Statens haverikommission
Swedish Accident Investigation Authority

Final report RL 2015:06e

Accident on Lake Vättern on 14 June 2014 involving the aircraft N5411Z of the model Cessna-TU206G.

File no. L-72/14

07/05/2015

SHK investigates accidents and incidents from a safety perspective. Its investigations are aimed at preventing a similar event from occurring again, or limiting the effects of such an event. The investigations do not deal with issues of guilt, blame or liability for damages.

The report is also available on SHK´s web site: www.havkom.se

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This document is a translation of the original Swedish report. In case of discrepancies between this translation and the Swedish original text, the Swedish text shall prevail in the interpretation of the report.

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Content

General observations

The Swedish Accident Investigation Authority (Statens haverikommission – SHK) is a state authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations are intended to clarify, as far as possible, the sequence of events and their causes, as well as damages and other consequences. The results of an investigation shall provide the basis for decisions aiming at preventing a similar event from occurring again, or limiting the effects of such an event. The investigation shall also provide a basis for assessment of the performance of rescue services and, when appropriate, for improvements to these rescue services.

SHK accident investigations thus aim at answering three questions: *What happened? Why did it happen? How can a similar event be avoided in the future?*

SHK does not have any supervisory role and its investigations do not deal with issues of guilt, blame or liability for damages. Therefore, accidents and incidents are neither investigated nor described in the report from any such perspective. These issues are, when appropriate, dealt with by judicial authorities or e.g. by insurance companies.

The task of SHK also does not include investigating how persons affected by an accident or incident have been cared for by hospital services, once an emergency operation has been concluded. Measures in support of such individuals by the social services, for example in the form of post crisis management, also are not the subject of the investigation.

Investigations of aviation incidents are governed mainly by Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and by the Accident Investigation Act (1990:712). The investigation is carried out in accordance with Annex 13 of the Chicago Convention.

The investigation

SHK was informed on June 14, 2014 that an accident involving one seaplane with the registration N5411Z had occurred on Lake Vättern near Visingsö, Jönköping county, the same day at about 14.00 hrs.

The accident has been investigated by SHK represented by Mr Jonas Bäckstrand, Chairperson, Mr Stefan Christensen, Investigator in Charge until 24 September 2014 and thereafter Mr Nicolas Seger, Mr Ola Olsson, Technical Investigator (aviation), Mr Jens Olsson, Investigator Behavioural Science, Mr Urban Kjellberg, Investigator specializing in Fire and Rescue Services.

The investigation team of SHK was assisted by Ms Liselotte Yregård as a medical expert.

Mr John M Brannen has participated as accredited representative on behalf of the National Transportation Safety Board (NTSB), United States, and Mr Jens Eisenreich has participated on behalf of the German Federal Bureau of Aircraft Accident Investigation (BFU).

Mr Magnus Axelsson of the Swedish Transport Agency has participated as an adviser.

Ms Helena Nässlander of the Swedish Civil Contingencies Agency (MSB) has participated as an adviser.

The following organisations have been notified: the European Aviation Safety Agency (EASA), the European Commission, the Swedish Transport Agency (Transportstyrelsen), the National Transportation Safety Board (NTSB), United States, and the German Federal Bureau of Aircraft Accident Investigation (BFU).

Investigation material

Interviews have been conducted with the co-pilot, a relative of the commander and with two witnesses.

Interviews have also been conducted with personnel at JRCC, at the municipal rescue services and at the Swedish Sea Rescue Society (Sjöräddningssällskapet).

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Aircraft:	
Registration, type	N5411Z, Cessna 206
Model	Cessna TU206G
Class, Airworthiness	Normal, Certificate of Airworthiness
Owner	Aircraft Guaranty Corp Trustee, Texas, United States
Time of occurrence	14/06/2014, about 14.00 hrs in daylight Note: All times are given in Swedish daylight saving time (UTC[1] + 2 hours)
Place	Lake Vättern near Visingsö, Jönköping county, (estimated position 5807N 01426E, 88 metres above sea level)
Type of flight	Private
Weather	According to SMHI's analysis: wind north to northeast 15 knots, gusting around 25 knots, visibility >20 kilometres, no cloud below 5 000 feet, temperature/dewpoint +15/+5°C, QNH[2] 1018 hPa. Significant wave height estimated to be 1 metre with a maximum wave height of 1.5 metres. Wind-driven surface water flow, primarily south-southeast direction, calculated to be 3-7 cm/s (0.06-0.14 knots).
Persons on board:	2
crew members including cabin crew	2
passengers	0
Injuries to persons	1 fatal, 1 minor
Damage to aircraft	Substantially damaged
Other damage	None
Commander:	
Age, licence	72 years, PPL (A)[3]
Total flying hours	2 428 hours, of which 109 hours on type
Flying hours previous 90 days	2 hours, of which 1.5 hours on type
Number of landings previous 90 days	4, of which 2 on type
Co-pilot:	
Age, licence	75 years, PPL (A)
Total flying hours	1 823 hours, of which 1 312 hours on type
Flying hours previous 90 days	6 hours, of which 6 hours on type
Number of landings previous 90 days	7, of which 3 on type

[1] UTC (Coordinated Universal Time).
[2] QNH (Barometric pressure at mean sea level).
[3] PPL (Private Pilot Licence Aeroplane).

SUMMARY

The accident occurred on the lake Vättern and involved an amphibious aeroplane of the model Cessna TU206G with registration marks N5411Z. After landing both pilots decided to stop flying due to rough sea and put on the life vests. The engine was shut off in order to sail backwards to the island Visingsö. The water rudders were left in the down position which caused the aeroplane to turn sideways across the wind and turn over. The pilots exited the aircraft.

The commander was killed and the cause of death was drowning. The co-pilot swam ashore. The alert about the accident was delayed as the co-pilot was able to call 112 after more than two hours.

The commander's life vest was dark blue and of the type sailing vest. Rescue operations were carried out under the command of JRCC and subsequently also by the Police Authority.

Both the aircraft and the commander were discovered by private individuals.

There are no requirements regarding the design and colour of life vests used in Swedish-registered amphibious aircraft and seaplanes.

The accident was caused by the water rudders remaining lowered when the engine was shut off in order to sail backwards under the prevailing weather conditions.

Safety recommendations

The Swedish Maritime Administration is recommended to:

- Facilitate the work to search for crashed aircraft in inland lakes where central government responsibility for air rescue services exists by developing existing or new aids for the calculation and analysis of how crashed aircraft and persons move in the water due to current winds and currents. *(RL 2015:06 R1)*

The Swedish Transport Agency is recommended to:

- Investigate whether there is reason to introduce, augment or modify the requirements regarding the colour and function of life vests required in aircraft not covered by Part CAT of Regulation (EU) 965/2012. *(RL 2015:06 R2)*

EASA is recommended to:

- Investigate whether there is reason to introduce, augment or modify the requirements regarding the colour and function of life vests required in aircraft not covered by Part CAT of Regulation (EU) 965/2012. *(RL 2015:06 R3)*

1. FACTUAL INFORMATION

1.1 Statement of the cource of events

1.1.1 Circumstances

The purpose of the flight was to practise take-off and landing on water. The floats were drained before take-off.

After refuelling at Feringe/Ljungby Airport, the aircraft took off and flew towards Vättern to carry out the exercises. The intention was to then fly to Visingsö Airport.

1.1.2 History of the flight

The commander landed on Vättern at Erstadviken, northeast of Visingsö, which was observed by two witnesses. At touchdown, the aircraft bounced and a go-around was performed. The co-pilot assumed control of the aircraft, flew north and landed again on Vättern, this time north of Visingsö.

