CANADIAN FORCES
FLIGHT SAFETY INVESTIGATION REPORT (FSIR)

FINAL

FILE NUMBER: 1010-130311 (DFS 2-3-2)
DATE OF REPORT: 7 Sep 2007

AIRCRAFT TYPE: CC130 Hercules
DATE/TIME: 251400Z April 2006
LOCATION: CFS Alert, Nunavut
CATEGORY: 'D' Category Incident

SYNOPSIS

The incident occurred during the landing phase of a resupply mission to Canadian Forces Station (CFS) Alert in support of Op BOXTOP. Upon completion of a precision radar approach (PAR), the aircraft landed long and after touchdown experienced directional control difficulties. The aircraft was unable to stop in the remaining runway available and departed the end, coming to rest in two-foot deep snow. There were no injuries. The aircraft sustained minor damage.

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1. FACTUAL INFORMATION

1.1 History of the Flight

The flight into Alert was in support of Op BOXTOP, a two-week, semi-annual operation staged out of Thule, Greenland. The mission was to resupply the Station with fuel. This was accomplished with four aircraft and eight crews working 24/7. The flight, call sign ‘Boxtop 11’, was the first of two flights planned for the day for the crew. The uneventful one and one-half hour transit from Thule to Alert culminated in a PAR approach to runway 23True (23T), flown by the First Officer. The instrument approach was flown to short final at which time transition to visual flight was made. The aircraft landed long, experienced directional control difficulties and departed the end of the 5500-foot runway. The aircraft stopped with its tail 80 feet from the runway end (Annex A, Photo 1). The crew conducted a normal shutdown and egressed the aircraft.

Emergency response personnel secured the site. The runway was closed and the Operation was suspended. Once the minor nature of the damage was ascertained by maintenance personnel, the aircraft was dislodged from the snow with the use of heavy equipment and tow bridles (Annex A, Photo 2). The runway was subsequently re-opened and the Operation resumed.

1.2 Injuries to Personnel

Nil.

1.3 Damage to Aircraft

The aircraft sustained minor damage (dents and scrapes) to the forward and aft nose wheel doors and external fuselage skin aft of the nose wheel. As a precaution, maintenance personnel from 8 Wing Trenton were dispatched to Alert to conduct non-destructive testing on the nose wheel oleo trunnion. No faults were found. The damaged nose wheel doors were removed and the aircraft was flown to Trenton under an operational restriction.

1.4 Collateral Damage

Nil.

1.5 Personnel Information

The operating flight crew of Boxtop 11 consisted of an Aircraft Commander (AC), First Officer (FO), Navigator (Nav), Flight Engineer (FE) and Loadmaster (LM). All crewmembers were qualified, current and well rested at the time of the occurrence. The crew had flown into Alert twice during this Boxtop in the days preceding the occurrence.

	AC	FO	Nav	FE
Category/Expiry	AC / Nov 07	Level 1 / n/a	Operational / Jun 07	Operational / Mar 07
IRT Category/Expiry	CAT 1 / Jul 06	CAT1R / Nov 06	N/a	N/a
Medical Expiry	30 Sep 06	31 Oct 06	30 Apr 06	31 Jul 06
HPMA Expiry	Dec 06	Dec 06	Dec 06	Dec 06
Total flying time	8450	402	3234	2373
Flying hours CC130	6040	188	3012	1193
Flying hours last 30 days	21	14	14	19
Duty hours last 24 hours	4	4	4	4
Flying hours last 24 hours	3.1	3.1	3.1	3.1
Flying hours on day of Occurrence	1.6	1.6	1.6	1.6

TABLE 1: Personnel Information

The AC was an experienced CC130 pilot having served in both the training and standards roles. Additionally, he had extensive exposure operating on BOXTOP and at CFS Alert.

The FO was new to the CC130 and its role, having completed the Operational Training Unit (OTU) in December 2005. His exposure to CFS Alert was limited to the occurrence flight and the two previous missions flown during this BOXTOP where he occupied the right seat and did not land the aircraft. This flight was the FO's first exposure landing at a heavy weight and landing on a short and icy runway. The FO had one exposure in the CC130 flight simulator landing at Alert; however, the aircraft was not operating at a heavy weight and the runway condition was not as icy.

All aircrew were current in Human Performance in Military Aviation (HPMA) training. The PAR Controller was qualified, current and rested at the time of the occurrence.

1.6 Aircraft Information

1.6.1 General

A review of the CC130311's Maintenance Record Set revealed no pertinent anomalies associated with the aircraft.

