FINAL REPORT

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In accordance with the provisions of S.I. 205 of 1997, the Chief Inspector of Accidents, on 18 August 2003, appointed Jurgen Whyte as the Investigator-in-Charge to carry out a Field Investigation into this occurrence and prepare a Synoptic Report.

Aircraft Type and Registration:	Sikorsky S-61 N, EI-CNL
No. and Type of Engines:	2 x General Electric CT 58-140-2
Aircraft Serial Number:	61746
Year of Manufacture:	1974
Date and Time (UTC):	18 August 2003 @ 13.31 hrs
Location:	Landing markers, Runway (RWY) 31 at Shannon Airport (EINN)
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - Nil
Injuries:	Crew - Nil Passengers - Nil
Nature of Damage:	Damage to keel area and anti-collision light
Commander's Licence:	UK JAR ATPL(H)
Commander's Age:	Male, aged 48 years
Commander's Flying Experience:	12,000 hours of which 8,500 were on type
Information Source:	Accident Report Form and Internal Investigation Report submitted by the Operator – AAIU Field Investigation

SYNOPSIS

While carrying out a pilot Operator Proficiency Check (OPC), the helicopter touched-on with the main Landing Gear retracted. Damage was caused to the underbelly anti-collision light and a section of the keel area. There were no reported injuries or fire.

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1. FACTUAL INFORMATION

1.1 History of the flight

The civilian[1] Search and Rescue (SAR) helicopter, registration EI-CNL was operating from its home base at EINN for the purpose of conducting a pilot OPC. The Pilot-Flying (PF), a rated Captain with 11,816 hours of which 848 were on type, was the pilot-under-test and was seated in the right hand seat (RHS). The Pilot-Non-Flying (PNF), who was also a rated Captain, was the aircraft Commander/Type Rating Examiner (TRE) and was seated in the left-hand seat (LHS). No other persons were onboard.

Weather for the exercise was reported as good with a surface wind of 270º/15 kt and a visibility of 10 km.

At the commencement of the OPC, the active runway was RWY 24. However, Air Traffic Control (ATC) allocated RWY 31 to EI-CNL, with the instruction that they carry out left-hand circuits and remain south of the active runway at all times.

Prior to lift off, part of the Audio Voice Alerting Device (AVAD) relating to Undercarriage and Decision Height (DH) warnings were inhibited in compliance with the laid down procedures for radio altitude (RADALT) bug settings for General Operations (onshore). **See Section 1.2 AVAD and Section 1.3 RADALT warnings**.

The first circuit carried out in the OPC consisted of a "FREE CIRCUIT" to allow the PF to settle into the training requirement environment with utilisation of the aircraft checklist. Subsequent to this particular circuit, the flight crew carried out "Training checks". In general, the training checks require the PF (under test or instruction) to state the check requirement and for the TRE/Instructor to call and perform the check where required without the use of a prompted checklist. **See Section 1.5 Training Checklist**. The PF then verifies the check.

The second circuit consisted of an "ENGINE FIRE" check during the downwind segment, followed by a single-engine run-on landing to RWY 31. Both these elements of the OPC were uneventful.

For the third circuit, the PF was advised by the TRE to expect a simulated engine failure at any phase of the circuit. The simulated engine failure was in fact initiated by the TRE just after the take-off decision point (TDP) on the third circuit. The PF continued the one engine inoperative (OEI) climbout for a left-hand circuit and requested the Landing Gear to be selected up as is procedurally required.

The Cockpit Voice Recorder (CVR) and Flight Data Recorder (FDR), confirm that the undercarriage was retracted and that the simulated engine shutdown checks were carried out as the aircraft reached the start of downwind. The TRE then acknowledged the conclusion of this particular check by calling "MALFUNCTION COMPLETE". Approximately six seconds later, towards the end of downwind, the TRE initiated a new failure by selecting the "AUXILIARY HYDRAULICS" off.