After the landing, the commander once again assumed control of the aircraft. The crew agreed to abort the landing exercises because the lake was rough.

The co-pilot has declared that he pointed out that there were two options; to take off again as soon as possible or to taxi forwards in a northeasterly direction by means of the engine. The commander decided to sail backwards towards Visingsö with the engine shut off.

The co-pilot has declared in interviews that he did not consider it was a good idea to sail backwards. He has also declared that the wave height was 30-40 cm, that the waves were long, but that these never washed over the floats. Both crew members put on the life vests.

Shortly after the engine had been shut off, the aircraft slowly tipped over to the right and ended up upside down in the water.

The co-pilot opened the window on the left door to let in water. He then helped the commander to release the safety belt. Both exited the aircraft through the left front door and went up to the surface of the water.

The co-pilot began to swim in a direction towards Visingsö. He looked at his watch when he discovered that the commander was not following after and noted that it was 14.11. He has declared that it had then gone about five minutes since they left the aircraft. The co-pilot swam back to the commander and discovered that he was lying lifeless face down in the water. His impression was then that the commander had perished. The co-pilot was a doctor by profession.

The co-pilot swam once more towards land and reached, in his view, the shore on Visingsö after about two hours. He has stated that he attempted to get up but collapsed. Thereafter, it took him about ten minutes to crawl two metres from the shore's edge as far as a green field. He could not get up but rolled himself forwards, with breaks, in a direction towards a farm that he discovered in the distance. He attempted to walk but fell again and again, moved towards the farm, and met a person who called 112.

The commander's body was found the day after the crash on Vättern's surface.

The accident occurred at the estimated position 5807N 01426E, 88 metres above sea level.

1.2 Injuries to persons

	Crew members	Passengers	Total on-board	Others
Fatal	1	-	1	-
Serious	-	-	0	-
Minor	1	-	1	Not applicable
None	-	-	-	Not applicable
Total	2	0	2	-

The commander was killed in the accident.

The forensic examination suggests that the cause of death was drowning. The examination also shows that the commander sustained superficial injuries to the head which had arisen through impact against a hard surface in connection with the accident.

The co-pilot became hypothermic after having swum for about two hours after the accident. Upon arrival at hospital, he was conscious and had a body temperature of 35.1 degrees Celsius.

1.3 Damage to aircraft

Substantially damaged.

1.4 Other damage

Some discharge of oil and fuel may have occurred.

1.5 Personnel information

1.5.1 Commander

The commander, was 72 years old and had a German EU[4] PPL (A) licence and a CRI SEP (sea)[5] with flight operational and medical eligibility. The commander also had a United States certificate that was valid provided that the German certificate was valid. At the time the commander was PF[6].

Flying hours				
Latest	24 hours	7 days	90 days	Total
All types	1	1	2	2 428
Actual type	1	1	1.5	109

Number of landings actual type previous 90 days: 2.
Type rating concluded in 2009.
Latest PC[7] (proficiency check) conducted on 30 Month 2013 on seaplane.

1.5.2 The co-pilot

The co-pilot, was 75 years old and had a German PPL (A) licence with flight operational and medical eligibility. The co-pilot also had a United States certificate that was valid provided that the German certificate was valid. At the time the co-pilot was PM[8].

Flying hours				
Latest	24 hours	7 days	90 days	Total
All types	5	6	6	1 823
Actual type	5	6	6	1 312

Number of landings actual type previous 90 days: 3.
Type rating concluded in 1989.
Latest PC conducted on 8 October 2013 on C172.

The co-pilot has stated during interviews that the commander was very experienced and judicious. No information has emerged regarding the commander's previous experience of sailing backwards with a seaplane.

[4] EU – European Union.
[5] CRI SEP (sea) (Class Rating Instructor).
[6] PF (Pilot Flying).
[7] PC (Proficiency Check).
[8] PM (Pilot Monitoring).

1.6 Aircraft information

1.6.1 The aircraft

The aircraft is a high-winged amphibious aircraft that can land on both land and water (see Figure 1). The aircraft has a span of approximately eleven metres. It is equipped with a turbocharged six-cylinder piston engine with fuel injection and a three-blade propeller.

Figure 1. The aircraft in question. Photo: Jens Wiemann.

TC-holder	Cessna Aircraft Company
Model	TU206G
Serial number	U20606109
Year of manufacture	1981
Gross mass, kg	Max authorised 1 633, current 1 600
Centre of gravity	Within limits
Total flying time, hours	2 226
Flying time since latest inspection	6
Type of fuel uplifted before the occurrence	100LL

Engine	
TC-holder	Continental Motors Inc.
Type	TSIO-520-M7B
Number of engines	1
Serial number	291719-R
Total operating time, hours	920
Operating time since overhaul, hours	6

Propeller	
TC-holder	Hartzell Propellers Inc.
Type	PHC-J3YF-1RF
Serial number	FP520A
Total operating time, hours	No information
Operating time since overhaul, hours	427

Deferred remarks	None

The aircraft had a valid Certificate of Airworthiness issued by the federal aviation authority in the United States.

1.6.2 Floats

The aircraft was equipped with amphibious floats of the model Wipline 3730 that were installed in accordance with Supplemental Type Certificate SA18GL.

1.6.3 Water rudders

Retractable water rudders are mounted on the rear part of each float. The water rudders are interlinked with the rudder pedals by a system of cables and springs. The water rudders are used for taxiing on water.

During sailing, i.e. when the aircraft is being manoeuvred backwards on the water, the water rudders are to be retracted up. There is a control for retracting the rudders on the floor between the pilot's seats.

According to instructions in the flight manual supplement and according to the type certificate, the water rudders should be retracted during sailing. In addition, a placard with the text "WATER RUDDER ALWAYS UP EXCEPT WATER TAXIING" shall be installed close to the control for the water rudders.

1.6.4 Limitations

The aircraft's manual specifies a limitation regarding a maximum crosswind component of 20 knots.

The manual does not specify other limitations regarding wind speed or wave heights.

1.7 Meteorological information

According to SMHI's analysis: wind north to northeast 15 knots, gusting around 25 knots, visibility >20 kilometres, no cloud below 5 000 feet, temperature/dewpoint +15/+5°C, QNH 1018 hPa.

Significant wave height estimated to be 1 metre, with maximum waves of 1.5 metres.

Wind-driven surface water flow, primarily south-southeast direction, calculated to be 3-7 cm/s (corresponding to 0.06-0.14 knots).

1.8 Aids to navigation

Not applicable.

1.9 Communications

On the way towards Visingsö, the aircraft passed to the east of Jönköping control zone. At the time of the accident, the air traffic control tower in Jönköping was not manned. The air traffic controller who was on duty before the event has no recollection of having seen or heard the aircraft in question earlier that day.

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders

1.11.1 Flight Recorders (GPS[9])

A GPS in the form of an Ipad was used during the flight. It has not been possible to read out data afterwards.

Two panel-mounted GPS units of the type Bendix/King KLN 90 have not been possible to read out.

1.11.2 Radar data

SHK has consulted the Swedish Armed Forces regarding radar data for the aircraft's route. However, the aircraft's actual route has not been possible to establish.

1.12 Accident site and aircraft wreckage

1.12.1 Accident site

Lake Vättern in the area northeast of the northern point of Visingsö.

1.12.2 Aircraft wreckage

After the accident, the aircraft came to float upside down in the water (see Figure 2 under Section 1.15.3).