1.6.2 CC130 Landing Performance Data

The Aircraft Operating Instructions (AOI) provide CC130 crews with performance data for all stages of flight. Landing performance data is presented for a range of aircraft gross weights, aircraft configurations, runway conditions and atmospheric conditions. Specific landing distance requirements that need to be calculated and satisfied in order to effect a safe landing are:

1. *Landing Distance Over 50 Foot Obstacle*: by definition, the distance determined by this calculation must be equalled or exceeded by the runway length available before a crew shall attempt a normal landing on this runway. To validate this distance, the aircraft must:
   a. Cross the runway threshold[1] at 50 feet above ground level (AGL);
   b. Cross the threshold at the calculated threshold speed;
   c. Continue on a nominal 3º G/P until the ground point of intercept (GPI);[2]
   d. Touchdown at the calculated touchdown speed; and
   e. Execute a landing ground roll.

2. *Landing Ground Roll*: by definition, the distance determined by this calculation is the minimum distance required to stop the aircraft once it has adopted the taxi attitude. To validate this distance, the aircraft must:
   a. Transition from touchdown attitude to taxi attitude within one second; and
   b. Achieve maximum braking and power selection upon reaching the taxi attitude.

Power selection performance data can be calculated for 4 Engines In Reverse Thrust, 2 Engines In Reverse Thrust/2 Engines In Ground Idle (2 Rev/2GI) and 4 Engines In Ground Idle. Crews procedurally calculate landing data using 2 Rev/2GI. This provides a conservatism; in the event of an engine or propeller induced directional control problem necessitating the reverse of only two symmetrical engines (2 Rev/2GI), the calculated landing distance available will be valid.

1.6.3 Mission TOLD Card

The pilots completed a Take-off and Landing Data (TOLD) card for the mission. The TOLD card, required for all take-offs and landings, is placed in the cockpit in view of the pilots and FE and serves as a reference document for performance

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[1] The threshold crossing height (TCH) for the Alert PAR was 34 feet due to its 2.7º glide path (G/P).

[2] GPI is the point at which any given G/P intercepts the runway and the value expressed refers to displacement in feet from the runway threshold. It is generally considered to be coincident with the touchdown point; however, the touchdown point is typically further from the threshold than the GPI. The time/distance traveled during the flare (transition from descent attitude to landing attitude) accounts for the difference. The Alert PAR GPI was 726 feet.

data. The determination of the TOLD data present at the time of the occurrence was based on the following conditions:

Aircraft gross weight (lbs)	138,000[3]
Flap configuration	Flap 100 (full flap)
Wheel brake anti-skid	Operative
Power selection (planned for)	2 Rev/2GI
Runway Condition Reading (RCR)[4]	5
Runway slope (%)	0
Pressure altitude (feet)	0
Outside air temperature (ºC)	-12
Wind	Variable at 3 kts

Landing data, specifically *Landing Distance Over 50 Foot Obstacle* and *Landing Ground Roll*, were calculated for a flapless landing. No data were calculated or included on the TOLD card for a Flap 100 landing, which was the flap configuration at the time of the incident. The pilots testified that although the required data for landing at Alert was not recorded on the TOLD card, they were cognizant of the values and these values were provided to the Investigators. The *Landing Distance Over 50 Foot Obstacle* and the *Landing Ground Roll* were calculated to be 4600 feet and 2700 feet respectively. The calculated threshold speed was 128 knots indicated airspeed (KIAS) and the touchdown speed was 118 KIAS.

The FDR indicated that the aircraft crossed the threshold at 137 KIAS and at 109 AGL (75 feet high, 9 KIAS fast). The AC was aware that the aircraft was high and fast upon crossing the threshold and he communicated this information to the crew. The FO testified that he 'floated the landing' and that the aircraft did not settle firmly onto the runway. Neither of the pilots was alarmed by the amount of runway remaining upon touchdown. None of the crew recalled the aircraft's touchdown point and only the Nav recalled seeing the passing of the 5000 and 4000 foot-to-go markers. The aircraft touched down at 116 KIAS (2 KIAS slow), 1824 feet beyond the GPI, which equates to 2550 feet beyond the runway threshold. The remaining runway available within which to stop the aircraft was 2950 feet, 250 feet more than the minimum 2700 feet required. The FDR data indicated the aircraft's groundspeed during the first few seconds after touchdown averaged 120 knots (kts), which translated to 200 feet per second. In order to satisfy the landing performance data, the pilot had approximately two seconds to attain maximum aircraft deceleration inputs.

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3 The C130 maximum recommended landing weight is 130,000 lbs. To maximize fuel airlift efficiency in support of the Operation, 1 Cdn Air Div authorized maximum landing weights of 140,000 lbs.

