FINAL REPORT

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Operator:	Private
Manufacturer:	Grumman
Model:	G 21A/JRF Goose (Amphibian)
Nationality:	USA
Registration:	N4575C
Location:	Knock International Airport
Date/Time (UTC):	26 May 2002 at 14.09 hrs

NOTIFICATION

The Station Manager, Air Traffic Control (ATC) Shannon (EINN) reported the accident directly to the Air Accident Investigation Unit (AAIU) Inspector-On-Call (IOC) at 14.30 hrs on the 27 May 2002. The IOC arrived at Knock International Airport (EIKN) at about 17.45 hrs and commenced the investigation.

Under the provisions of S.I. No. 205 of 1997 (Air Navigation, Notification and Investigation of Accidents and Incidents, Regulation, 1997) and the International Civil Aviation Organization (ICAO), Annex 13, (Aircraft Accident and Incident Investigation), the Chief Inspector of Accidents, Mr Kevin Humphreys appointed Mr. Jurgen Whyte, as Investigator-In-Charge (IIC) to carry out a formal investigation into the circumstances of the accident and to prepare a Report. Mr Graham Liddy of the AAIU provided engineering assistance to the Investigation.

SYNOPSIS

During its landing rollout on Runway (RWY) 27 at EIKN, the aircraft veered to the right, the left retracted wingtip float[1] made contact with the runway surface, the left main undercarriage collapsed and the left main wheel separated from the aircraft. The aircraft departed the right hand side of the paved surface and came to rest with its nose at near right angles to the edge of the runway **(Appendix A)**. The flightcrew and the passengers exited the aircraft unaided. There were no reported injuries or fire.

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[1] The wingtip floats are required to be in the down position for landing on water. For landing on runways the floats are retracted into the wing, forming the wing tip.

FINAL REPORT

1 FACTUAL INFORMATION

1.1 History of the flight

Prior to the flight to EIKN, the aircraft and flightcrew had flown into Weston (EIWT) in west county Dublin earlier that morning (11.45 hrs) having completed an uneventful Visual Flight Rules (VFR) flight from Swansea, in Wales. The flightcrew had been made aware in Swansea of the owners' intention to have the same flightcrew fly him out to the West of Ireland that afternoon.

The policy for crewing the aircraft was that each pilot would fly alternate legs as Pilot-Flying (PF) from the left seat. While it was possible to fly the aircraft from the right-hand seat, no foot brakes were available on the right-side rudder pedals. For the leg EIWT to EIKN, the PF was seated in the left-hand seat, while the Pilot-Non-Flying (PNF) was seated in the right-hand seat. The PNF was also designated by the Private Operator (Section 1.17.1) as the Chief Pilot-in-charge of all flight operations for the aircraft.

After landing at EIWT from Swansea, the aircraft was topped up to 180 US Gals of fuel, which gave an endurance of approximately four hours. No specific destination had been stated by the owner for the afternoon flight, other than to fly out west to Mayo. The flightcrew then suggested a landing at EIKN and this was agreed upon by the owner.

At 13.00 hrs, the PNF made contact by telephone with Air Traffic Control (ATC) at EIKN and filed a verbal flight plan for the West, with a landing at EIKN. The general weather for the West was checked as suitable by the PNF. However, no specific weather check was carried out for EIKN.

At 13.20 hrs, N4575C took-off from EIWT with four passengers (including the owner) and the two flightcrew onboard. The take-off weight was calculated at approximately 8,900 lbs. Maximum all up weight (MAUW) is certified as 9,200 lbs.

The en-route segment of the flight to EIKN was flown VFR at 2,000 feet without incident. Prior to becoming established for an Instrument Landing System (ILS) approach to RWY 27, the flightcrew had a brief discussion on the landing conditions, in particular, the prevailing crosswind, which was reported at the time as *360 degrees 14 kt*. It was decided amongst the flightcrew that they would continue with the approach, have a look, and if unsuitable, they would carry out a go-around. Flap 30º was set for the approach.

At about 14.03 hrs, N4575C reported localizer established and was advised by ATC to "*report the marker*". At about 14.05 hrs, ATC responded to a request for weather from British 926 (parked on ramp), advising that the, "*runway was 27 for departures wind is 360 degrees 14 kt"***.**

At about 14.06 hrs, N4575C reported 3 miles final. ATC responded, "*Roger cleared to land RWY 27, wind is 360 degrees at 15 kt*".

At about 14.08 hrs, the aircraft was observed by the ATC Tower Controller landing at the mid-point of the touchdown zone (TDZ), south of the runway centreline. Shortly thereafter, the aircraft commenced a veer to the right, with the right wing seen to lift. Prior to the aircraft passing through the runway centreline, the left main wheel separated from the aircraft and rolled ahead into the grass verge on the right side of the runway.