After the aircraft was found, it was towed to the harbour in Gränna, where an initial technical examination was conducted. The aircraft was later conveyed to a nearby hangar, where the examination was completed.

[9] GPS (Global Positioning System).

The aircraft had substantial compression damage to the upper and lower side of the right wing, from the wing tip and about one and a half metres in. The damage was similar on both sides of the wing.

There was minor damage on the underside of the left wing flap at the wing root.

During the salvage operation, damage arose to the propeller spinner and its attachment plate as well as damage to the upper part of the rudder.

Upon examination, the following configuration of the aircraft was concluded:

- Wing flaps retracted
- Water rudders lowered
- Throttle in idle position
- Mixture control in the rich position
- Ignition off
- Transponder in the off position

The remaining quantity of fuel that was drained from the wing tanks amounted to approximately 200 litres.

The investigation revealed that there was no mandatory placard that is to indicate that the water rudders shall always be retracted except when taxiing on water.

1.13 Medical and pathological information

The commander had valid medical eligibility. The latest aeromedical examination was performed on 1 April 2014.

Nothing has emerged to suggest that the commander's state of health had deteriorated after this or that any illness should have contributed to the accident. The commander was, according to interview information, healthy and physically active at the time of the accident.

Forensic chemistry analysis demonstrated no presence of alcohol, medicines or drugs.

The co-pilot survived the accident. He had a pacemaker on account of problems with cardiac arrhythmia, but was free of medicine.

1.14 Fire

There was no fire.

1.15 Survival aspects

1.15.1 Provisions on rescue services

Provisions on rescue services are found primarily in the Civil Protection Act (2003:778) and the Civil Protection Ordinance (2003:789), in the following referred to by use of the their acronyms in Swedish, LSO and FSO respectively.

According to Chapter 1, Section 2, first paragraph of LSO, the term "rescue services" denotes the rescue operations for which central government or municipalities shall be responsible in the event of accidents or imminent danger of accidents, in order to prevent and limit injury to persons and damage to property and the environment. Central government is responsible for mountain rescue services, air rescue services, sea rescue services, environmental rescue services at sea and rescue services in case of the emission of radioactive substances, as well as for searching for missing persons in certain cases. In other cases, the authorities of the municipality concerned are responsible for the rescue services (Chapter 3, Section 7, LSO).

The Swedish Maritime Administration is responsible for the air rescue services led from Sweden's Joint Rescue Coordination Centre, JRCC. Lake Vättern is part of the areas in which JRCC is, under the provisions, responsible for rescue services with search and rescue in the event of aircraft crashes. Guidelines for sea and air rescue services are contained, among other places, in IAMSAR[10] Volume II.

Regulator for air rescue services is the Swedish Transport Agency (Chapter 5, Section 1, FSO).

1.15.2 Incoming alerts about the event

The co-pilot got to land on the northern point of Visingsö. There he encountered at a private individual who called 112 at 18.32 hrs on the day of the accident. The telephone call was connected with the Air Rescue Coordinator at JRCC, who took over the interview from the emergency operator at SOS Alarm. The conversation revealed that an aircraft with two persons on board, after landing on Lake Vättern, had turned over five to ten nautical miles[11] north of Visingsö. Both the commander and the co-pilot got themselves out of the aircraft, and the co-pilot had swum for about two hours in order to reach land. He assessed that the commander had perished as he had floated lifeless in his life vest face down in the water. The aircraft was reported to have probably sunk. The co-pilot had himself left his life vest on the shore, where it was later found (see Appendix 1 figure B1) by rescue

[10] IAMSAR (International Aeronautical and Maritime Search and Rescue Manual).
[11] Nautical mile – 1 852 metres.

services personnel. The interview was ended when rescue services personnel from Visingsö arrived at the site and took care of the co-pilot.

1.15.3 Rescue operation for air rescue services

Assessment of the event and outgoing alert

At JRCC, the event was classified as an emergency, and a rescue operation for air rescue services was initiated in order to locate the aircraft and the missing commander and to rescue him. The rescue helicopter Lifeguard 901 from Gothenburg and the Swedish Sea Rescue Society's rescue units in Vättern, RESCUE CAMBIO, RESCUE SKEPPSKÄR and RESCUE GUSTAF OLSSON were alerted.

From SOS Alarm, an alert was issued to the Jönköping Fire and Rescue Service with rescue units from the fire stations Visingsö, Gränna and Jönköping. The ambulance service was alerted with, among other things, two ambulances. The police authority was informed of the event and sent several police patrols and a police operation commander to the operation.

The first search area along a track

At around 19.00 hrs, according to directives from JRCC, a first search for the aircraft was organised along a track (see Appendix 1, figure B1) in a northeasterly direction (35 degrees) from the northern tip of Visingsö out to 5 nautical miles (about 9 km) in Vättern. At the time, the wind was northerly with a wind strength of 4 m/s. There was also a direction of current in the water from north to south.

The second search area

At JRCC, a second search area (see Appendix 1 figure B2) was established, which was 2.5 nautical miles long (about 5 km) and extended around the northern point of Visingsö. The size of the area was determined on the basis of an analysis of how far the surviving person probably could have swum during the two hours that had been stated. Radar positions from the aircraft were sought at the Swedish Armed Forces in order to obtain a more precise position for the landing, but no results could be obtained as no radar stations around Vättern had been active. The co-pilot, who was transported by ambulance to the hospital in Jönköping, stated in a supplementary interview conducted by the police that the missing commander had jeans, a dark sweater and was wearing a blue life vest which was probably a sailing vest and had no capacity to hold a head above the surface of the water. The co-pilot further stated that he was a good swimmer, but that the commander's swimming skills were poorer. The current water temperature was measured to be 13-14 °C. This temperature was assessed at JRCC to entail a longest theoretical survival time of about 20 hours, according to data from IAMSAR II.

The passenger vessel and steamer TRAFIK was in the vicinity of the area and offered to participate in the search. At most, there were a total of six surface units, which were formed like a rake with a certain distance between the boats and which searched within different areas that were allocated from JRCC. The surface units were coordinated by the master on RESCUE CAMBIO, who had been appointed OSC[12]. The municipal rescue services and the police as well as an ambulance set up a command site in Gränna harbour to provide on-site assistance to the Rescue Coordinator at JRCC with the operational command of the air rescue operation. From the command site, a number of observations were also made of various objects in the water, which were controlled by the rescue helicopter or by boat.

Liaison

The liaison between participating units, SOS Alarm, internal command at Jönköping Fire and Rescue Service, the police's county communications centre, LKC, and JRCC was largely conducted via Rakel[13]. In this way, it was possible for the various units to directly hear and apprise themselves of each other's conversations containing important information that was reported. However, the rescue helicopter lacked the opportunity to communicate via Rakel, and major disruptions arose when attempts were made to communicate via VHF[14] channel 67. Communication with the helicopter was therefore mostly conducted by means of telephone to and from JRCC.

The aircraft found

A private individual called 112 at 20.16 hrs and stated that from his home in Gränna he saw an object that was floating on the surface of the water between Gränna and Visingsö. SOS Alarm put the call through to JRCC. The object had drifted from the north and was at the time in the vicinity of the ferry line between Gränna and Visingsö. The rescue helicopter, which at the time was searching outside the northern tip of Visingsö, was redirected to the specified location and found the aircraft in position 58 02N 014 25E (see Appendix 1 figure B2). The aircraft was floating upside down, and only parts of the floats with respective water rudders were visible above the surface of the water, see Figure 2. The rescue helicopter's rescue swimmer dived down and checked the cabin but no person was discovered. At a later stage, the cabin was also checked by a rescue swimmer from the rescue services. Neither on that occasion was any person discovered in or near the aircraft.