4 RCR is a numerical decelerometer reading used by aircrew to determine runway braking action. RCR 23 denotes the maximum friction value associated with a bare and dry hard surface, RCR 0 denotes a frictionless surface. CFS Alert has no RCR capability. Given that the Alert runway was hard-packed snow and ice, the crew used an RCR of 5 to quantify their anticipated braking effectiveness. RCR 5 to RCR 1 (RCR 0 is theoretically impossible) equates to an equivalent braking action of 'nil'.

1.6.4 C130 Deceleration Mechanisms

Deceleration of the CC130 aircraft during the landing ground roll is accomplished through the coordinated use of wheel brakes and propeller reverse pitch thrust. The brunt of deceleration is accomplished through braking, the effect being greatest when the aircraft's speed is low and the runway coefficient of friction is high (bare and dry). The deceleration effect of reverse thrust is greatest when the aircraft's speed is high and it is independent of runway friction.

The pilots testified that after touchdown the brakes were applied and the throttles were selected to ground idle (GI); however, the number one propeller (left wing outboard) was slow to respond. The FDR indicated that after touchdown, five seconds elapsed before illumination of the number 2,3 and 4 Beta lights, an additional two seconds elapsed before illumination of the number 1 Beta light and an additional two seconds elapsed before full reverse power was selected. The slow response of the number one propeller to reach Beta Range[5] created an asymmetry in drag. The aircraft veered to the right and the pilots delayed further propeller and brake deceleration efforts while attending to the directional control difficulties generated by the asymmetry. During the nine seconds between touchdown and the application of maximum deceleration inputs, the airspeed decreased from 116 to 88 KIAS and 1750 feet of runway were consumed. Notwithstanding full deceleration efforts once directional control was attained, the aircraft was unable to stop in the 1200 feet remaining and it departed the end of the runway, on centreline, at 34 kts groundspeed.

Four pilots who had flown CC130311 in the days preceding the occurrence were interviewed to ascertain whether a trend existed regarding the slow response of the number one propeller. One pilot recalled such a tendency with this aircraft; three pilots had not experienced this tendency. A slow response of one or more engines to reach Beta is not uncommon in the CC130. The adverse effect of this event can range from a minor concern to a directional control issue, the severity ultimately being dependent upon the time available to the pilot for compensatory action

1.6.5 CC130 Directional Control Mechanisms

Directional control of the CC130 aircraft during the landing ground roll is accomplished through the coordinated use of nose wheel steering (NWS), differential braking, rudder and differential power. NWS and differential braking effectiveness decreases as RCR decreases (NWS typically isn't used until rudder effectiveness is lost and NWS is ineffective on icy surfaces above taxi speed). Rudder effectiveness decreases as airspeed decreases and becomes ineffective below approximately 60 KIAS.

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[5] Beta light illumination indicates to the pilot that the propellers are in Beta Range. In Beta Range the propellers reach a negative blade angle; the lights provide visual indication that the throttles can be fully retarded effecting full propeller reverse thrust.

The FDR indicated that the aircraft landed left of the runway centreline and on runway heading (228º). Immediately after the throttles were selected to GI, the aircraft heading veered from 228º to 234º. The pilots testified that differential power was used to regain directional control and during this period the brakes were released. The FDR indicated that throttles 1 and 2 were maintained in GI and throttles 3 and 4 were slightly advanced, producing forward thrust. The aircraft heading backed to 223º and then veered to 228º at which point the runway centreline and runway heading was attained.

The FO testified that he did not recall using the rudder during the landing ground roll and the AC testified that the correct control inputs were made throughout the landing ground roll. The FDR indicated 3º to 10º left rudder input from the moment the aircraft veered right and during the directional control efforts. Maximum left and right rudder input was 10.3 and 12.8 degrees, respectively. The CC130 FDR does not capture NWS or wheel brake data.

The AC testified that all brake, throttle and flight control inputs were deliberate to pre-empt runway lateral departure. The Cockpit Voice Recorder (CVR) indicated nil cockpit coaching or commands issued during the landing ground roll.

1.7 Meteorological Information

The Alert meteorological observations available to the crew at the time of the incident were:

METAR: CYLT 251300Z 32006KT 10SN- FEW006 BKN012 OVC012 M12/M12 A3019

CYLT 251319 34004 7SN- FEW005 BKN008 OVC012 M12/M12 3019

TAF: AMD CYLT 251531Z 251324 VRB03KT 2SM –SN BR BKN004 OVC012 TEMPO 1324 P6SM –SN SCT005 OVC012

The ceiling and visibility conditions provided to the crew by the PAR Controller prior to the approach were 800 feet, 7 statute miles (SM). The crew reported that the weather conditions prior to landing were approximately 300 feet, 1 SM. There was no evidence to suggest that the weather was a factor in this occurrence.