[1] The Operator/Company provides Search and Rescue services from a number of bases in Ireland for the Department of Communications, Marine and Natural Resources. The Company is a subsidiary of a larger helicopter Parent Company that has its operational headquarters in Scotland.

The net effect of this particular failure is that the automatic flight control system (AFCS) is automatically disengaged and the flight controls become heavy. Control inputs on the cyclic, collective and rudder pedals during the hydraulics failure require a sensitive but firm touch by the PF. This is particularly noticeable as speed decreases during the latter stages of the approach and when transitioning to a hover/landing.

The PF responded with the appropriate corrective action requirements involving both the PF and the TRE cross checking the system failure. It was then agreed by both pilots to recover the aircraft (with the selected failure) back to RWY 31 for a hover/landing.

Prior to becoming established for RWY 31, both pilots engaged in a cockpit discussion relating to the status of another aircraft movement (G-BOHX), which at the time was taxiing across RWY 31 for a departure off RWY 24. The discussion concluded approximately two minutes (13.29:23) from actual touchdown with a TRE requirement call to ATC for "*Shannon Tower EI-CNL established final RWY 31*". EI-CNL was cleared to land RWY 31 by ATC and this was acknowledged by EI-CNL at 13.29:44. No other transmissions took place between ATC and EI-CNL until after the mishap.

CVR data confirms that no reference was made by either flight crewmember to any pre-landing checks requirements other than:

- PF: *"Okay, LDP* (Landing Decision Point) *will be standard 100 feet 35 kt"*.
- PNF *"Roger"*.
- PF: *"Okay, Speed Selects fully forward please"*.
- PNF: *"Roger, 100 feet going forward"*.

At 100 feet above ground level (AGL) the AVAD activated with an audio voice advisory of "ONE HUNDRED FEET". Approximately 22 seconds later, the PF announced, "*okay and landing*".

The first point of contact between the aircraft and the runway was made by the non-retractable full swivel tail wheel. As the collective was lowered to settle the aircraft on the runway, the second point of contact was with the belly anti-collision light, followed by the left-hand side of the keel centreline, forward of the Landing Gear sponsons. The time lapse from tail wheel contact to the aircraft settling on the runway was approximately 14 seconds. CVR data and discussion with the PF confirmed that his personal thought process was that he perceived something was abnormal (probably due to the lower than normal nose down attitude) just as the aircraft was about to settle on the runway. However, neither pilot reacted to this until the keel came in contact with the runway. On realisation of the error, the PF recovered the aircraft back to the hover, the Landing Gear was extended and the aircraft was landed back on.

A visual inspection of the keel area by the TRE confirmed that the aircraft had been damaged. The aircraft was then ground taxied back to the dispersal area where an engineering inspection determined that the aircraft was unserviceable.

Information provided to the Investigation indicates that a detailed and unrushed briefing was given as part of the training plan and that the aircraft's preparation for flight was also methodical. A review of flight crew duty time indicates that fatigue was not a factor in this particular occurrence.

1.2 Audio Voice Alerting Device (AVAD)

EI-CNL is fitted with an AVAD. The aircraft has a modification embodied (Bond Mod No 1757) coupled to the AVAD in the form of an audio warning control panel. The AVAD control panel contains test and reset switches, an amber "FAIL" light and a Landing Gear test switch.

The AVAD is a self-contained voice advisory device mounted in the nose bay. The female voice audio output level is preset internally and routed to the pilot and co-pilot audio selector panels. Height and undercarriage warnings are triggered by radio altimeter (RADALT) settings, which are height selectable.

The undercarriage voice warning system is incorporated in the AVAD and will be triggered under the following conditions:

- The landing gear handle red light (transition) is on for over eight seconds; or
- DH warning is activated when the landing gear handle red light is on; or
- DH warning is activated with the landing gear is up; or
- When the test button is depressed for longer than eight seconds.