[12] OSC (On Scene Coordinator) - A person who on behalf of the Rescue Coordinator at JRCC coordinates and leads direct operations within an established geographic area.
[13] Rakel - Radiokommunikation för effektiv ledning (Radio Communication for Effective Command and Control).
[14] VHF (Very High Frequency) - Frequency range for radio.

Figure 2. The aircraft was found floating upside down. Photo: Swedish Maritime Administration, Lifeguard 901.

Simulation program Seatrack Vättern

Where necessary in its operations, Jönköping Fire and Rescue Service uses a simulation program, Seatrack Vättern,[15] for the monitoring of substances that are moving and spreading in Vättern. The program was used for this aircraft crash to calculate and present how the aircraft moved after it turned over on the basis of an approximate landing position in the lake. When the aircraft was found, the position in question was compared with the calculation model's result, which at the time had just been completed. It turned out that the aircraft's actual site of discovery and the model's calculated position corresponded well with each other. Several calculations were also made regarding how a floating person would move under the prevailing conditions. The results from the model suggested in this case that a person ought to float ashore on the beach south of Gränna below Röttle, which is level with the southern point of Visingsö. However, no one was found within this area.

The third and fourth search areas

After the aircraft had been found, JRCC gave a new third search area (see Appendix 1, figure B2). The area was determined in light of the site where the aircraft was found and was limited to the south by the aircraft's discovery site and in the north by the area outside the northern tip of Visingsö. Shortly thereafter, the search area was moved to a new fourth area (see Appendix 1 figure B3), which was limited by

[15] Seatrack Vättern – A version of SeaTrack, which is a program for particle tracking in water produced by SMHI.

the southern point of Visingsö and in the north adjoined search area 2. Shortly after 21.00 hrs, the wind in the area had completely subsided. The rescue services and the police conducted searches along the occasionally steep and inaccessible shore north and south of Gränna.

Conclusion of air rescue services

Recorded radio and telephone traffic shows that the Rescue Coordinator at JRCC planned to terminate air rescue services at nightfall. The background was the difficulties in searching in darkness, the information from the co-pilot who had assessed that the commander had perished as he was floating lifeless in his life vest and the time of about 4.5 hours that had elapsed during the operation. The rescue helicopter and the surface units had searched under very good conditions with little waves and clear weather with good visibility without cloud. The view was that if there had been any floating person in the area, this person would have been found.

IAMSAR II contains instructions stating that it should be explicitly noted when an operation is concluded and a missing person has not been found. The Rescue Coordinator concluded air rescue services at 23.02 hrs as the area was assessed to be well searched from both helicopter and surface units. The log at JRCC states that air rescue services were terminated at nightfall on account of the time that had elapsed and the co-pilot's information that the missing person had probably perished.

1.15.4 Continued search for the missing commander

After air rescue services were concluded, the Jönköping County Police Authority commenced rescue services at 23.25 hrs on 14 June 2014 with a search for missing persons according to LSO. The rescue operation was carried out as a continuation of the special event[16] already initiated in conjunction with the police assisting JRCC during air rescue services. During the police's rescue operation, dog patrols and the police's helicopter, among others, participated in the search along prioritised parts of Vättern's shore. The operation was also carried out with assistance from the municipal rescue services, which searched by boat. The police concluded its search at 13.28 hrs on 15 June 2014, approximately 19 hours after the alert about the event, without the missing commander having been found.

1.15.5 How the missing commander was found

The day after the aircraft crash, during the afternoon of Sunday 15 June 2014, the steamer TRAFIK was according to its list of sailings on the way back from Visingsö to Hjo. One of the passengers discovered in the distance something dark in the surface of the water. The vessel steered towards the specified location, where the

[16] Special event - Event deemed by the police to be particularly extensive or serious according to the National Police Board's regulations and general advice (RPSFS 2006:14) on special events (FAP 201-1).

commander of the aircraft was found floating and deceased in his inflated life vest. The commander was taken on board the steamer and was subsequently retrieved by the Swedish Sea Rescue Society's rescue boat RESCUE CAMBIO for onward transportation to the harbour in Gränna. According to the crew of TRAFIK, the deceased person was found about three nautical miles, approximately 5.5 km, north of Visingsö at position 58 09N 014 23E (see Appendix 1 figure B1).

1.15.6 Survival possibilities

Emergency Locator Transmitter

The Emergency Locator Transmitter (ELT[17]) of the type AF model DM ELT 6.1 was not activated.

Life vests

The commander's life vest was dark blue of the brand Stormy Seas. It is a type of vest that lacks the ability to keep the head above the surface of the water and turn the person to the supine position. The life vest is equipped neither with crotch strap nor support collar. The life vest is inflatable by means of a carbon dioxide cartridge that is activated manually. The carbon dioxide cartridge was exhausted. There was a whistle in one of the side pockets. The life vest was inflated when the person was salvaged from the water.

The co-pilot was wearing a yellow life vest with neck collar. The vest can be equated with a life preserver. It was inflated when it was found on the shore.

The Federal Aviation Administration in the United States (FAA) recommends that seaplanes for private use be equipped with life vests that are approved by the FAA or the United States Coast Guard. Furthermore, the FAA proposes that operators should consider having a policy that entails that all persons on board have put on an inflatable life vest when seaplanes are operated on or in the proximity of water. The FAA has also recommended that a life vest with a bright colour be used because this increases the possibilities for rescue.

The Swedish Civil Aviation Authority's regulations and general advice (LFS 2007:58) on private flying with aircraft state the following: “When taking off and landing on water with amphibious aircraft and seaplanes, all persons on board shall have put on life vests.” According to the same regulation, seaplanes and amphibious aircraft shall, when taking off and landing on water, be equipped with, inter alia, a life vest for each person on board. The regulations apply to Swedish-registered aircraft. There are no requirements or instructions regarding the design or colour of life vests.

[17] ELT (Emergency Locator Transmitter).

When it comes to commercial air transport, Part CAT[18] of the Regulation (EU) 965/2012[19] refers to the Regulation (EU) 748/2012[20] laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances. The regulation states that life jackets used in commercial air transport shall meet the requirements set by ETSO[21] C13f. These requirements mean, among other things, that the life jacket should turn the user into a supine position in five seconds and that the colour of life jacket must be orange-yellow.

1.16 Tests and research

1.16.1 The aircraft's yaw stability in the water

Information from the float manufacturer

According to the float manufacturer, the water rudders are designed to provide a neutral or positive stability during forward motion with the engine running. The water rudders then interact with the vertical stabilizer that is helped by the propeller wash.

When the aircraft moves backwards in the water, the water rudders take over the authority from the vertical stabilizer because the water rudders' force becomes greater than the forces on the vertical stabilizer.

The aircraft's backward motion on the water can cause a yaw into crosswind which increases the risk of the aircraft tipping to the side.

The manufacturer has apprised itself of facts surrounding the event in question and has submitted the following explanation: During the event in question, the engine was shut off, upon which the aircraft's backward motion caused a negative stability of the water rudders. The water rudders, through their design, have thereby not been able to function as intended. The manufacturer has furthermore explained that the water rudders have probably reached their full deflection after they had been manoeuvred to the left or right, and subsequently become impossible to correct.