1.8 Aids to Navigation

Alert runway 23T (228º actual) was served by a PAR approach. The PAR is not a permanent navigation aid at Alert; it is set-up at Alert during Boxtop to enhance safety and expediency amongst the increased volume of air traffic. The PAR has a 2.7º G/P, a 34-foot TCH and a 726-foot GPI.

1.9 Communications

Not applicable.

1.10 Aerodrome Information

CFS Alert is located at the northern tip of Ellesmere Island, Nunavut. The lone runway is 5500 ft long by 150 ft wide and is constructed of crushed gravel. Geographical limitations preclude the establishment of runway overruns. Runway 23T abruptly ends at 5500 ft; the land slopes upward from this point and is used as a receptacle for runway snow clearing efforts. The runway is served by a Visual Approach Slope Indicator System and runway lights that include centre row, high intensity lead-in lights and runway identification lights. Distance-to-go marker boards are also present, as is a well-defined service road (called the 'Met Shack Road') that intersects the runway on the north side, 2600 feet from the departure end of runway 23T.[6]

1.11 Flight Recorders

The aircraft was equipped with an independent FDR and a CVR. All recorded data were successfully retrieved from both devices. The PAR ground station recorded information on 8mm digital tape that was used for incident analysis.

A civilian helicopter employee recorded a videotape, capturing the incident from touchdown to aircraft stopped. A copy was provided to the investigation team and was used for incident analysis.

1.12 Wreckage and Impact Information

The aircraft came to rest in two-foot deep snow. The aircraft's right wingtip came within approximately 100 feet of a parked helicopter; the left wingtip came within approximately 100 feet of a large storage building.

1.13 Medical

The crew reported to the Station medical clinic for toxicology. The Physician Assistant (PA) was unfamiliar with post-aircraft occurrence aeromedical response procedures; consequently, the aircrew briefed the PA of the toxicology requirement, which resulted in a delay in the samples being drawn. The PA also reported that the supplied toxicology kit (Medical Specimen Transport Unit - MSTU) was incomplete.

All toxicology yielded negative results.

1.14 Fire, Explosives Devices, and Munitions

Not applicable.

1.15 Survival Aspects

Not applicable.

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[6] Alert Aerodrome Layout Chart 8WCE 08/99, refers.

1.16 Test and Research Activities

Not applicable.

1.17 Organizational and Management Information

Nil.

1.18 Additional Information

1.18.1 Approach Preparation

Based upon the weather provided by the PAR Controller at the time of the approach, the AC exercised the option for the pilots to execute a left-seat flown approach. The alternative, a pilot-monitored approach (PMA)[7] was not elected so that the FO could benefit from the exposure of both flying and landing the aircraft. In addition to the briefed PAR approach, the pilots had discussed other considerations associated with landing at Alert once they had transitioned to visual references. Notably, the agreed upon aim point was ‘a few hundred feet’ past the runway threshold and the agreed upon 'bolter point’[8] was the ‘Met Shack Road’. The pilots testified that the road was located ‘at about’ the 3000 foot-to-go point, and the crew had briefed this point on previous missions. Other interviewed CC130 pilots also cited this road as the final G/A decision point.

1.18.2 PAR Events Overview

The PAR Controller informed the crew at 13:49:57 UTC that they had intercepted the G/P. Over the next 69 seconds, the PAR Controller informed the crew five times that they were “on G/P”. During this period, the FDR pressure altitude indicated that the aircraft was approximately 40 to 170 feet above G/P. Over the subsequent 72 seconds, the Controller informed the crew five times that they were ”above” or “slightly above G/P”. During this period, the FDR pressure altitude indicated that the aircraft was approximately 170 to 230 feet above G/P. This deviation typically warrants PAR Controller commands to ‘adjust descent’, which weren’t provided. Prior to the third ‘above G/P’ call, the crew transitioned to visual references. At this point the aircraft was 1.3 nautical miles (NM) from the threshold, 225 feet above the PAR 2.7º G/P and on approach speed (148 KIAS). The two final calls from the Controller informing “above G/P” were then made. The aircraft descended at 2300 feet per minute (fpm)[9] in an attempt to

[7] A PMA occurs when the right-seat pilot flies the approach and the left-seat pilot monitors the flight progress. The left-seat pilot makes the decision, at the appropriate time and under specific conditions, to either assume control and land the aircraft or command a go-around (G/A). A G/A is a procedure whereby the aircraft climbs away from the runway during the approach, to either start the approach again, or proceed to an alternate airport.

[8] ‘Aim point’ is a point on the runway where the pilot will aim to land. The crew used the non-standard term ‘bolter point’ to define a geographical point on the runway at which the final decision to go-around (G/A) must be made.