The aircraft departed the paved surface at an angle of approximately 45º to the runway heading and then, almost immediately, ground looped back left towards the edge of the runway. The final position of the aircraft was that of the left retracted wing tip float resting on the runway edge, with the nose of the aircraft pointing towards the runway on a heading of approximately 200º Magnetic (M).

At about 14.09 hrs, N4575C made a call to ATC advising that they had departed the runway and that no one was injured.

On completion of the shutdown checks, both the passengers and the flightcrew evacuated the aircraft through the main passenger door on the rear left side, without injury. The airport Rescue and Fire Fighting Service (RFFS) was in attendance at the accident site at this time.

1.1.2 Witness observations

1.1.2.1 Pilot Flying (PF)

The PF informed the Investigation that just prior to becoming established for RWY 27, he discussed the prevailing crosswind conditions with the PNF. It was agreed to have a look and if unsuitable to carry out a go-around. The PF was however, confident that under the prevailing wind conditions he could carry out a safe and successful landing. He told the Investigation that he had completed a crosswind landing of 17 kt at Dublin (EIDW) and a 12-15 kt crosswind landing at EIWT with an instructor. When queried by the Investigation regarding a crosswind limit set by the Private Operator, the PF stated that, *"he could not recall that the Operator had set a crosswind limit of 5 kt"*.

The approach was flown in smooth conditions at 80 kt with a flap setting of Flap 30º. The Investigation determined that during the conversion course on type, flap configuration was dependent on aircraft weight. At low weight, Flap 30º was used, while at high weights, Flap 60º was used.

The PF told the Investigation that touch-on was a firm 60 kt main wheel landing, at a point near the mid-section of the TDZ and slightly left of centreline. Directional control was initially maintained with, the control column forward, right aileron into wind, left rudder and left pedal braking. As the aircraft decelerated through 30 kt, it started to veer gently towards the right. The PF felt a loss of left pedal braking as the left wing dropped. Loud scraping was then heard as the aircraft continued, with its left wing down, across to the right-hand side of the runway. The aircraft departed the paved surface and then ground looped left back towards the runways edge. On completion of the shutdown checks and an ATC call advising of the situation, the PF evacuated the aircraft with the other crewmember and the passengers. On being asked by the Investigation, if any pressure had been put on the flightcrew to land at EIKN, the PF replied "*None whatsoever*".

1.1.2.2 Pilot-Non-Flying (PNF)

The PNF confirmed to the Investigation that the Private Operator had appointed him as the Chief Pilot for this particular aircraft. As a result of training received on type, he was familiar with the idiosyncrasies of landing the aircraft in crosswind conditions on land. He confirmed that the normal flap configuration for landing at high aircraft weight was Flap 60º and that he was also aware of a limitation set by the private operator of not landing the aircraft in crosswind conditions exceeding 5 kt.

He confirmed that a discussion had taken place with regard to the prevailing wind conditions, prior to the aircraft becoming established on final approach. He had acknowledged the wind of 360 degrees 14 kt, back to the control tower. His recall of the approach discussion had left him with the impression that the PF had indicated that he had landed in similar conditions with the instructor, that the PF was happy to continue, but would initiate a go-around if he had any problems.

As the stable and smooth approach continued, the PNF became more concerned about the prevailing crosswind conditions. While he recognised and respected the fact that the PF had a significant amount of flying experience on tail wheel (land) aircraft, the PNF briefed for a go-around, with a reminder to the PF to remember when advancing the throttles, to do so slowly (*in order to reduce torque effect*). The fact that the PF had selected Flap 30º, rather then the normal Flap 60º, re-affirmed his belief that the PF would carry out a go-around.

As it was, the approach and landing was continued. In the opinion of the PNF, the landing was a firm, main wheel landing, left of centreline. He did not recall any bounce. After the touch-on, the aircraft started to drift to the left side of the runway. As his rudder pedals were not equipped with pedal braking, he could not assist in counteracting the drift to the left. The aircraft then ran parallel to the runway edge for a distance before it started to drift right towards the runway centreline. In the early stages of the drift right, he felt the left leg and wing drop. This was followed by a loud scraping sound, as the aircraft continued across the runway in a left wing down attitude. After departing the runway, the aircraft swung sharply to the left where it came to a halt with the nose facing the runway.

Asked by the Investigation, if any pressure had been put on the flightcrew to land at EIKN, the PNF replied "*No*".

1.1.2.3 The Tower Controller

The Tower Controller recalled that the last wind check he passed to N4575C was at approximately 2 nautical miles (nm) from RWY 27, giving *360 degrees at 15 kt*. He observed the aircraft touch-on initially abeam the ILS/GS antenna (mid point of TDZ) and south (left) of the centreline. In his opinion the landing was firm, in a "*more tail down attitude*". The aircraft bounced and then settled on its main undercarriage. Passing abeam the control tower, the controller observed the aircraft commence a gentle veer to the right towards the centreline. At the same time he saw the right wing rise and the left wing make contact with the runway. Almost immediately after that the controller saw the left wheel depart the aircraft. He then hit the crash alarm button.