The manufacturer has also pointed to the following text in the flight manual supplement that is applicable to the amphibious version:

[18] CAT (Commercial Air Transport).
[19] Commission Regulation (EU) No 965/2012 laying down technical requirements and administrative procedures related to air operations pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council.
[20] Commission Regulation (EU) No 748/2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations.
[21] ETSO (European Technical Stardard Order) - The European Technical Standard Order is a detailed airworthiness specification issued by the European Aviation Safety Agency to ensure compliance with the requirements of this Regulation as a minimum performance standard for specified articles.

"Even if taxiing is very simple with the water rudders, it is sometimes necessary to sail the amphibious aircraft under conditions of high wind forces. In addition to conventional flight controls, flaps and cabin doors will assist in sailing. The water rudders should be retracted during sailing."

Finally, the manufacturer has concluded that it is probable that the aircraft became unstable when the water rudders were lowered.

Sailing and yaw stability in the water

Sailing with a seaplane means that the aircraft can be manoeuvred on the water with the wind as the primary driving force. The weathervane effect causes the aircraft's nose to be directed into the wind, which in turn means that the aircraft normally moves backwards.

Sailing can be performed with the engine running or with the engine shut off. With the engine shut off, the aircraft will move backwards faster at a given wind speed than with the engine running. When the engine is shut off, there is no possibility to reduce the speed backwards.

When a float-equipped aircraft floats in the water with the engine shut off and with the water rudders lowered, two counteracting moments arise in the yaw plane. The wind that hits the aircraft's vertical stabilizer wants to turn the aircraft's nose into the wind. The wind will drive the aircraft backwards through the water. The water current over the floats then hits the water rudders, which want to turn the aircraft's nose from the wind (see Figure 3).

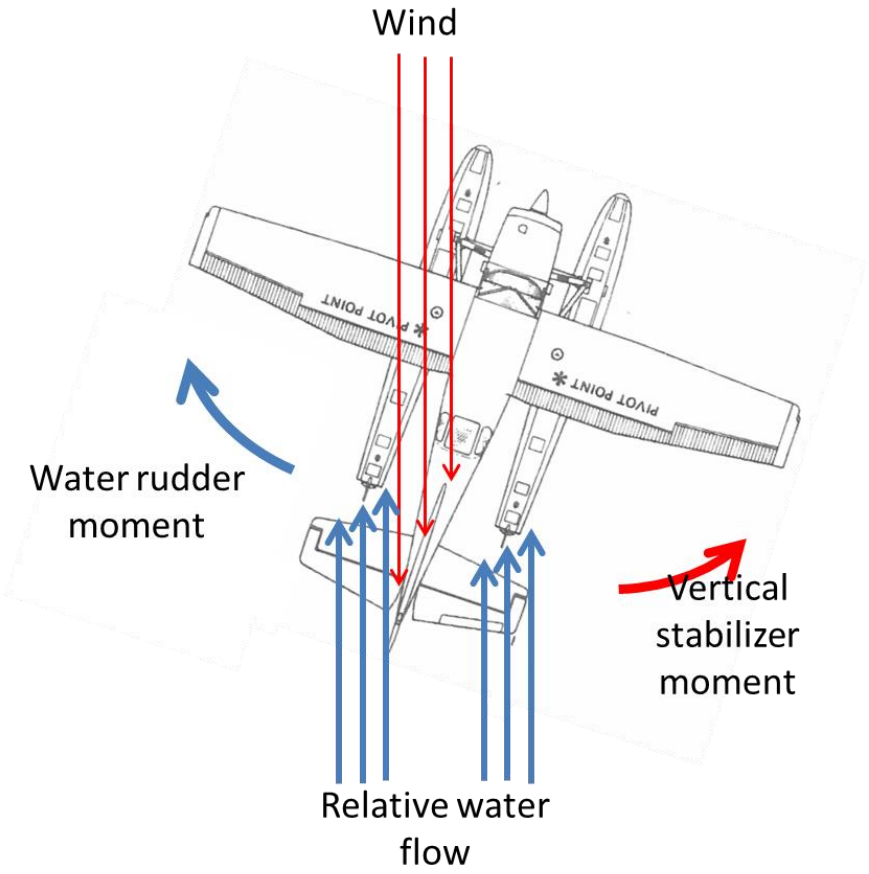


Figure. 3. Moments acting on the aircraft.

Which of these two moments will be the greatest depends on the wind speed and the speed through the water. Since water has a density that is about 1000 times greater than air, it will suffice with a speed through the water much lower than the wind speed for the moment from the water rudders to be greater than the vertical stabilizer's moment. Rough estimates performed by SHK show that at a wind of 15 knots, it will suffice with a speed of about 2 knots through the water for the moments to balance.

1.16.2 Hydrostatic pressure and the wing's compression damage

Hydrostatic pressure refers to the pressure caused by a liquid (e.g. water). The hydrostatic pressure at a depth of five metres is 50 kPa, corresponding to approximately 5 000 kg/m^2.

The aircraft's co-pilot has stated that the aircraft tipped to the right. During such a movement, the right wing tip will pass a point at which it is about five metres (just under half the span) below the surface of the water and will then be subjected to the pressure corresponding to that depth of water. The pressure causes compression damage because the outer part of the wing, which does not contain any fuel, had not had time to fill with water.

1.17 Organisational and management information

Not applicable.

1.18 Additional information

1.18.1 Problem solving ability

Common causes of erroneous actions may be that a problem is not correctly perceived due to lack of knowledge and skills. It may also be due to the problems being difficult to identify or inadequately presented. The capacity for judgment places demands on both knowledge and experience and can be improved through regular and repeated practice.

Problem solving can be based both on knowledge and on regulations in the memory faculty. In knowledge-based problem solving, attention may come to be focused on something other than what is logically important and instead occasion a prioritisation of the information that is most readily available. Knowledge-based problem solving can also manifest itself in that a person does not at that moment see or understand relations of causes and effects[22].

1.18.2 Actions taken

Through a contractual supplement, the Swedish Maritime Administration has in autumn 2014 provided Rescue Coordinators at JRCC the opportunity for consultation from Sahlgrenska University Hospital in issues regarding survival associated with hypothermia in water.

1.19 Special methods of investigations

Not applicable.

2. ANALYSIS

2.1 Circumstances

The crew's decision to carry out the take-off and landing exercises on Vättern under the prevailing weather conditions can be explained by their not having had access to detailed information regarding conditions on the lake. It was only after the landing that they became aware of the lake conditions, which explains why they only then decided to abort the exercises.

[22] Ternov, S. (1998). Människor och misstag i sjukvården. Lund: Studentlitteratur.

2.2 History of the flight

When the engine was shut off, the aircraft came to move backwards with the wind, which was 15-25 knots. This was also the commander's intention. The fact that the water rudders, probably unintentionally, were lowered meant that the yaw stability decreased as the speed backwards increased.

Since the engine was shut off, there was no longer any possibility to regulate the speed backwards and stabilise the aircraft.

SHK has been unable to determine the reason why the commander chose to sail with the engine shut off.

The aircraft probably turned itself across the waves even before the speed backwards was high enough for the yaw stability to completely subside. This is due to dynamic effects in the relatively high waves as the rear parts of the floats can have dug down into the water.

When the aircraft was lying completely sideways and was rolling in the waves, the wind gained an angle of attack against the wing that created a lifting force, which together with the dynamics of the waves caused the aircraft to capsize (see Figure 4).

