Accident
Investigation Board
Norway

Issued July 2015

REPORT SL 2015/05

REPORT CONCERNING THE SERIOUS AIRCRAFT INCIDENT ON 18 MAY 2014 NORTHEAST OF BJØRKELANGEN WITH APEX AIRCRAFT CAP 10C, LN-KAP

The Accident Investigation Board has compiled this report for the sole purpose of improving flight safety. The object of any investigation is to identify faults or discrepancies which may endanger flight safety, whether or not these are causal factors in the accident, and to make safety recommendations. It is not the Board's task to apportion blame or liability. Use of this report for any other purpose than for flight safety shall be avoided.

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This report has been translated into English and published by the AIBN to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

Photos: AIBN and Trond Isaksen/OSL

Statens Havarikommisjon for Transport

REPORT

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Date of submission: 07.07.2015
SL Report: 2015/05

This investigation has had a limited scope, and the AIBN has therefore chosen to use a simplified report format. This report format, in accordance with the guidelines given in ICAO Annex 13, is only used when necessitated by the scope of the investigation.

All hours stated in this report are local time (UTC + 2 hours) unless otherwise indicated.

Aircraft:	
- Type and reg.:	Apex Aircraft CAP 10C
- Year of manufacture:	1981
- Engine:	Textron Lycoming AEIO 360 B2F
- Propeller:	EVRA CAP 3.180.170.H5G
Operator:	Nedre Romerike Flyklubb
Date and time:	Sunday, 18 May 2014 at 1210 hours
Incident site:	Northeast of Bjørkelangen, Akershus at approximately 4 700 ft
ATS airspace:	Oslo TMA, Class C controlled airspace
Type of incident:	Serious aircraft incident, loss of propeller during flight
Flight type:	Private (club)
Weather conditions:	Calm. CAVOK
Light conditions:	Daylight
Flight conditions:	VMC
Flight plan:	None
Persons on board:	1 commander/instructor and 1 student
Injuries:	None
Damage to aircraft:	Minor damage to cowling, loss of propeller
Other damage:	Unknown
Commander:	
- Age:	49 years
- Licence:	PPL (A) with instructor privleges
- Pilot experience:	Total flight hours approximately 2 050 hours, of which 76 hours over the last 90 days, 2 hours over the last 24 hours. Number of hours in relevant aircraft type: 340 hours, of which 17 hours over the last 90 days, 1 hour over the last 24 hours.
Sources of information:	"NF-2007 Reporting accidents and incidents in civil aviation" from commander, report from Analytical laboratory at Armed Forces Logistics' organisation – FLO/LUFT, as well as AIBN's own examinations.

FACTUAL INFORMATION

LN-KAP took off from Kjeller airport at 1140 hours with a commander/instructor and student on board. Weather information obtained before the flight indicated good visibility, almost clear sky and calm. The purpose of the trip was to fine-tune the student's skills before attaining the right to perform aerobatic manoeuvres. After departure, they switched to Oslo Approach Sector East on 118.47 MHz and requested training area "Airwork Alfa", which is located east of Bjørkelangen up to 6 000 feet QNH. This was granted, and two-way communication was maintained throughout the rest of the flight.

Once they were established at altitude in the area, they started the aerobatic manoeuvres. In his report, the commander writes that, after about 10 minutes, they heard a faint noise in the aircraft, immediately followed by a subtle vibration. He immediately assumed command of the aircraft, reduced the throttle (from approximately 2 400 to 2 000 rpm) and put the aircraft in horizontal flight. The commander has estimated that this took about 5 seconds. After another 4-5 seconds, the vibrations increased significantly. The throttle lever was then pulled to the idle position, and at the same time they heard a loud bang. They could see a small puff of smoke go past them and noticed that something in front of the aircraft disappeared out to each side in the horizontal plane. This is when they understood that the propeller had come loose and disappeared. At this time, the aircraft was at 5 500 feet QNH, estimated at approximately 4 700 ft. AGL. The time was then 1206 hours.

The commander established a speed for the best glide ratio, and set course for the nearest area that could be used for landing. This was some fields north of Bjørkelangen at Haugrim farm. (See Figure 1.)