[9] An aircraft established on the G/P and on airspeed, under the given wind conditions, would require approximately 800 feet per minute rate of descent.

regain the G/P; however, it crossed the threshold 75 feet higher and 9 KIAS faster than the targeted values. Figure 1 presents an overview of these events.

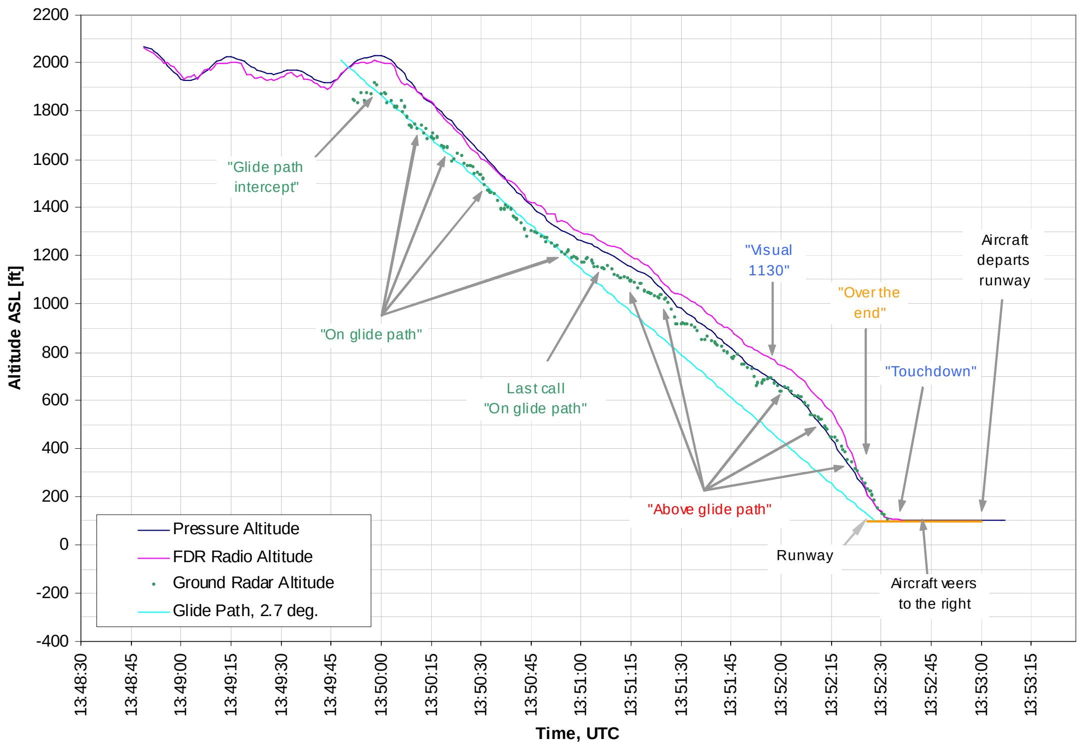

FIGURE 1: Events Overview

A review of the PAR tape by 8 Air Communication And Control Squadron (8 ACCS) Standards personnel revealed that the PAR control provided was 'satisfactory with debrief'. This assessment denotes that the standard was met in terms of traffic density and complexity, however minor monitor input would have been required for the PAR to be assessed as satisfactory.

1.18.3 The Go-Around Option

Thirty-nine seconds elapsed from the time the pilots transitioned to visual flight until the aircraft touched down during which the option to execute a G/A was available to the crew. The CVR did not indicate any voiced concern amongst the crew pertaining to this option. The AC testified that he had landed long at Alert in the past and was prepared to G/A if required. Additionally, he stated that he believed the aircraft had landed prior to reaching the briefed 'bolter point'. The Nav testified that he had been in a similar high and fast/long landing position once before, while going into Alert, in which the landing was safely executed. The remaining crew testified that they were cognizant the aircraft was high crossing the threshold and that they had not considered the G/A option. Established HPMA principles support the practice that any crewmember can provide input to the pilots regarding the G/A option. The decision rests with the AC.

The CC130 Standard Maneuver Manual (SMM) provides the following G/A criteria:

1. During a precision approach, the pilot non-flying (PNF) gives the G/A command if the runway environment is not positively recognized or the aircraft is not in a stabilized approach;

2. During a non-precision approach, the G/A command is given at the missed approach point if the PNF does not have adequate visual reference or the aircraft is not in a position to be flown to a successful landing; and,

3. The G/A command is also given when adequate visual reference is lost, or at any time when either pilot considers it necessary to discontinue the approach or landing.