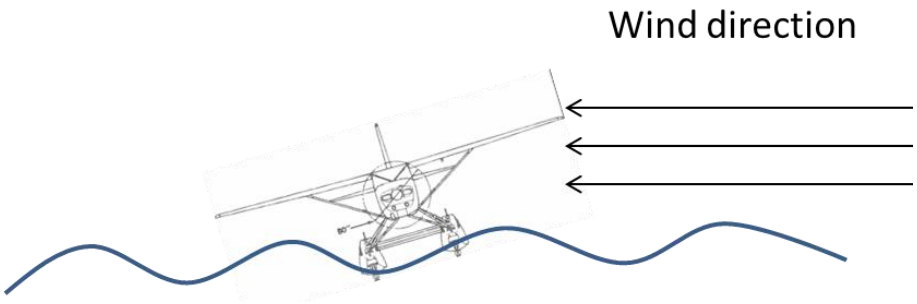


Figure. 4. The wind's action on the aircraft.

There are several possible factors contributing to the water rudders being left in the lowered position:

- The crew agreed to abort the take-off and landing exercises due to the prevailing lake conditions and had a dialogue on various conceivable options that required different positions for the water rudders.
- The lake conditions were more difficult than what the crew had expected, and the problems faced cannot be described as routine.
- There was no placard that was to draw the crew's attention to the fact that the water rudders were always to be retracted except when taxiing on water.

The decision to sail the aircraft backwards was one of several possible options under the prevailing conditions.

The co-pilot's opinion was that the commander had good judgment and was experienced, which may have contributed to his finding no reason to intervene in the decision to sail backwards, something which is corroborated by the co-pilot's witness statement.

It is likely that the crew did not correctly perceive the overall problem scenario, which may have contributed to not all aspects of the aircraft's configuration being discussed.

After the decision had been made to sail backwards, the crew prepared by, among other things, putting on life vests. This, together with the other tasks in the cockpit, e.g. manoeuvring, and the circumstance of being in an unexpected situation, may have influenced the crew to subconsciously have attention on something other than what was logically important at that moment.

It is not known which previous experience or knowledge the commander had of sailing backwards with aircraft. Therefore, it has also not been possible to clarify the extent to which the situation in question was consistent with the commander's mentally stored information, i.e. how prepared he was for handling the situation.

That the pilots exchanged tasks during the flight may have contributed to uncertainties and deficiencies in procedures but also to deficiencies in terms of assisting, informing and alerting each other during the work in the cockpit.

The compression damage to the right wing tip has probably been caused by the hydrostatic pressure when the aircraft had tipped and the wing had been directed straight down in the water. The damage indicates that the aircraft tipped over to the right in accordance with the co-pilot's witness statement.

The damage to the upper part of the rudder has either arisen during the salvage operation or by the aircraft having had contact with the bottom of the lake when it drifted from the accident site.

The damage to the underside of the left wing flap was probably caused by the crew's kicking movements during the evacuation.

2.3 The rescue operations

2.3.1 Rescue operation for air rescue services

Alert management

The rescue operation was delayed because the co-pilot was not able to raise the alarm until he had swum ashore and come in contact with a private individual who could call 112. At the same time as the 112 call with the co-pilot was in progress, the Rescue Coordinator at JRCC immediately initiated a rescue operation in order to locate the aircraft

and rescue the missing commander. A rescue helicopter and several surface units, municipal rescue services, police and ambulance were alerted.

Search and localisation

Various search areas were established and search measures were conducted by deployed units under the command of JRCC and with assistance from the OSC and the local operational command that had been temporarily established in Gränna harbour. The aircraft was reported to have landed on the water north of Visingsö without the position or the time when the aircraft had landed being able to be established with certainty. There was thus no exact position and more precise date from which the search could proceed. An aggravating circumstance was also that the commander hand was dressed in dark clothes and was wearing a dark blue life vest that did not facilitate discovery in the water. While the operation was in progress, the weather conditions became increasingly better in the area and were described as having been almost ideal in the final stage before it became dark and the operation was concluded.

According to SHK, there is reason to reflect on the fact that neither the upside-down aircraft nor the missing commander was discovered by any deployed unit during the, in terms of resources, considerable rescue operation. The aircraft was localised in the vicinity of the ferry line between Gränna and Visingsö by a private individual who was on land in Gränna. At the same time, the search operation was located to the area around the northern point of Visingsö. The day after the accident, the missing commander was discovered in the water north of Visingsö by a private individual who was on board the steamer TRAFIK.

Neither the commander nor the aircraft was found through the rescue operation, but by private individuals, despite access to a considerable number of units that were actively searching on the water and a rescue helicopter that was searching from the air at the same time as the weather conditions were good. In addition, the crew of the rescue helicopter has reported the view that if there had been any person in the search area, this person would have been found in view of the good conditions prevailing.

Planning conditions

With reference to what has been stated above, it should be particularly considered whether the conditions at JRCC for planning a corresponding search can be improved. At JRCC, which was responsible for the command of the operation, there was, for example, no access to the simulation program Seatrack Vättern that, among others, Jönköping Fire and Rescue Service used in its operations for municipal rescue services and that at the initiative of the rescue services was placed at the disposal of the search. However, the results

of the calculations performed using the program were not ready before the aircraft was found by a private individual.

The position where the aircraft was discovered could be calculated with good accuracy by the program, whereas the calculations of where the missing commander could reach land did not correspond with reality. The program, or similar aids, could be valuable in the analyses carried out at JRCC in order to determine various search areas in the event of similar operations in the major inland lakes. The type of aids that should be used and whether this should be handled under its own auspices or with the support of some other government agency are issues that should be considered by the Swedish Maritime Administration. However, the result of the operation conducted indicates that some form of additional aids are needed at JRCC in order to raise the ability to search for missing people or aircraft/objects within a similar water area where there are various factors of influence, such as wind strength, waves and the water's direction of current.

Conclusion of search

The motive to conclude the search for the missing commander was, according to the log from JRCC, based on the description that had been submitted by the surviving co-pilot, that it was becoming dark and the time that had elapsed.

When he was found, the co-pilot was hypothermic, exhausted and he had just managed to survive after having experienced an aircraft crash in the water. It should be carefully considered how much significance should be attached to information provided under such conditions in the planning of an ongoing rescue operation. According to SHK, it may be rash to, e.g. rely on information that the other person who also managed to exit the aircraft had perished, even though the description essentially suggests this.

SHK notes that the rescue operation was already concluded after about 4.5 hours, despite IAMSAR II, which is a support at JRCC, containing a survival curve indicating about 20 hours' survival possibilities. Furthermore, there is no detailed information in the log at JRCC that makes it clear which other reasons were weighed into the decision to conclude the rescue operation. As a comparison, it may be noted that the Police Authority concluded its search approximately 19 hours after the 112 call to SOS Alarm. In summary, SHK believes that the decision to abort the rescue operation already after 4.5 hours is questionable.

Liaison

The rescue helicopter belongs to a generation of helicopters that is being replaced by the Swedish Maritime Administration. The absence of appropriate communications equipment was a deficiency during the rescue operation that was temporarily resolved by instead using the

telephone. However, according to the Swedish Maritime Administration, the need of new communications equipment in the form of Rakel is being successively addressed in connection with the change to new helicopters.

The commander's life vest

The commander's dark blue life vest was of a colour that would have been difficult to discover on the water surface in a lake. To enable the rapid localisation of a person in the water with a life vest, the colour of the life vest should be adapted for the best conceivable visibility in the water.

SHK also believes that the commander's life vest was not appropriately designed since it lacked a support collar for the head and the ability to turn the person to the supine position.