The aircraft then slid through the centreline at an angle of approximately 30º right of the runway heading and out towards the right hand side of the runway. The aircraft departed the runway on the right side and almost immediately ground looped left back towards the edge of the runway. A radio transmission from N4575C confirmed to the Tower Controller that the aircraft had departed the runway without any injuries.

1.1.2.4 The Owner

The Owner of N4575C confirmed to the Investigation that he had an arrangement with a private operator to operate the aircraft on his behalf for his personal use in the private category. The Owner had requested the flightcrew to fly him to Mayo that afternoon, with an agreed landing at EIKN.

He had owned this particular aircraft for 5 years where it had been mainly operated out of the United Kingdom (UK). Through personal experience he was acutely aware of the aircrafts' susceptibility to ground looping in crosswind conditions. The Owner had previously experienced a ground loop in the aircraft. He stated that he had put no pressure on the flightcrew to carry out the landing at EIKN and just assumed that the wind conditions for landing were suitable.

For the accident flight, he was seated on the right side of the aircraft with his back facing the bulkhead of the cockpit. In his opinion, he considered that the approach was long, but stable. He observed that the flightcrew were in discussions during the approach, but as the communications were not linked to the cabin, he was unable to decipher what was said. The aircraft made a firm 3-point landing followed by one bounce prior to settling on the runway. In his opinion, "*the aircraft went out of control immediately upon touching the ground"*. On looking out the cabin window on the left side of the aircraft, he observed that the windsock was indicating a significant crosswind to the runway. He called to his daughter, who was seated across from him, to "*brace yourself, it's going to ground loop*". Almost immediately after that, he felt the aircraft start to drift towards the right, as the right side wing (right wing) lifted up. This was followed by a loud scraping sound, which came from the bottom left side (left wing) of the aircraft. The scraping sound continued until the aircraft departed the runway. The aircraft then swung sharply to the left where it came to rest at the edge of the runway. Once the engines were shutdown the passengers and flightcrew evacuated the aircraft. This witness was not aware that the left main wheel had separated from the aircraft during the accident sequence.

1.2 Injuries to persons

There were no injuries reported to the investigation.

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Serious	0	0	0
Minor	0	0	0
None	2	4	-

1.3 Damage to aircraft

During the landing rollout, the left main undercarriage failed and the left wheel and shock-strut detached from the aircraft. The departing wheel struck the lower surface of the left wing causing skin damage. It also struck the aft left fuselage.

As a result of the left undercarriage collapse, the left lower fuselage came into contact with the ground and suffered damage. The main fuselage frame, supporting the undercarriage and forward wing attachment points, suffered compression damage on the left side. The fuselage skin buckled above the cockpit. The lower left undercarriage doors were also torn off. The left retracted wingtip float was extensively damaged by ground impact, and the outer section of the left wing was deformed upwards.

1.4 Other damage

Damage to the runway, in the form of deep gouge marks, occurred as a result of the left retracted wingtip float, the left side of the floatable hull and the remaining parts of the left undercarriage strut assembly coming in contact with the asphalt surface.

1.5 Personnel information

1.5.1 Pilot Flying (PF)

Personal Details:	Male, aged 56 years
Licence:	ATPL-USA
Last Periodic Check:	24 May 2002
Medical Certificate:	5 January 2002 (Class I)

Flying Experience:

Total all types:	6,330	hours
Total all types PI:	5,870	hours
Total on type:	58	hours
Total on type PI:	33	hours
Last 90 days:	71	hours
Last 28 days:	26	hours
Last 24 hours:	3	hours

1.5.1.1 Tail wheel operations

Almost half of the PF flying experience was achieved on DC 3 tail wheel aircraft.

1.5.2 Pilot-Non-Flying (PNF)

Personal Details:	Male, aged 57 years
Licence:	CPL-Irish with FAA Validation
Last Periodic Check:	7 August 2001 with FAA Validation
Medical Certificate:	28 May 2002 Class I (IAA)
	4 April 2002 Class I (FAA)

Flying Experience:

Total all types:	8,728	hours
Total all types PI:	8,445	hours
Total on type:	90	hours
Total on type PI:	9	hours
Last 90 days:	182	hours
Last 28 days:	60	hours
Last 24 hours:	1.5	hours

1.5.3 Training

1.5.3.1 General

The Private Operator contracted a Federal Aviation Authority (FAA) instructor to train the pilots onto type for both land and water operations.

The instructor has a total of 35 years of aviation experience, with a total of 20,000 hours flying experience of which 12,000 hours are on type. The majority of his experience was achieved in Alaska. He holds both a current FAA Instructors Licence and an Airframe/Power Plant Maintenance Licence.

1.5.3.2 Training schedule

The pilot training schedule for conversion on type consisted of three separate periods between February and May 2002.