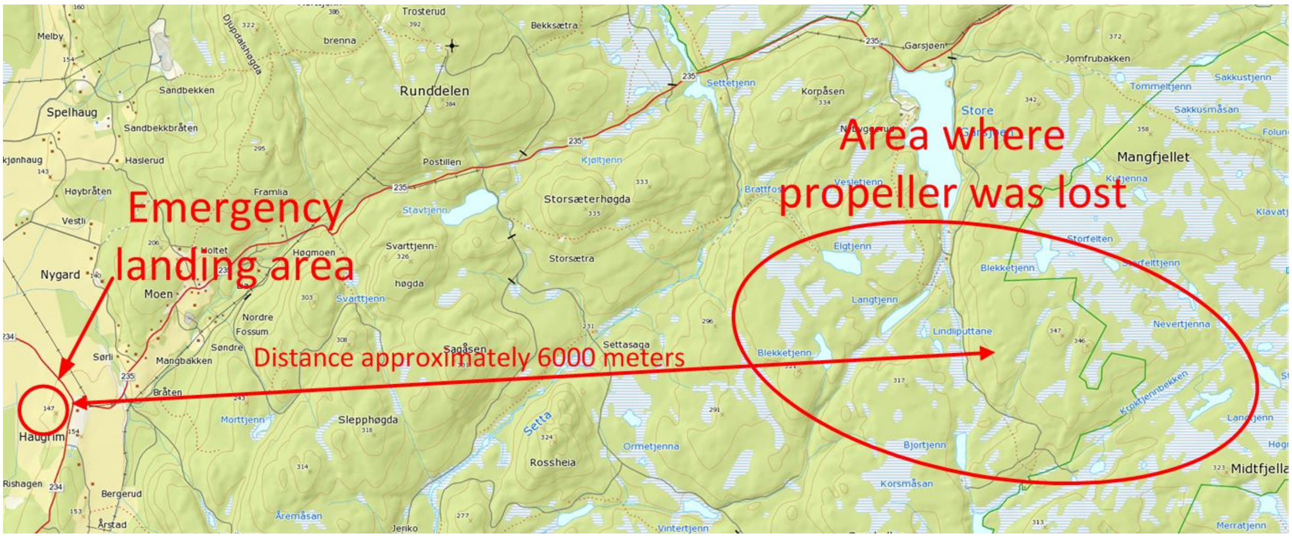

Figure 1: Illustration of area. Source: Norwegian Mapping Authority, Geovekst and municipalities

He knew they were within gliding distance of the fields, which were pre-defined by the club as an emergency landing area. A mayday message was sent approximately 10 seconds after the propeller disappeared. The call was immediately answered by Air Traffic Control, which maintained contact while they were gliding down toward the agricultural area. Several relevant fields could have been used, and the commander chose the one that looked the most flat and dry.

The commander described the unpowered flight and landing as undramatic. After landing in the field, the aircraft came to rest at about 1210 hours, four minutes after the propeller disappeared (Figure 2).

Figure 2: LN-KAP at the crash site. Photo: Private

When he exited the aircraft, the commander called Air Traffic Control and informed them that the emergency landing was successful and that no-one was injured. The emergency services arrived within 15-20 minutes: police helicopter, air ambulance, fire engine and local police.

With assistance from Nedre Romerike Flyklubb, and in agreement with AIBN, the aircraft was pulled off the field the same afternoon.

The commander is of the opinion that, if the propeller had been lost a few minutes before, they would have been so far east that it is unlikely they would have found anywhere to land. In such an instance, it could have been necessary to make a parachute jump from LN-KAP.

After landing, it was observed that the propeller, spinner, spinner bulkhead and starter ring gear had disappeared. The starter ring gear also drives the aircraft's generator using a transmission belt. The transmission belt was still in the nose compartment. There was also minor damage on the front left side of the cowling (Figure 3).

Figure 3: Aircraft nose compartment after landing. Photo: Private

Two searches were conducted for the aircraft's propeller, spinner, spinner bulkhead and starter ring gear. The search area was defined from where the aircraft had flown, based on ATC radar. A helicopter was used to search the relevant area on a large scale without finding the propeller. Then the area was searched using volunteers on the ground. This search was also unsuccessful. The area includes boggy terrain and bodies of water.

The investigation of the propeller flange on the engine crankshaft showed that three of the six propeller bolts were missing in their entirety. The other three had broken, and remaining parts were still in the bushings. There were signs of fretting[1] on the contact face of the propeller flange, which indicates that the propeller and starter ring gear had moved in relation to the crankshaft (Figure 4).