2.3.2 The police's search for missing persons

The police assisted JRCC and commenced a rescue operation "for the search for missing persons" according to LSO when air rescue services were concluded. SHK believes that the measure was relevant in view of the fact that the commander was still missing.

In this context, it can be stated that the circumstance that air rescue services had been concluded does not constitute any prerequisite for the police being able to commence a rescue operation. If the conditions for a rescue operation for the search for missing persons are fulfilled in accordance with LSO and FSO, parallel (simultaneous) rescue operations can be carried out. It is the agency itself that decides whether conditions exist which according to LSO justify commencing a rescue operation.

3. CONCLUSIONS

3.1 Findings

a) The crew was qualified to perform the flight.
b) The aircraft had the Certificate of Airworthiness FAA Form 8100-2.
c) The aircraft lacked a placard with the instruction "WATER RUDDER ALWAYS UP EXCEPT WATER TAXIING".
d) The crew in the aircraft put on life vests after the landing.
e) The aircraft sailed backwards with the water rudders lowered and the engine shut off.
f) The aircraft tipped to the right and came to lie upside down in the water.
g) Both the commander and the co-pilot got themselves out of the upside-down aircraft.

h) The alert about the accident was delayed as the co-pilot was first compelled to swim to land and find someone who could call 112.
i) The exact time and position of the accident have not been possible to establish.
j) The commander's life vest was dark blue and of the type sailing vest.
k) Rescue operations were carried out under the command of JRCC and subsequently also by the Police Authority.
l) Both the aircraft and the commander were discovered by private individuals.
m) The municipal rescue services used a simulation program to calculate where in Vättern the aircraft and the commander could probably be found.
n) Air rescue services were terminated after approximately 4.5 hours.
o) There are no requirements regarding the design and colour of life vests used in Swedish-registered amphibious aircraft and seaplanes.

3.2 Causes/Contributing Factors

The accident was caused by the water rudders remaining lowered when the engine was shut off in order to sail backwards under the prevailing weather conditions.

4. SAFETY RECOMMENDATIONS

The Swedish Maritime Administration is recommended to:

- Facilitate the work to search for crashed aircraft in inland lakes where central government responsibility for air rescue services exists by developing existing or new aids for the calculation and analysis of how crashed aircraft and persons move in the water due to current winds and currents. *(RL 2015:06 R1)*

The Swedish Transport Agency is recommended to:

- Investigate whether there is reason to introduce, augment or modify the requirements regarding the colour and function of life vests required in aircraft not covered by Part CAT of Regulation (EU) 965/2012. *(RL 2015:06 R2)*

EASA is recommended to:

- Investigate whether there is reason to introduce, augment or modify the requirements regarding the colour and function of life vests required in aircraft not covered by Part CAT of Regulation (EU) 965/2012. *(RL 2015:06 R3)*

The Swedish Accident Investigation Authority respectfully requests to receive, by **07/08/2015** at the latest, information regarding measures taken in response to the recommendations included in this report.

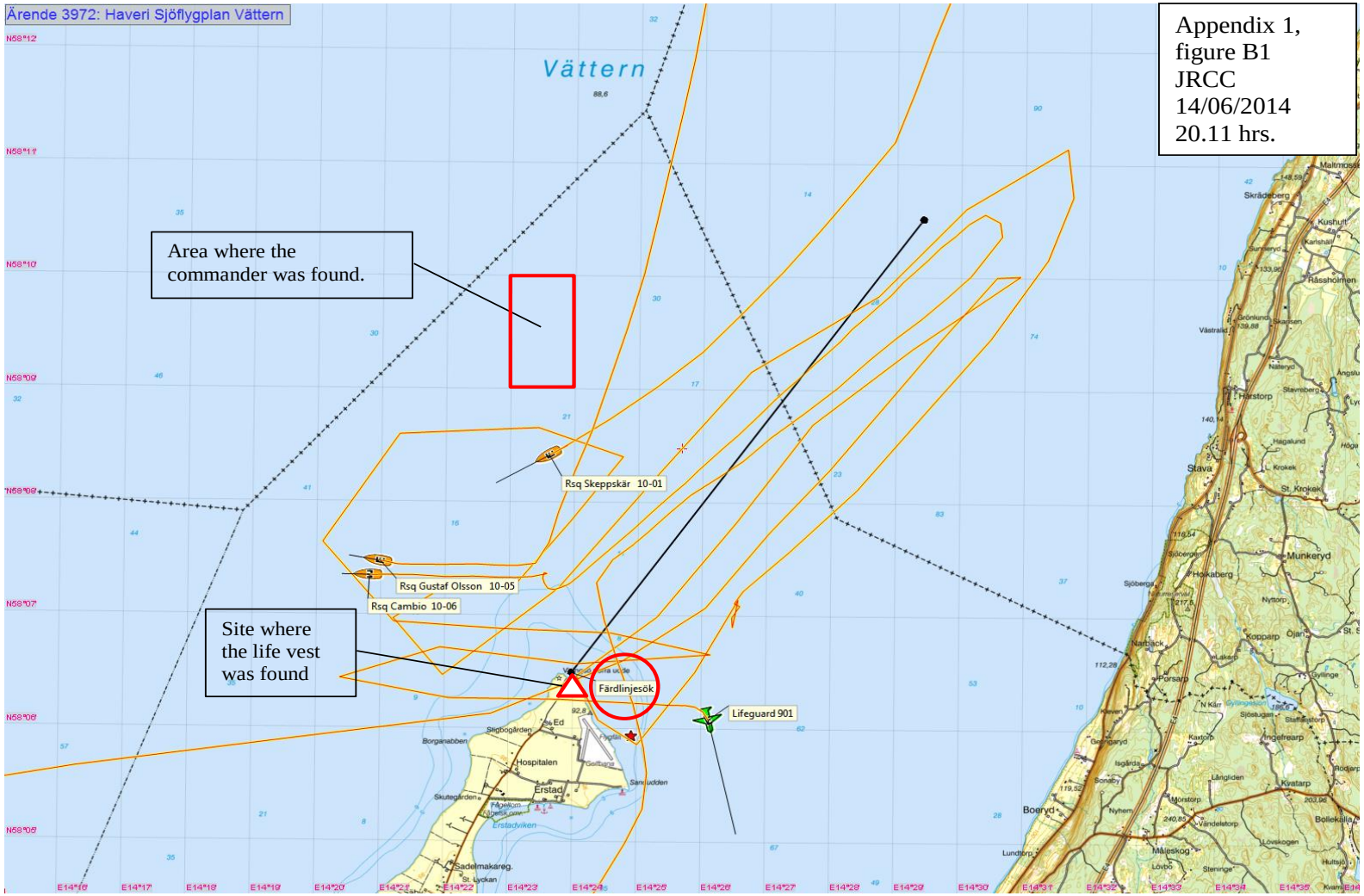
On behalf of the Swedish Accident Investigation Authority,