In February 2002, the instructor came to Ireland, collected the aircraft from Belfast, where it had undergone heavy maintenance/re-fit, and commenced training with the PNF. The PNF had no previous experience of water operations. The flying time achieved during this training was insufficient to allow the PNF to go solo (Land).

During March - April 2002, the instructor completed a period of three weeks training with the PF and PNF and also carried out some on-going maintenance on the aircraft. Both pilots achieved the required standard to operate to and from runways.

During April - May 2002, an additional 3 weeks training was completed with the PF, PNF and the Private Operator. During the second and third week, all 3 pilots went to Florida to complete further water training and each were awarded their FAA multi-engine sea rating.

The instructor provided a total of approximately 70 hours flying instruction between the three pilots. In addition, the non-instructed pilot would normally sit in the jump seat to observe each lesson given.

1.6 <u>Aircraft information</u>

1.6.1 Leading particulars

Aircraft type:	G 21A/JRF Goose
Manufacturer:	Grumman
Constructor's number:	B-120
Year of manufacture:	1943
Certificate of Registration:	13 May 1997
Certificate of Airworthiness:	12 December 1983
Total airframe hours:	13,467 hours
Engines:	2 x 450 hp Pratt & Whitney R-985-AN6
Maximum authorised take-off weight:	9,200 Lbs
Actual Take-off weight:	8,900 Lbs
Estimated weight at time of incident:	8,678 Lbs
Centre of gravity limit (C of A):	15.2% to 28.0% MAC
C of A at time of incident:	22.84% MAC

1.6.2 General information

The Grumman G 21 A – Goose, began life in the pre-World War 2 (WW 2) days as Grumman's first design intended for civilian use as a utility amphibian. Most of the type's production ultimately was against military orders placed during WW2 (G 21 A/JRF). The Goose's first flight occurred in June 1937. Its rugged construction included features such as a braced tailplane, a deep two-step hull and a retractable undercarriage. Capacity included a two-place cockpit and cabin seating for 6 to 7 people. Production ceased in 1945, after total deliveries of 376 aircraft. Subsequent modifications (since 1966) have seen some of the aircraft modified with retractable wing tip floats (as per N4575C) and turbine powerplants.

1.6.3 Aircraft Flight Manual

1.6.3.1 General

A photocopied Aircraft Flight Manual (AFM), entitled, *"Flight Manual for Grumman Goose G21A"* (Registration N4575C) was carried onboard the aircraft.

1.6.3.2 Relevant extracts

The following extracts are considered relevant to the investigation.

<u>Section I - Airplane Operating Limitations (Extract)</u>

Para 4, Flap position

Take-off	*0^o or 30^o*
En-route	*0^o*
Landing	*30^o or 60^o*

<u>Section IV - Flying Characteristics (Extract)</u>

g. Stalls

(5) 30^o Flap, wheels down floats up - 63 KT TIAS
(6) 60^o Flap, wheels down, floats up - 56 KT TIAS

1.6.3.3 Crosswind Limits

The aircraft flight manual made no reference to crosswind limitations. However, the Instructor told the Investigation that the accepted crosswind limit for the aircraft was 17 kt. Crosswind take-off and landing training was conducted with both pilots. However, on completion of training, the Instructor set a crosswind limit of 8 - 10 kts for both pilots.

1.7 <u>Meteorological Information</u>

1.7.1 General

Met Éireann, the Irish Meteorological Service, provided the following information after the accident:

<u>General Situation:</u>	A large depression of 996 hPa centred over the northwest of England maintained a fresh northerly flow over the area.
Wind:	2,000 feet: 360/30 kt Surface: 340/15 kt to 350/17 kt.
Weather:	Nil, although there were some active convective cells south of Knock International, some possibly of thunderstorm intensity. These cells were about 25 nm south southwest of Knock at the time of the accident. Radar analysis indicated light shower activity in the vicinity of the area at the time.

Visibility:	10 + km.
Cloud:	FEW 1,200 feet, Broken (BKN) 1,800 feet.
Temperature:	12º Celsius
Dew-Point:	08º Celsius
Mean Sea Level (MSL) Pressure:	998 hPa

1.7.2 Wind measuring system

The anemometer system at EIKN was specified by Met Éireann to International Civil Aviation Organisation (ICAO) standards and was certified by Vaisala as complying with these specifications, including the accuracy specifications from ICAO.

The anemometer display unit located in ATC and the Meteorological Office has been programmed to display wind data to ICAO ANNEX 3, Meteorological Service for International Air Navigation, specifications.

The sighting of the anemometer system is representative of the touchdown area for RWY 27 and along the runway.

1.7.3 Wind profile

The wind output for local (plain language) reports and for the ATC wind display units is the 2-minute average for the mean data, with gusts and directional variations taken over the previous 10-minute period, except where there is a "marked discontinuity" in the wind speed and direction during this 10-minute period.

A marked discontinuity occurs when there is an abrupt and sustained change in wind direction of 30 degrees or more, with a wind speed of 10 kt before or after the change, or a change in wind speed of 10 kt or more, lasting at least 2 minutes. In the event of a marked discontinuity in the 10-minute period, then only data occurring after the discontinuity is taken into account in determining the gust.