This wear indicates that the propeller bolts were not holding the propeller tightly enough against the starter ring gear and propeller flange. The friction between the propeller flange and starter ring gear/propeller was not sufficient to absorb power pulses from the engine. The propeller flange has 6 threaded bushings for fastening the propeller bolts. These bushings are not designed to absorb such strain. Thread residue from the propeller bolts was found in three of the bushings.

[1] A process that occurs in the contact area between two materials under strain and which is susceptible to small relative movement.

Figure 4: Areas with fretting on the crankshaft flange. Photo: AIBN

All bushings were removed from the propeller flange and sent to the Armed Forces' FLO materials laboratory for further analysis. Bolt pieces were found in three of the bushings. Two of the remaining bolt pieces were in a position in the bushings indicating that the bolts had partially unscrewed themselves before they broke. The last one (no. 5 in Figure 5) was still in correct position.

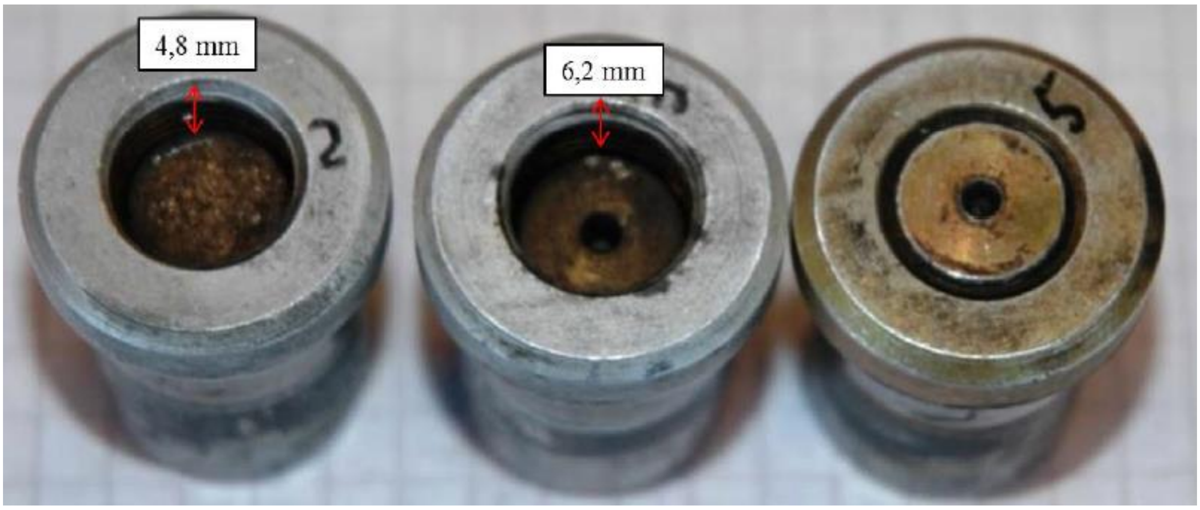

Figure 5: Bolt pieces screwed into bushings to varying degrees seen from the engine side. Photo: FLO materials lab

In the three bushings where no bolt pieces were found, the bolts have most likely unscrewed themselves entirely. This is evident as traces of the bolt threads in the part of the bushings without threading (Figure 6).