After a Landing Gear unsafe indication for more than 8 seconds, the audio warning will give the message "UNDERCARRIAGE" 3 times. The message will be repeated each one minute until the condition disappears. When the Landing Gear is not in the safe down position and the aircraft is at or below DH, the voice warning will give the messages "DECISION HEIGHT" and "UNDERCARRIAGE". The undercarriage voice warning system can be inhibited by setting either of the RADALT DH bugs to below zero feet.

The AVAD system will output messages under certain conditions and with defined priorities. The only message with an attention is the "ONE HUNDRED FEET" warning. The "initial repeat" specifies the number of times and at what interval the initial message is produced; the "time delay" defines the delay after which the whole message sequence is repeated, provided that the appropriate conditions still prevail. The messages, priorities, conditions and time delays are presented as **APPENDIX A** to this report.

1.3 RADALT Warnings

1.3.1 General

Both RADALT's have DH knobs, which control the DH bugs. The DH bugs indicate the height at which the DH lamp (warning light) will illuminate. The DH lamps will illuminate when the aircraft descends below the height set on the individual DH bug. The DH lamp can be turned off by pushing the lamp in. The lamp can be turned on again by pressing the DH lamp a second time. Once turned off, the DH lamp will automatically re-arm upon climb out, as the aircraft passes up through the DH bug setting.

In addition, a "DECISION HEIGHT" voice warning will be triggered when the aircraft descends below the RADALT height at which the lower of the two DH bugs are set. With both DH bugs set at the same height, the DH lamp and the "DECISION HEIGHT" voice warning will illuminate/activate simultaneously.

When either one of the RADALT's is set below zero feet, the undercarriage warning system is inhibited. If the other RADALT bug is set above zero feet, the DH lamp will activate when the aircraft descends below the set height. However, the "DECISION HEIGHT" voice warning will not sound, as its activation is linked to the lower bug, which in this particular case is set below zero feet.

Irrespective of the RADALT bug settings, the AVAD will provide a "ONE HUNDRED FEET" voice warning, which is triggered when the aircraft descends below 100 feet AGL indicated on the right hand side RADALT position.

1.3.2 RADALT DH bug setting procedures

Part A, Section 8.3.4.6.1 of the Air Operators Manual (AOM) contains procedures for RADALT DH bug settings for General Operations (*including training*) and are presented as **APPENDIX B** to this report.

Part B, Section 14.10 of the AOM contains procedures for RADALT bug settings for SAR Operations and are presented as **APPENDIX B** to this report.

1.4 Operator's/Company philosophy to bug setting procedures

In general, the philosophy behind the Operator's/Company bug setting procedure is to ensure, as far as possible, that the AVAD "DECISION HEIGHT" warning is only triggered when the aircraft is in an unintentional descent.

Additionally, discussions between the AAIU and the Irish Operator revealed that some of the actual DH bug setting procedures may have evolved over the years in consideration of reducing the number of audio advisories/warnings presented to flight crew during critical phases of flight, for example, approach and landing.

1.5 Training Checklist

Training Checks are specified under Part D, Section 2.1, paragraph 8.3.8 of the AOM.

Para 8.3.8 states that, "*A Training Checklist may be issued for each aircraft type, to be used in the circuit for training or non-CAT Checks flights only. This will be done when the normal checklists would be inappropriate. The Checklists will be issued to Training Captains only and do not form part of the aircraft library*".

In general, the training checks require the PF (under test or instruction) to state the check requirement and for the TRE/Instructor to call the check (*challenge*) and perform the check where required without the use of a prompted checklist. The PF verifies the check (*response*).

Use of the normal checklist is conducted in the same way as the Training Checklist, with the exception that the PNF challenge comes directly from a referenced/prompted checklist. No new check in the list should be called until the active check has been responded to by the PF. If used correctly, the normal prompted checklist ensures that each and every check for the particular phase of flight requirement is called and responded to. In the event of a minor distraction/interruption, the PNF has a reference point on the checklist where he/she can recommence the checklist without missing a particular checklist item.