Jonas Bäckstrand Nicolas Seger

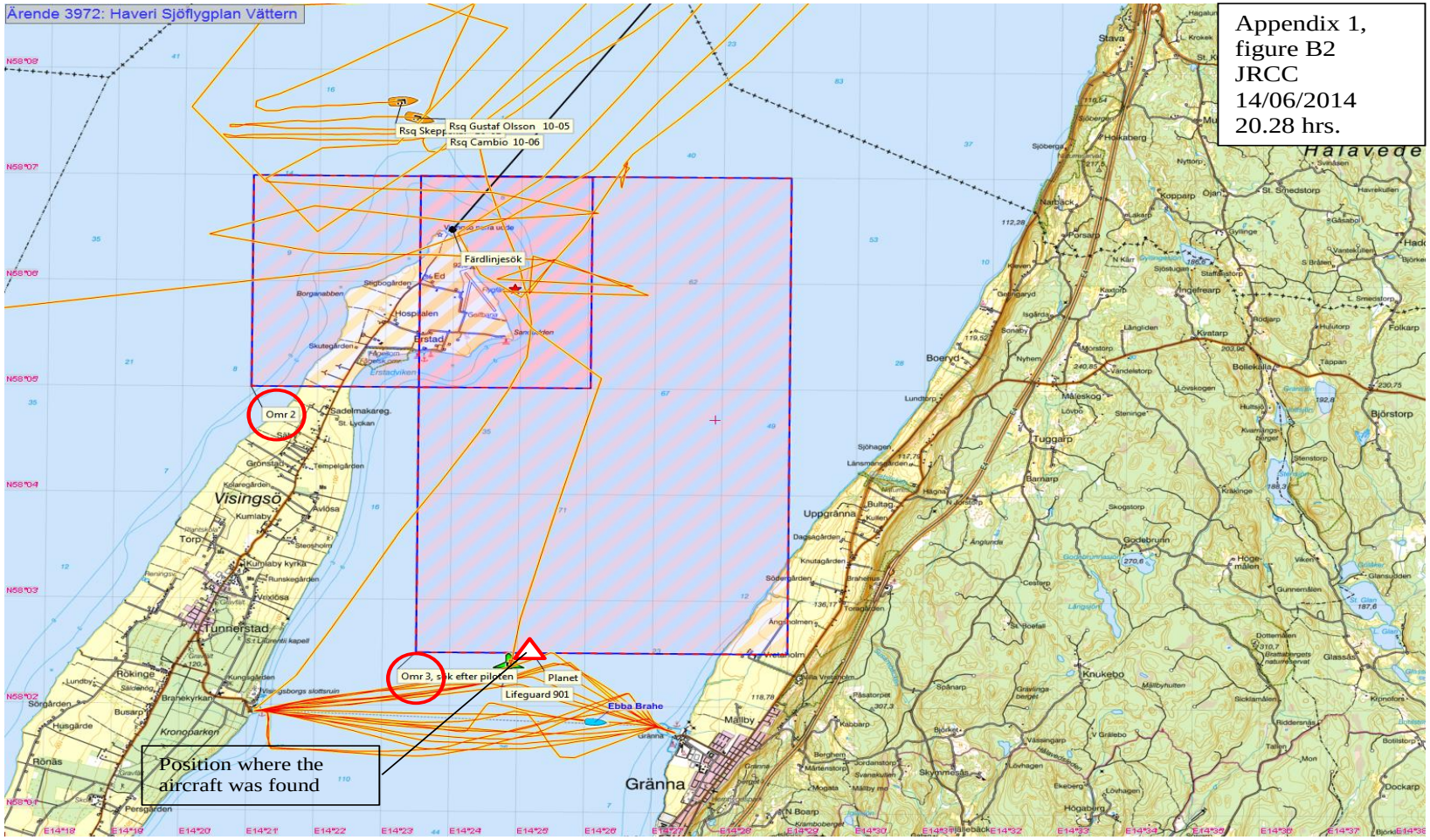
Appendices

Appendix 1

Description of search areas.



Appendix 1,
figure B1
JRCC
14/06/2014
20.11 hrs.



Appendix 1,
figure B2
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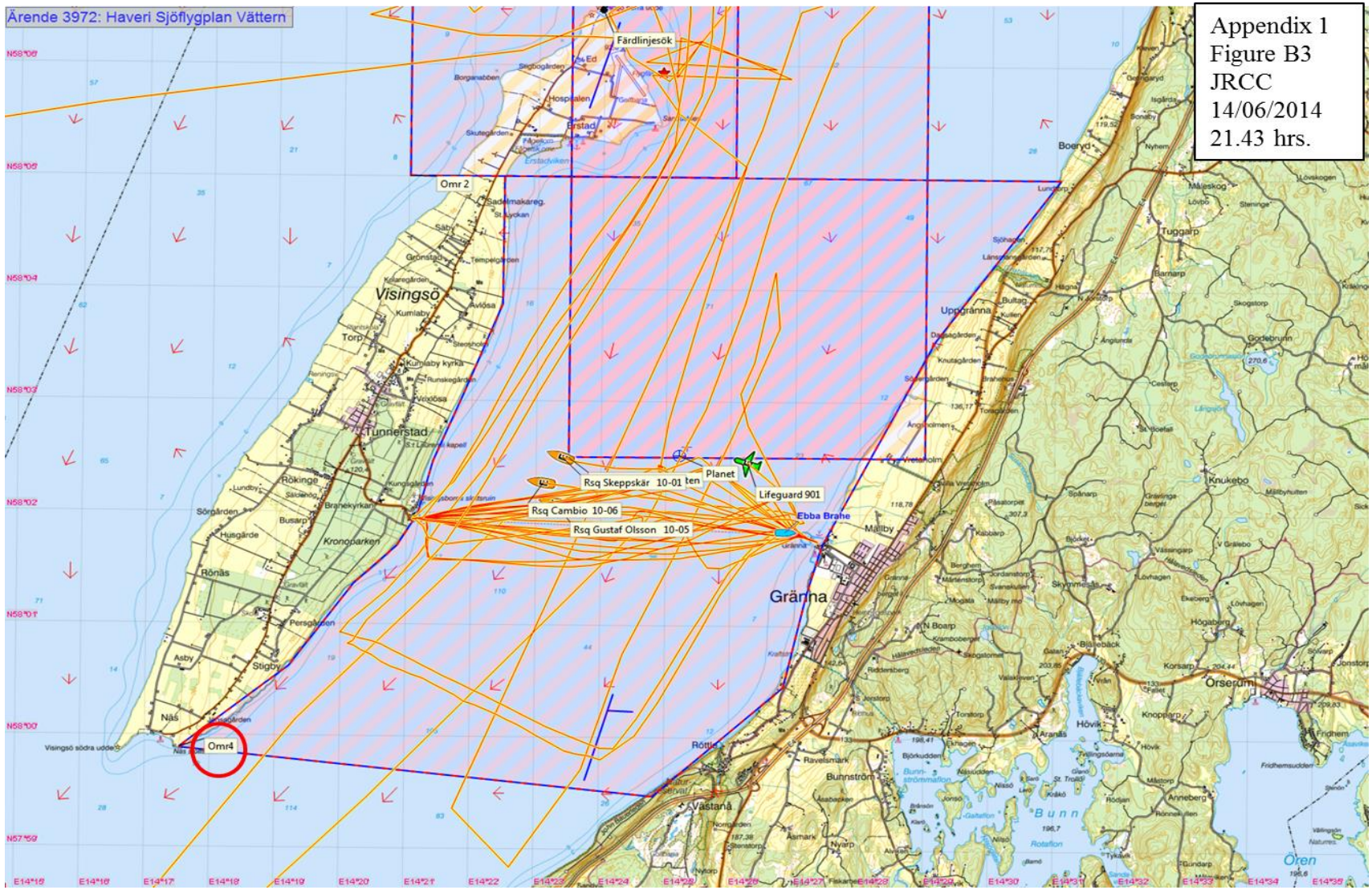
20.28 hrs.



Appendix 1
Figure B3
JRCC
14/06/2014
21.43 hrs.