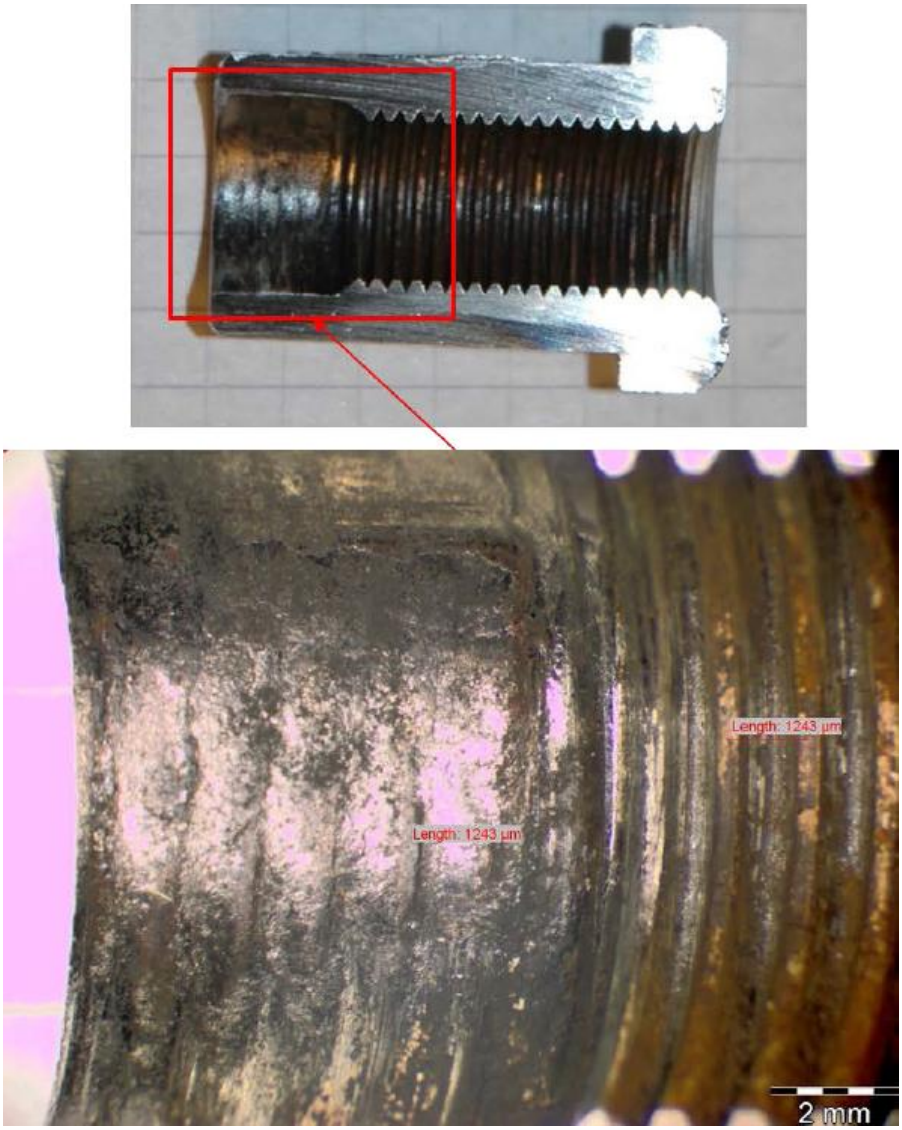

Figure 6: Traces of bolt threads in bushing. Photo: FLO materials lab

The bolt pieces' fracture surfaces showed fatigue fractures with subsequent ductile final fracture (Figure 7).

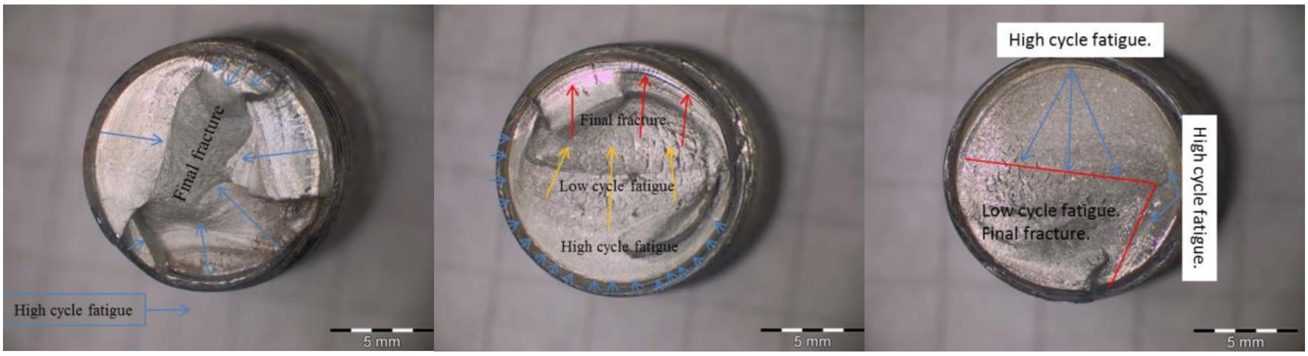

Figure 7: Fracture surfaces on bolt pieces. Photo: FLO materials lab

Traces of corrosion were observed on parts of the bolts where the cadmium plating had worn off. This wear is presumed to be caused by movement between bolts and bushings. The corrosion indicates that this process has been under way for some time.