In discussions with the Irish Operator, it was determined that the Parent Company in Scotland does utilize a Training Checklist, usually during repetitive VFR type training/circuit work. However, the Irish element of the operation made a conscious decision not to develop such a Training Checklist, therefore the NORMAL and EMERGENCY checklists were the only approved checklists for flight.

1.6 Internal Aircraft Accident Investigation Report

An internal investigation into this accident was conducted by a member of the Head Office of the Parent Company in Scotland and a copy of the subsequent Aircraft Accident Investigation Report was provided to the AAIU on the 5 September 2003. In general, the Report was very detailed and clearly indicated that a pro-active and positive safety culture exists within the Company.

2. DISCUSSION

2.1 General

The damage incurred to EI-CNL during the wheels-up landing was not extensive. However, the Investigation recognizes that under different circumstances (run-on landing, confined area etc), the outcome could have been far more serious. While this was the first such occurrence of its type to happen to the Company, the potential does exist for a similar type event to re-occur unless some remedial action is put in place.

2.2 Training Checklists

Both of the experienced pilots were familiar with the use of a Training Checklist from previous training/rating flights conducted with the Parent Company in Scotland. The Irish Operator did have a provision in their AOM for the use of a Training Checklist. However, as the decision was made by the Irish Operator not to utilise such a checklist, none was issued for the aircraft type. Therefore the NORMAL and EMERGENCY checklists were the only approved checklists for the flight and as such should have been used accordingly.

The Investigation does not support the use of a training checklist for critical phases of flight, as its format is contrary to that which is used in both the manufacturers/operators NORMAL and EMERGENCY checklist. The "TRAINING CHECKLIST", relies primarily on memory (recall) alone. While this is not a problem in itself, it is considered by the Investigation that, once the checklist is not referenced, the potential will always exist for a check/checklist item to be excluded or missed, particularly if a flight crewmember is momentarily interrupted or distracted.

2.3 Inhibiting of the undercarriage warning system

The AVAD system fitted to EI-CNL provides a number of voice advisories to the flight crew including; "ONE HUNDRED FEET", "DECISION HEIGHT", "FIRE" and "UNDERCARRIAGE" warnings.

The "UNDERCARRIAGE" warning activates if the Landing Gear handle (Red light) remains on for over 8 seconds or when the "DECISION HEIGHT" warning is activated with the Landing Gear (Red light) is on or the Landing Gear is up. SAR helicopters frequently operate at extremely low cruise height/hover height, in varying operational environments. This complicates the bug settings normally imposed on offshore non-SAR operations.

The Operators philosophy for DH bug setting procedures in general relate to the "DECISION HEIGHT" voice warning only being activated when the helicopter is in an unintentional descent from the planned cruise height/DH/hover height. Some of the bug settings would appear to have evolved from a need to reduce distractive calls (such as DECISION HEIGHT) during the critical phases of flight (Take-off, approach and landing). It is fair to say that, the combination of the pilot requirement checklist/calls, SAR crewman patter and the advisories/warnings generated by the AVAD, do make for a "very busy" cockpit environment.

In reviewing the RADALT DH bug setting procedures for General and SAR operations, it can be seen that the UNDERCARRIAGE warning facility is provided for all stated phases of flight, except during take-off, approach and landing in VFR/IFR onshore operations.

The repetitive nature of circuit work can expose flight crews to an increased risk of forgetting or missing a crucial check or checklist item. The availability of equipment generated safety feature such as a flap or undercarriage warning, does provide the human element of the operation with an additional source of protection, which enhances safety and thus should be utilized.

To inhibit the UNDERCARRIAGE warning ultimately denies the flight crew a vital safety feature of the AVAD system. Therefore, the inhibitation of an established safety feature is not supported by the Investigation.