1.7.4 Anemograph trace

It was noted by the Investigation that the anemograph record (printout trace) was 10 minutes slow at the time, but this has been taken into account in the current analysis and would not have had any impact on operations at EIKN.

The anemograph trace indicates that the wind went gradually from 330º true to 350º true and from 13 to 16 or 17 kt around the time of the accident. The wind reported by ATC just prior to landing (360 degrees 15 kt) was confirmed as accurate against the anemograph trace.

1.8 Aids to navigation

ILS to RWY 27.

1.9 Communications

Normal communications were achieved between N4575C and EIKN ATC on frequency 130.7 MHz.

At about 14.08 hrs a carrier transmission was heard on the ATC tape (possible inadvertent keying from N4575C).

1.10 Aerodrome information

1.10.1 General

Knock International Airport (EIKN) is located approximately three nautical miles south west of Charlestown, Co Mayo.

RWY 09/27 has an asphalt surface and measures 2,300 metres in length and 45 metres in width. The airport elevation is 665 feet above mean sea level (amsl).

1.10.2 Emergency Response

EIKN has a Category (Cat) 6 Rescue and Fire Fighting Service (RFFS) available for scheduled flights and general aviation flights during normal operational hours. Cat 7 is available on request.

When the ATC tower controller observed the left wheel depart the runway, he immediately sounded the crash alarm. The RFFS was in attendance at the aircraft within 2 minutes. While no fire was present, a significant amount of fuel had drained from the aircraft. A layer of foam was laid over the fuel soaked ground and the RFFS maintained a presence at the accident site until the aircraft was recovered back to the airport ramp.

1.10.3 Runway inspection

A runway surface inspection was carried out by the IIC some three hours after the runway excursion. The surface condition was recorded as “DAMP” with no standing water present.

A rubber tyre mark originating from the left main tyre and which was more dominant than the right main tyre mark was visible from the mid-section of the TDZ approximately 10 metres to the left of the centreline.

The tyre mark continued parallel to the runways edge for a further 166 metres before veering right in a gentle arcing turn towards the runway centreline. The aircraft then crossed through the centreline at a point 297 metres from where the initial tyre marks were recorded. Continuing out towards the right-hand edge of the runway, the aircraft came to rest just off the right side of the runway at a total distance of 360 metres.

Just prior to the aircraft crossing through the centreline (approximately halfway across the left side of the runway), a scrape mark of 6.7 metres in length was identified as being caused by the retracted wingtip float coming in contact with the runway surface. The left tyre mark was no longer visible from the end of this particular scrape mark. However, the right side tyre mark did become more dominant from this point on.

Approximately 2 metres after the end of this particular mark, a second and more deeper scrape mark of 1 metre in length was identified. This second mark was caused by part of the left side undercarriage assembly impacting the runway surface.

Some additional scrape marks originating from the left side retracted wingtip float and the aircraft hull were also found between the runway centreline and the point at which the aircraft departs the edge of the runway.

1.10.3 Airport closure

Due to the final resting position of N4575C and some difficulties experienced in recovering the aircraft, the airport reminded closed from 14.29 hrs until 22.11 hrs on the day of the accident. One scheduled passenger flight was diverted and one scheduled passenger flight had its departure delayed from EIKN for approximately eight hours during the airport closure.

1.11 Flight recorders

The aircraft was not fitted with flight recorders, nor was it required to be under existing regulations.

1.12 Wreckage and impact information

Nil

1.13 Medical and pathological information

Nil.

1.14 Fire

There was no fire

1.15 Survival aspects

Lost of directional control occurred at approximately 30 kt. The lateral forces experienced at these speeds would normally be light and the wearing of the conventional type lap restraints (as in this case) was sufficient to prevent injury to the persons onboard.

1.16 Tests and research

1.16.1 Failures

The initial structural failures were those that occurred in the left undercarriage. All the fractures, including those in the upper and lower drag braces/links, the main strut folding joint, the main strut upper and lower attachment points were examined. This examination showed that all the failures were single-event overload failures, and there was no evidence of pre-existing cracks, fatigue or other faults.

It was noted that the wall thickness of the support housing for the left main strut centre-point folding bolt was thinner than expected. There was also some braze material present at one end of the inner diameter of this housing, and some pitting was noted in the surface of the housing.

1.16.2 Defects

It was noted that the surface of the sliding section (inner cylinder) of the left undercarriage had a deep surface defect approximately 15 mm above its normal resting (extended) position **(Appendix B)**. The appearance of this defect indicated that the damage was present before this event and would have been clearly visible during a daily inspection or pilot walkround. The defect appeared to be the result of impact damage. Further research found that maintenance personnel had previously noted the defect, as it was causing damage to the seal in the cylinder, when the leg was compressed by landing loads, to a point where the seal passed over the defect. In order to prevent seal damage, the shock-strut was inflated to approx 1,200 pounds per square inch (p.s.i.), so that during normal landings the shock-strut would not compress to such an extent that the seal would pass over the defect. It was also necessary to over-inflate the right shock-strut to the same pressure, in order to keep the aircraft level. The normal inflation pressure for the struts is 800 to 900 p.s.i.