Aerobatic manoeuvres lead to extra strain on the propeller assembly in the form of gyroscopic forces. One of the reasons for choosing a wooden propeller with relatively small mass on an aerobatic aircraft, is precisely to keep this type of force as small as possible. Wooden propellers, which are made of a material that absorbs humidity, requires that the torque on the propeller bolts are monitored more closely than on propellers made of non-absorbent materials such as composites or metal. Changes in climatic conditions like seasonal changes with permanent changes in humidity requires torque check of the propeller bolts on a regular basis.

In Nedre Romerike Flyklubbs (Aeroclub) own investigation report on the incident with LN-KAP the following is discussed:

> *After the incident, the CAP 10C Maintenance Program has been compared with documentation from several propeller manufacturers (Sensenich, MT and EVRA). There are several differences that are identified. For ½ inch bolts the torque value varies for a new EVRA propeller from 30 Nm (CAP 10 Maintenance program), 31-37 Nm (Sensenich), 33-35 Nm (MT) and 45 Nm (EVRA). For torque check, eventual reinstallation of repaired propeller, the CAP 10 Maintenance Program differs significantly from the other documents through the following Note:*
>
> *"Only retighten when the torque value is less than 50% of the values indicated above (30 Nm). To do so, adjust the torque wrench to 50% of the torque value indicated above and check that it releases automatically before the bolt turns."*

Further, the report contains the following:

> *When performing maintenance on the NRF CAP 10 aircraft, the owner/user and maintenance organisation is obliged to use the approved documentation from the aircraft manufacturer. The propeller is thereby maintained in accordance with the aircraft manufacturers procedures, and control of the propeller bolt torque shall be controlled as described with a value of 15 Nm (50% of 30 Nm). This is significantly lower than the recommendations from three different propeller manufacturer's recommendations. Going through available documentation regarding torque values for the propeller bolts, differences were observed. There were differences in the documentation from the propeller- and the aircraft manufacturer. In addition, there is a source for misunderstanding in the aircraft manufacturer's maintenance procedures.*

The “Note” mentioned in the Aeroclub’s investigation report is located at the bottom of the page in the aircraft manufacturer’s Maintenance Program chapter 4.9 (see Figure 8).

CAP10C

4.9 Change in climatic conditions

Climatic conditions, i.e. temperature and humidity greatly influence the tightening of parts when they are attached on wooden structures.

This inspection applies to any part attached to the fuselage, for which tightening must be verified when a climatic change is stated. This problem is more noticeable when the aircraft is new.

Every item for which a torque value is given in section 6 of this manual is concerned by this inspection. In Europe, this inspection should be carried out at the end of Spring and at the end of Autumn.

Torque check

Important: following torque values do not take into account the friction torque due to nut lock, and possibly due to the contact of the screw in wood.

It is therefore advised to increase the following torques by the amount of the value of the friction torque pertaining to each nut, the value being measured with a torque wrench.

	Torque (daN.m)	lbf.ft
Hoffmann propeller	(3.5)	25.8
Evra propeller	(3.0)	22.1
Sensenich propeller	(8.13 to 8.81)	60 to 65
Engine mount	(1)	7.38
Wing-fuselage forward attachment	(5)	36.9
Wing-fuselage rear attachment	(1.5)	11.1
Landing gear attachment	(4)	29.5
Bracket of ailerons and flaps	(0.15)	1.11
Hinge angle of ailerons and flaps	(0.15)	1.11
Pivot pin of ailerons and flaps	(1.5)	11.1
Horizontal stabilizer attachment	(0.5)	3.69
Hinge support on horizontal stabilizer	(0.15)	1.11
Pivot pin of vertical and horizontal rudder controls	(1)	7.38
Attaching bolt of the engine to the engine mount	(3 ± 10%)	22.1 ±10%

If, before tightening, the friction torque values are less than the following, it is necessary to check the screw and replace the nut.

Screw ∅	mm	4	5	6	8	10
	inch	0.157	0.197	0.236	0.315	0.394
Minimum torque value	daN.m	0.02	0.03	0.04	0.08	0.12
	lbf.ft	0.148	0.221	0.295	0.590	0.885

Note: Only retighten when the torque value is less than 50% of the values indicated above. To do so, adjust the torque wrench to 50% of the torque value indicated above and check that it releases automatically before the bolt turns.

Maintenance program SPECIAL INSPECTIONS Page 4-6

Document nr 1000830 GB Issue 1 dtd November 1st, 2001 – Rev. 0

Figure 8: Exerpts of APEX CAP 10 Maintenance Manual. Source: Apex Aircraft

The aircraft maintenance program issued by the Norwegian Air Sports Federation requires a torque value of 3 daN.m when checking the propeller bolts at 50, 100 and 400 hours intervals.

