gear's actual position.
- The ineffectiveness of the Gear Advisory System due to the improper setting for the activation speed.
- Lack of training in terms of the discipline to restart a checklist after an interruption.
- Lack of prioritization of the critical phases of flight with respect to the fire.
- The inherent pressure in firefighting operations to reach the fire site as soon as possible, and prioritizing this above the need to obtain the necessary information before takeoff.
- Lack of conscious awareness of the need to check the gear panel when executing procedures as it is not an important task during this phase of flight and as this component is not operated after takeoff until the aircraft returns to base.

The accident has also shed light on aspects involving the use of firefighting frequencies and the design of life preservers.

## 4. SAFETY RECOMMENDATIONS

**REC 40/13.** It is recommended that AVIALSA T-35, in an effort to avoid interruptions during phases critical to safety, since an inherent part of firefighting operations is that communications are constantly received throughout the flight, and since cockpits are occupied by a single pilot:

- Define which phases of flight are considered critical to flight safety (for example, those involving the retraction of the gear after takeoff).
- For said critical phases, draft operating procedures that minimize pilot interruptions until the aircraft is properly configured (for example, leaving the firefighting working frequencies inactive and having only ATC frequencies operational).
- For said critical phases, enhance its pilot training and instill in them the importance of prioritizing flight-related actions over other activities during certain phases of flight.
- Train its pilots so that if a checklist is interrupted, it is restarted from the beginning to avoid omitting any of its steps.

**REC 41/13.** It is recommended that AVIALSA T-35, given that the Gear Advisory system was not effective in alerting the pilot about the gear position:

- Revise the speed at which the Gear Advisory system notifications are activated in all the aircraft in its AT802A amphibious fleet so that it is consistent throughout its fleet without varying from one aircraft to the next, and so as to avoid either nuisance or excessively late alerts.

**REC 42/13.** It is recommended that the Regional Government of Valencia, considering the function of the coordination unit as the sole intermediary and manager of air resources during a fire:

- Review the need to use the COMDES working group and the 130.500 MHz frequencies in every case, considering, on the one hand, that the air resources coordinator should be, as per the PEIF, the sole intermediary for air resources and, on the other, the fatigue that having to monitor so many frequencies in a setting as stressful as a fire creates in pilots.

**REC 43/13.** It is recommended that Air Tractor, considering the safety consequences of an improperly positioned landing gear during scooping operations, improve the design of the actuating, indication and/or gear advisory landing gear system, in order to advise the pilot of improper position of the landing gear.

**REC 44/13.** It is recommended that Spain's Civil Aviation Directorate, considering the potential situations confronting pilots of amphibious aircraft in the event of an accident over water:

- Make the necessary regulatory changes to require operators of AT802 amphibious aircraft to provide practical or theoretical training to their pilots on the recommended procedures and techniques to use in the event an aircraft capsizes and the cockpit floods.

**REC 45/13.** It is recommended that Spain's Civil Aviation Directorate, considering the need for pilots of AT802 amphibious aircraft to wear life vests, their inflation mechanism and the small size of the cockpit:

- Make the necessary regulatory changes to require operators of AT802 amphibious aircraft to equip their pilots with life vests that are certified according to an aviation standard and whose inflation mechanism does not have any hanging cords that can get caught resulting in an inadvertent inflation.