1.17 <u>Organizational and management information</u>

1.17.1 The Private Operator

The Private Operator informed the Investigation that he had an arrangement with the owner to operate the aircraft on his behalf. The arrangement included, providing maintenance for the aircraft, parking, sourcing of pilots', training of pilots' and in general to ensure safe operation of the aircraft in the private category.

No operations manual was developed for the aircraft, nor was it required under its category. However, the operator had briefed both pilots that the operation was limited to daytime VFR flight only and he set a runway crosswind limit of maximum 5 kt. In addition, the aircraft had to be flown with two fully rated flightcrew seated in the front of the aircraft at all times. He insisted on this requirement for two reasons. Firstly, to comply with the insurance cover and secondly, so that each flightcrew member would act as a safety check on the other.

1.18 <u>Additional Information</u>

1.18.1 Flap configuration

The Goose is a hand built aircraft and as a result it is generally recognised that they all fly somewhat differently. With regard to elevator trim, some fly nose heavy, while others fly tail heavy. Pilot's who flew N4575C regarded it as a nose heavy aircraft, requiring more nose-up trim. The weight and C of G position determines the flap configuration for landing. With the aircraft loaded to an aft C of G, full flap can be used with sufficient elevator trim available. However, when the aircraft is flown light, with only two pilots and full flap, it can run out of nose-up elevator trim. Therefore at lighter weights Flap 30º is recommended for landing.

1.18.2 Tail effect

The tail wheel weight of the Goose is as much as 450 pounds when the tail is in the fully down position. Weight and Balance requires that the aircraft be in flight attitude to weigh for Weight and Balance. The tail in flight attitude is only about 140 pounds. It is clear therefore that the rudder is much less effective if the tail is in the down position, because it must move 450 pounds, while if the tail is up in flight attitude the rudder is capable of moving 140 pounds much easier. In addition, with the tail down, the load on the main wheels becomes lighter, therefore the brakes become less effective.

1.18.3 Crosswind landing technique

A discussion with an experienced Goose operator revealed, that a recognised technique for landing this particular aircraft on a runway with a crosswind at the limit, would be to land on the main wheels with some power on, in order to keep the tail up. Full flap will help to keep the tail up on landing. Keeping the tail up during the landing rollout, reduces the masking effect created by the highwing/engine configuration, and also keeps a strong airflow over each side of the tail fin, thereby making the rudder more effective. In order to keep the aircraft aligned with the centreline, differential/asymmetric power must be incorporated during the rollout, by applying a proportional amount more power on the upwind side. The amount of power is dependent on the strength of crosswind. Deceleration is achieved through a combination of differential pedal braking and power. Once the aircraft is virtually at a stand still, the power can be reduced and the tail drops to the ground.

1.18.4 Ageing aircraft

This aircraft was designed in the late 1930's with first deliveries being made in 1937. The aircraft was not designed to today's modern airworthiness standards, and was also designed without current knowledge of metal fatigue. As the type has been out of production since 1945, and relatively few remain in existence, fleet technical support is not comparable to more modern aircraft.

The use of aging general aviation aircraft and veteran retired military aircraft has been the subject of concern within the international aviation community. There have been a number of serious accidents in the USA involving the structural failure of ex-military aircraft, which were considerably younger than N4575C. In addition, a number of WW 2 aircraft have also suffered accidents in the UK in recent years, due to a variety of maintenance and operational causes. The USA FAA in association with the EAA, AOPA and AAA have seen fit to issue a Best Practices Guide for Maintaining Aging General Aviation Aircraft, which can be found at: http://www.eaa.org/communications/eaanews/agingbestpractices9021.pdf

2. ANALYSIS

2.1 Wind regime on landing

Analysis of the anemometer chart for Knock International Airport indicates that the wind went gradually from 330 to 350 degrees and from 13 kt to 16/17 kt around the time of the accident. No "marked discontinuity" occurred during the 10 minutes prior to the actual landing. The wind reported by ATC just prior to landing (360 degrees 15 kt) can be confirmed by the anemometer trace. The lack of significant radar echoes suggests that Cumulonimbus (Cb) downdrafts were not a significant feature of the weather at the time of the accident. In addition, the pressure gradient would be expected to generate moderate turbulence at most.

2.2 Crosswind Limitations

The photocopied flight manual available to the flightcrew of N4575C did not contain any information pertaining to crosswind limitations. This would have been the norm for vintage type aircraft of that era. In the absence of stated crosswind limitations, a crosswind limit would have been at the discretion of the operator or the pilot. Modern day aircraft manufacturers generally incorporate a maximum demonstrated crosswind (MDC) into the AFM.