If the flight crews can, for the majority of the stated phases of flight, accept the different DH bug settings, which incorporate and satisfies the UNDERCARRIAGE warning system, it should follow that they can accept (live with) this safety feature for the remaining unprotected phases of flight, namely take-off, approach and landing VFR/IFR onshore.

3. CONCLUSION

(a) General

The PF, who is required to initiate the approach check and checklist requirement, did not do so on this occasion. The TRE, who by authoritive position has overall responsibility for the safety of the flight, did not detect or correct this oversight. How this situation arose, must remain a matter of conjecture. However, the loss of situational awareness in relation to the approach check requirement and the aircraft approach configuration may have occurred through distraction resulting from the flight crews discussion/concern for G-BOHX crossing RWY 31 during EI-CNL's approach. The demands on the PF to maintain stable and precise control of the helicopter during an auxiliary hydraulics failure and the use of the memory-sourced Training Checklist, as opposed to a referenced/prompted NORMAL checklist, may also have been a contributory factor.

(b) Cause

An oversight by the flight crew to properly configure the helicopter for landing.

(c) Contributory

Improper use of a recall training checklist, which although employed operationally by the Parent Company in Scotland, was not adopted by the Irish element of the operation.

Adherence by the flight crew to Company laid down procedures for RADALT DH bug settings, which inhibited an available and established equipment based undercarriage warning device.

4. SAFETY RECOMMENDATIONS

The Investigation recommends that:

The Operator/Company should review its RADALT DH bug setting procedures for General Operations (onshore) or consider any other initiative that would ensure that the UNDERCARRIAGE warning facility is available during all the stated phases of flight.
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APPENDIX A

AVAD Warning Priority

Message	Priority	Initial Repeat	Time delay	Condition required to initiate message
100 feet	1	None	None	Aircraft below 100 feet on P1 RADALT
Decision Height	2	2 at 1.5 sec	None	Aircraft below lower of P1 and P2 RADALT DH bug height
Fire Warning	3	2 at 1.5 sec	1 minute	#1 or #2 engine fire detector OR warning system tested
Undercarriage	3	3 at 1.5 sec	1 minute	Landing gear handle red light on for over 8 seconds, OR Decision Height warning activated with landing gear handle red light on, OR Decision Height warning activated with landing gear up, OR warning test button depressed for longer than 8 seconds
Cabin Call	4	2 at 1.5 sec	None	Winch operator call switched pressed
AVAD Test	4	None	None	AVAD test switch on control unit pressed

APPENDIX B

RADALT D.H. BUG SETTING PROCEDURES GENERAL OPERATIONS			
Flight Phase	**RAD ALT**	**Setting Onshore**	**Setting Offshore**
En-route VFR/IFR	PF	1000 ft or MOCA[2]	1000 ft
	PNF	1000 ft or MOCA	1000 ft
En-route at 1000 ft Or descent for 1000 ft	PF	500 ft	500 ft
	PNF	500 ft	500 ft
Take-off VFR/IFR	PF	0 ft	50 ft
	PNF	250 ft	250 ft
Approach & Landing VFR/IFR	PF	0 ft	50 ft
	PNF	250 ft or MDH/DH	250 ft or MDH/DH
Note: Pilots are not to set the radar altimeter bugs such that a "Check Height" warning will be activated between 100 and 170 feet, as this will cause the "ONE HUNDRED FEET" call to be inhibited or delayed.			

RADALT D.H. BUG SETTING PROCEDURES – SAR OPERATIONS		
Flight Phase	**RAD ALT**	**Setting Offshore**
En-route VFR/IFR	PF	1000 ft
	PNF	1000 ft
Below 1000 ft and above 500 ft amsl	PF	Not below 500ft
	PNF	500 ft
Below 500ft	PF	20 ft below desired height
	PNF	30 ft below desired height
Hover Height (Auto or manual)	PF	10 ft below desired height
	PNF	20 ft below desired height

[2] Minimum Obstacle Clearance Altitude