The propeller manufacturer EVRA gives the following torque values in their recommendations:

- Aux montages suivants ou contrôles ou hélices réparées
Vis de 6 mm ou ¼ de pouce 1,5 daN.m
Vis de 8 mm ou 5/16 de pouce 2 daN.m
Vis de 10 mm ou 3/8 de pouce 2,5 daN.m
Vis de 12 mm ou 1/2 de pouce 4 daN.m
Vis de 14 mm ou 9/16 de pouce 4,5 daN.m
Vis de 16 mm ou 5/8 de pouce 5,5 daN.m

Figure 9: Table of torque values recommended by the propeller manufacturer for torque checks or reinstallation. Source: EVRA

To have an understanding for the history of Type Certificate Holders for the CAP 10 aircraft, a summary of this is necessary.

CAP10 was produced by Avions Mudry & Cie from 1970. CAP Industries took over the production and changed name to APEX Aircraft. This company went bankrupt in 2008, and Dyn'Aviation took the Type Certificate responsibility. Dyn'Aviation went bankrupt in 2012, and Aerodif took the Type Certificate responsibility. AUPA DynAero acquired the activities of Aerodif In march 2015, while CEAPR will have the Type Certificate responsibility for the CAP 10 aircraft.

THE ASSESSMENTS OF THE ACCIDENT INVESTIGATION BOARD

The commander handled the situation that occurred in an exemplary fashion. Quick perception of the problem, correct handling by levelling out when abnormal noise and vibration occurred, reduction of throttle and immediate planning for a precautionary landing at a suitable location, were all elements that contributed to a good outcome of the incident.

AIBN is of the opinion that the cause of the loss of the propeller is that the torque on the bolts was too low. The low torque caused the propeller and starter ring gear to have too little friction against the propeller flange on the engine's crankshaft. This looseness caused the bolts to fracture. The main cause for loss of torque on wooden propellers is absorbtion of moisture and dehydration, depending on the environment the aircraft is in. Wood that absorbs moisture will swell, and shrink when it dries. It is therefore important to check the torque on the propeller bolts in the event of permanent changes in humidity, such as seasonal changes.

AIBN cannot attribute a single cause explaining the loss of the propeller bolt torque. The torque has probably been too low for some time, something that fretting, worn cadmium plating and corrosion of the propeller bolts indicate. AIBN has not attempted to establish a time line based on the bolt fracture surfaces.

The propeller bolt torque values, as specified in the propeller- (EVRA) and aircraft manufacturers (APEX) maintenance procedures, have significant differences. This applies both to installation and inspection/retightening. AIBN has also noted that a “Note” in the aircraft manufacturer’s maintenance recommendations in section 4.9 for control of torque can be understood so that the propeller bolts at seasonal changes shall be checked for movement with a value of 1,5 daN.m set on the torque wrench. If so, this is half of the required torque given by the manufacturer’s maintenance program, and only 37.5 % of the values given by the propeller manufacturer (see Figure 9).

To be able to explain the differences in the propeller bolt torque values given by the propeller manufacturer (EVRA) and the airframe manufacturer, the French Accident Investigation Board (BEA) have assisted in communicating with EVRA and the Type Certificate Holder (Aerodif). The differences in torque values could not be explained.

The CAP 10 aircraft has since 1970 had four Type Certificate Holders. To obtain qualified answers in this situation is challenging. AIBN’s opinion regarding the uncertainties that exist, both the differences in torque values given by the propeller manufacturer and the airframe manufacturer, and the room for different interpretations in chapter 4.9 in the airframe manufacturer’s maintenance program, may have been contributing factors in this serious incident.

Norwegian Air Sports Federation’s maintenance program for the CAP 10 aircraft uses the same propeller bolt torque values as the airframe manufacturer’s maintenance program. The propeller bolt torque checks were performed with significantly lower values than what was required in the Norwegian Air Sports Federation’s maintenance program. In AIBN’s opinion, uncertainties regarding interpretation should have been discussed with the Part M organization in the Norwegian Air Sports Federation. It is their maintenance program that was approved by the Norwegian CAA, and should have been used when maintaining the aircraft.

The Accident Investigation Board Norway

Lillestrøm, 7 July 2015