The MDC is normally published in the performance section of the AFM and is considered to be the maximum crosswind component that has been encountered and documented during certification flight tests or subsequently. Experienced test pilots normally conduct the flight certification flights.

Ordinarily, MDC is not considered to be an operating limitation, nor does it necessarily reflect the aircraft maximum crosswind capability. It does, however, normally apply to a steady wind state. Practically speaking, the majority of commercial operators do consider the MDC as a limitation and generally will set the operational crosswind limitation at or below the MDC. When no demonstrated gust value is available in the AFM, normal practice would be to plan and use a reported tower average wind or a tower gust wind that is lower than the MDC. In addition, operators normally reduce crosswind limits from the maximum stated for operation on a contaminated runway

For aircraft where no crosswind limitation or MDC is specified, a good rule of thumb would be for the 90 degree crosswind not to exceed 20% of the type stall speed. When the rule is applied to the stated stall speed of the Goose (Section 1.16.3.2) it is found that the full crosswind limitation for Flap 30 and Flap 60 is 12.6 kt and 11.2 kt respectively.

No response was forthcoming from the aircraft manufacturer with regard to requests for information from the Investigation. This would indicate that the manufacturer no longer provides manufacture support to their vintage type aircraft. Discussions between the FAA Certified Instructor and the Investigation determined that the crosswind limitation for the Goose was accepted as 17 kt.

On completion of the conversion course on type, the FAA Instructor verbally set a crosswind limitation for both pilots of 8-10 kt. The Private Operator verbally set a limitation of 5 kt.

2.3 The accident

Conflicting views were presented with regard to the type of landing N4575C performed on the day. Both pilots believed that the landing was a firm main wheel landing. The Owner/passenger believed it to be a firm three-point landing with a bounce and the Tower Controller considered it to be a firm landing, in a more tail down attitude, followed by a single bounce.

In any event, tyre marks observed on the runway clearly indicate that the aircraft landed in the mid-point area of the TDZ, approximately 10 metres left of the runway centreline. This would indicate that the aircraft drifted left, just prior to touch-on, or during a possible bounce after the initial touch-on, or after the final touch-on. The dominant left tyre mark found on the runway indicates that the left undercarriage assembly was subjected to high lateral loads from the right, which would have been caused by the full crosswind of between 16 and 17 kt.

Initially, directional control was maintained, albeit left of centreline. As ground speed reduced, the tail of the aircraft would have been either on or dropping down towards the runway surface. In this tail down attitude, the fin and rudder becomes largely masked by the high wing/engine configuration and the effectiveness of directional control of the aircraft would reduce significantly. With this reduction in directional controllability, the crosswind element from the right would have become dominant on the fin/rudder area and would have pushed the tail towards the left. As the nose of the aircraft veered right, the right wing would have become more exposed to the prevailing wind, with the result that the right wing lifted. As the right wing lifted, virtually no lateral loads would have been imposed on the right undercarriage assembly, but significantly more lateral loads would have been transferred to the left undercarriage assembly. The combination of the aircraft veering to the right, coupled with the high centre of gravity and the centrifugal forces generated by the swing to the right, resulted in the lateral over-load of the left undercarriage.

The lower drag links failed first in overload, followed by the upper strut member. With failure of either of the lower drag links, the entire wheel and axle assemble rotates outwards at the top. With excess force on the bottom of the wheel toward the centre of the aircraft, the force would have been, a compression on the upper drag link, and tension on the lower one. The left wheel was then detached from the aircraft, and departed. The left undercarriage leg was also torn from the aircraft during this collapse. The damage to the left retracted wingtip float, the left outer wing section, and the fuselage skin resulted from the collapse of the undercarriage. The damage to the fuselage frame was as a result of the ground impact and ground loop forces.

An effect of the over-inflated shock-strut would have been to reduce the compression of the leg during landing, thereby increasing the effective length on the leg. During the ensuing swing to the right, this would have increased the lateral leverage on the leg, thus aiding to its failure in overload. The reduced thickness of the support housing of the centre-point folding bolt also reduced the lateral strength of the leg.

The overall aircraft was well maintained. However two defects existed in the left leg undercarriage shock-strut, namely the readily-seen defect on the surface of the sliding cylinder and the reduced thickness of the support housing of the centre-point folding bolt. Both of the defects both merited repair or replacement of the leg.

When one considers the independent witness observations of the Tower Controller and taking into account the tyre marks/scrapes identified on the runway and the fracture sequence of the left undercarriage assembly, there is sufficient evidence to determination that the instigator for the failure of the undercarriage assembly was the lateral forces generated during the loss of directional control in the latter stages of the landing rollout.