1.18.4 Stabilized Approach Criteria

The SMM defines a stabilized approach as a flight condition that exists when the instrument approach is stable in accordance with the following criteria:

1. Plus or minus one half dot on the ILS localizer (on course PAR);

2. Plus or minus one half dot on the ILS glide slope (on glide slope PAR);

3. Plus or minus five knots of calculated approach speed;

4. Stabilized rate of descent; and

5. Aircraft in trim for continuation of a normal approach and landing.

1.18.5 Trans-Cockpit Authority Gradient

A trans-cockpit authority gradient can be an adverse condition when a crewmember's desire to avoid conflict and/or defer to the experience and authority of the AC exists. Two crewmembers testified that they were aware the aircraft was out of position over the threshold and that their concern was allayed when the AC communicated his awareness that the aircraft was high and fast.

1.18.6 Approach Procedures – Crew Understanding

A review of the CVR data indicated that the pilots had discussed PMA procedures in preparation for the approach. The discussion pertained to the options available to the FO, as the left-seat pilot flying the approach, when he called "minimums". The options cited that the right-seat pilot could respond with were 'visual 12 o'clock', 'continue' or 'go-around'. The pilots agreed that if the response 'continue' was made, the left-seat pilot could continue descent a further 100 feet. At this point the options cited that the right-seat pilot could call were 'nothing seen' or 'go-around'. These options, as they were presented for a left-seat flown approach, were contrary to procedures prescribed in the AOI. The option to continue instrument decent below minimums only exists during a PMA and only when a prescribed set of conditions are satisfied. Additionally, the response ‘nothing-seen’ is not a recognized executive command.

1.19 Useful or Effective Investigation Techniques

Nil.

2. ANALYSIS

2.1 Introduction

In this incident, the pilots' decision not to execute a G/A and to accept landing considerably beyond the GPI placed the aircraft in a position where the runway available to safely stop the aircraft was greatly reduced. This created a time limitation that was exacerbated when the crew delayed deceleration inputs and was subsequently confronted with a directional control issue. The analysis will focus on the events, conditions and underlying factors that were causal or contributory to the occurrence.

2.2 The Approach

2.2.1 Preparation

The TOLD card was incomplete in that landing data was calculated for Thule vice Alert. AC oversight was not provided to detect this error. The pilots were aware, however, of the required values.

The pilots briefed the Met Shack Road as the 'bolter point', a common practice amongst CC130 pilots as the road is relatively easy to distinguish, even in adverse weather conditions. However, at 2600 feet from the departure end of the runway, this road was located 100 feet beyond the minimum 2700 feet required to satisfy the landing ground roll. None of the publications available to the crew denoted the road's precise location and the pilots' estimation that it was 'at about' the 3000 foot-to-go point was incorrect. As a result, pilot situational awareness was subsequently eroded. It is possible that had the crew known the location of the road relative to the amount of runway remaining, they would not have chosen it as a feature on which to base a critical decision. Ultimately, the crew selected a point on which to base a critical decision that was not accurately defined, nor did it satisfy landing performance requirements.

In addition to the selection of a 'bolter point' point that did not numerically satisfy landing requirements, the selection of any point located substantially beyond the GPI may have promoted a mindset amongst some of the crew to view landing long as acceptable. An AOI directive states: 'normal landings shall be planned to use all of the available runway length to promote safe, smooth and unhurried operating practices'. There was no operational imperative to justify deviating from this directive. Noting that both the AC and Nav had previously landed long at Alert, with other crews, such a deviation from normal landing procedures may have become normalized amongst some of the crew. This may have repressed election of the G/A option amongst some of the crewmembers.

2.2.2 PMA

The AC's election of conducting a left seat flown approach was consistent with orders and beneficial from a training perspective; however, it had the adverse effect of contributing to pilot workload. The PMA alternative would have better balanced both pilots' workload and maximized crew situational awareness. This is the prime benefit of conducting a PMA. The SMM provides crews with guidance regarding the selection criterion for conducting a PMA. The SMM states: *'The pilot monitored approach is the standard instrument approach procedure on the CC130 aircraft when the weather is at or near minima for the approach being flown'*.[10] The direction *'at or near'* introduces subjectivity into the order. It was subjective that the weather at the time of Boxtop 11's approach was 'near' minima; therefore, the crew was able to legally elect a left-seat flown approach. Current PMA selection criterion does not incorporate other potential risk elements, such as crew inexperience, aircraft parameters or aerodrome factors, into the determination process. Basing the requirement to conduct a PMA solely on the environmental risk element is an incomplete risk mitigation strategy. Clear direction as to when a PMA shall be flown, that incorporates broader risk determination, is warranted.