Contributory to the difficulty of maintaining directional control in the prevailing crosswind conditions would have been the higher-than-normal pressure in the undercarriage shock-struts. Due to the geometry of the undercarriage, the undercarriage track width, already narrow, would have been reduced further. This would have reduced directional stability during take-off and landing. The nose of the aircraft, in the landed attitude, would have been raised further than normal, thereby increasing the blanketing effect on the fin and rudder, again reducing direction stability on the runway. In addition, the aircraft would have had to be landed-on very gently to avoiding bouncing. This tends to result in a "floater" landing. In a crosswind situation, a firm landing is preferable, in order to reduce the risk of sideways drift over the runway.

2.4 Discussion

In the design of amphibious aircraft there is always compromise between water landings and on-ground landing requirements. Primarily, the Goose was designed to operate from the water. This resulted in a high wing cantilever monoplane, with high mounted radial engines, resulting in a high centre of gravity. The all-metal hull contains recesses where the narrow track main retractable undercarriage can be withdrawn into the sides of the hull. The tail wheel, which is located at the rear of the two-step hull, but forward of the empennage, is of short-coupled retractable type with a centering lock.

Crosswind landings on water would generally not be considered an issue as normally one could expect a pilot to plan to utilise an expanse of water that would ensure that the aircraft takes-off or lands into wind.

Landing on runways with a crosswind component would tend to be more problematical than other conventional type aircraft. In general, this is because of the overall amphibious type design, the narrow undercarriage track, masking of the tail area in the tail down position and the fact that, if or when the tail drops to the ground, the centre of gravity moves aft with the result that the rudder becomes less effective.

The reported average wind conditions during the final approach of N4575C were 360 degrees 14 kt and 360 degrees 15 kt. However, good airmanship dictates that one should consider that the actual prevailing wind maybe somewhat higher or lower than the reported wind (Section 1.7.2). Analysis of the anemograph trace confirms that the prevailing wind conditions at the time of landing were 350 degrees 16 to 17 kt. Both the reported mean wind and the actual recorded prevailing wind were in excess of the wind limitation that was verbally set by the FAA Instructor (8-10 kt) and the Private Operator (5 kt). These limitations were mindful of both pilots experience on type and the fact that the Goose is recognised as a difficult type to land in strong crosswind conditions.

Landing N4575C on the day of the accident, in crosswind conditions that were on the accepted crosswind limit, provided a significant challenge to the PF and would have required an instinctive knowledge of the aircraft type.

A review of the PF overall flying experience shows that almost 50% of his 6,330 hours were achieved on DC 3 (tail wheel) type aircraft. However, his total time on the Goose was 58 hours of which only 33 were as Pilot-in-Command (PIC).

The landing/rollout technique used by the PF was unsuitable for maintaining directional control under the prevailing wind that existed across the runway during the landing. Had the PF complied with the wind limitations that had been set by either the FAA Instructor or the Private Operator, no landing would have been attempted and therefore no accident would have occurred. In addition, the PNF, who was designated as the Chief Pilot of the private operation, was not sufficiently forceful in ensuring that the PF complied with the instructions of the FAA Instructor and the Private Operator for crosswind limitations.

3. CONCLUSIONS

(a) Findings

1. The flightcrew were properly certified, licensed and medically fit to undertake the flight in question.
2. The aircraft had a valid Certificate of Airworthiness (C of A).
3. While the aircraft was well maintained, the Investigation did find two significant defects to the left shock-strut, which should have been rectified.
4. The ATC reported average wind on final approach was accurate as confirmed against the anemograph trace.
5. The prevailing wind for RWY 27 at time of landing was confirmed against the anemograph trace as 350 degrees 16 to 17 kt.
6. The actual prevailing wind at the time of landing was on the accepted crosswind limits of the aircraft.
7. Crosswind limits verbally set by the FAA Instructor and the Private Operator were not adhered to by either the PF or the PNF.
8. The crosswind limits set by the FAA Certified Instructor were appropriate in view of the particular aircraft type and the limited Pilot-in-Command (PIC) type experience of both pilots.
9. The landing and rollout technique used by the PF was unsuitable for maintaining directional control on the runway in the prevailing crosswind conditions that existed at the time of landing.
10. The failure of the left undercarriage assembly was as a direct result of directional control being lost during the landing rollout.

(b) Cause

1. Use of a landing and rollout technique that was unsuitable for maintaining directional control on the runway in the prevailing crosswind conditions that existed at the time of landing.

(c) Contributory

1. Non-compliance with verbal crosswind limitation instructions that had been set by an FAA Certified Instructor and the Private Operator.

2. Over inflation of the undercarriage shock-struts.

4. Safety Recommendations

This report does not sustain any Safety Recommendations.

Appendix A

Fig 1. Normal hard surface configuration

Fig 2[2]. Final resting position

[2] The port side wingtip float is seen in the fully retracted position with the wing bent slightly upwards. The starboard wingtip float is partially extended towards the down position. This float condition occurred subsequent to the aircraft coming to a halt.

Appendix B

Fig 3. Sliding section of left shock-strut.

Fig 4. Magnified surface defect area