CVR evidence suggested that the pilots were not conversant with the mechanics of the PMA approach (and, by extension, they were not fully conversant with normal left-seat flown procedures). The demonstrated knowledge deficit did not manifest itself since a PMA was not elected. It is probable, however, that had minimum weather conditions dictated a PMA, confusion could have occurred at minimums that would have seriously eroded pilot situational awareness and possibly resulted in instrument descent below minimums conducted in an unprescribed manner.

The PMA is fundamental to the safe execution of an instrument approach, especially during adverse weather conditions. Consequently, PMA procedures are emphasized during initial and continuation training. However, there are presently no standards requirements to assess PMA proficiency. Noting that one pilot had extensive CC130 experience and the other had recently completed the OTU, the demonstrated PMA knowledge deficit bridges experience levels and warrants review of pilot ab-initio training, continuation training and standards regarding PMA performance objectives.

2.2.3 PAR

The PAR approach provided by the Controller and flown by the crew was not effective, as the aircraft was 225 feet above the G/P at 1.3 NM from the threshold, the point at which the pilots transitioned to visual flight. It is probable, based upon the approach profile flown, that had the approach continued under instrument meteorological conditions, the aircraft would have been out of position at the decision height necessitating a missed approach.

Once visual, the pilots assumed terrain avoidance responsibility and the decision was made to continue with the approach and landing. All subsequent events were a direct result of that decision and were not directly attributable to the PAR. However, to compensate for being high on G/P, the FO had to initiate a

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[10] Previous PMA selection guidance stated: *'A PMA shall be flown when the destination weather is at or below alternate minima for the approach being flown'.*

demanding aircraft-handling regime comprising a variety of elements. The attempt to regain the ideal G/P necessitated a relatively high rate of descent that had to be balanced with the requirements of configuring the aircraft with landing flap and reducing airspeed to targeted values. Time to affect this balance was generated by moving the touchdown aim point further down the runway. This act had two adverse affects. First, from a flight dynamics aspect, it accounted for the long landing and elevated pilot workload. Second, this act contradicted the pilot's agreement to use the threshold as the aim point and did not contribute to the essential development of the FO's G/P and aim point control.

The increased workload confronting the FO was not balanced by assurance that typically accompanies experience. The FO had no previous practice with heavy landings, relatively short-field landings or icy runways.[11] This precluded any advantage experience recall may have otherwise had in the FO coping with the unfolding dynamic situation. Effective task assignment was dependent upon both pilots' balanced allocation of tasks to prevent overload. The task saturation associated with flying the aircraft in this challenging situation may have channelized the FO's attention and suppressed any consideration of the G/A option.

2.3 Go-Around Option

In addition to the previously analysed factors that precluded election of the G/A option, the risk associated with not electing this option and landing long was accepted by the AC. The AC's personal experience and comfort level essentially bounded the risk and, in the absence of any crewmember voicing concern, the decision to continue with the approach was re-enforced. However, the experience of the pilot who was to land the aircraft did not mitigate the risk associated with what was essentially unfolding as a 'short-field' landing (generally referred to as a maximum effort landing). The alternative to a maximum effort landing is a 'normal landing', which is what the crew briefed and flew. This was appropriate for the 5500-foot runway under the given conditions; however, once the aircraft reached approximately the 3000 foot-to-go-marker and had not yet landed, the protocols established for a normal landing ('*use all of the available runway length to promote safe, smooth and unhurried operating practices'*) could not be safely met. The AC, by virtue of his AC category, was fully trained in maximum effort landing procedural requirements. The FO, by virtue of his category, was not. As a result, the FO did not possess the skill set to cope, nor should he have been expected to aptly cope with the short-field demands presented. Specifically, neither was he trained to identify how much runway is 'not enough,' nor was he trained on the mechanics of executing a G/A from a near-touchdown attitude. Without this training, as the aircraft approached the 'bolter point' point, it is probable that the G/A option for the FO was not a rote consideration. The AC's incorporation of the FO's limitations into the G/A

[11] The OTU syllabus typically schedules an Arctic Trainer to provide enabling objectives that include exposure to Alert. Due to 8 Wing operational priorities, the FO's scheduled Arctic Trainer was not routed to the Arctic and consequently the Alert exposure objective was not met.

decision-making process, especially as the aircraft approached the ‘bolter point’ point, may have prevented this occurrence.

The SMM did not provide the crew with sufficient stabilized approach or G/A criteria to minimize approach and landing risks. Notwithstanding that the aircraft crossed the threshold 75 feet high, nine kts fast and at a 2300 fpm descent rate, the only applicable regulatory G/A criterion for that stage of visual flight was: ‘*The G/A command is given at any time when either pilot considers it necessary to discontinue the approach’.* This criterion is necessary but it is subjective and does not mitigate the risk associated with errors in judgement. The SMM only provides objective stabilized approach criteria that apply when an aircraft reaches decision height (DH), or the missed approach point, that if not satisfied demand a G/A. There are no stabilized approach criteria however, that define conditions that must exist to preclude a G/A while conducting an instrument (final) approach. Further, there is no guidance as to what flight conditions constitute a stabilized visual approach or the latter portion of an instrument approach when the pilot has transitioned to visual references. Without clearly defined stabilized approach parameters for all types and phases of approaches, crews have no reference on which to objectively determine what constitutes a stabilized approach. Based upon the magnitude of Boxtop 11’s deviation from the ideal flight profile at the threshold, it is reasonable to state that the aircraft was not on a stabilized approach, yet the crew did not conduct a G/A. Without regulatory, objectively based stabilized approach criteria that would dictate a G/A, the crew was not compelled to do so. Had regulatory criteria existed, it is probable that the crew would have recognized that they were not on a stabilized approach, at some point, and they would have mitigated the landing risk by executing a G/A. A review of CC130 stabilized approach and G/A criteria are warranted.

2.4 Landing Ground Roll

Based upon the AOI performance data and assuming that the actual RCR was 5, the aircraft landed with sufficient runway remaining to accommodate stopping. The aircraft did not safely stop because prescribed deceleration mechanisms were not fully employed. The requirement to transition from touchdown attitude to taxi attitude within one second and to achieve maximum braking and power selection upon reaching the taxi attitude was not met. Satisfying this requirement was critical since the aircraft touchdown point was essentially coincident with the minimum runway required. Five seconds elapsed before ground idle was attained. This delay, which occurred prior to the onset of the directional control problem, invalidated the performance data and ensured runway overrun.

Two factors accounted for the delay. First, the landing was ‘floated’. Unlike a ‘firm’ landing, which would signal with clarity the start-point for deceleration inputs, the ‘floated’ landing introduced ambiguity. Although unquantifiable, time elapsed during which the pilot processed visual and proprioceptive cues, assessed that the aircraft had landed and actioned the appropriate deceleration inputs. Second, noting testimonial evidence that neither pilot recalled the aircraft’s touchdown point, nor was alarmed by the amount of runway remaining, it is reasonable to attribute some delayed deceleration response to both pilot's misperception of the immediacy of the situation. Unhurried operating practices are the prescribed norm and are especially prudent on an icy runway unless the situation dictates immediate reactions. The FO was new to the aircraft and his experience recall was primarily from the OTU and training scenarios in which judicious application of control/throttle/brake inputs are taught. Without the perception of immediacy, the FO was conditioned to react unhurriedly. Without the perception of immediacy, the AC remained content with the FO retaining aircraft control; it is probable he would have otherwise assumed control to minimize risk.

Once the throttles were in GI, the slow response of the number one propeller to reach beta precipitated the onset of the directional control problem. The pilots correctly perceived the directional control problem associated with the asymmetry and reacted to achieve their immediate goal, which was to maintain directional control and avoid runway lateral departure. The reaction was deliberate and coordinated; the FO made brake, throttle and flight control inputs and the AC shadowed these inputs without overriding them, implying concurrence. The response was also effective insofar that runway lateral departure was averted and aircraft control was maintained, evidenced by the aircraft's ideal on-centreline, on-runway heading orientation when it departed the runway end. However, the pilot's response of not reversing symmetrical engines, of applying forward thrust on the number three and four engines and releasing the brakes, albeit effective in maintaining directional control, further compromised deceleration.

2.4.1 RCR

The crew's election of using RCR 5 to quantify braking effectiveness at Alert was consistent with conventional practice. However, the actual reading may have been as low as RCR 1, which would have increased the landing ground roll from 2700 to 3200 feet. Without an official reading to the contrary, the use of RCR 1 to quantify 'nil braking effectiveness' would provide the most conservative response.

2.5 Trans- Cockpit Authority Gradient

Although two crewmembers testified that they were concerned about the aircraft's profile during the latter stages of the approach, neither voiced their concern. There was no evidence to suggest their silence was to avoid conflict; testimonial and CVR evidence suggested the existence of a synergistic and harmonious crew environment in which all crewmembers felt free to communicate concerns. It thus appears that they had deferred to the AC's experience and judgement. This action negated the 'check and balance' advantage inherent to the multi-crew cockpit. It is probable that had any crewmember voiced concern, assertively if required, the AC would have processed the information and elected the G/A option.

2.6 Summary

Human Performance in Military Aviation (HPMA) practices were not gainfully employed by the crew and regulatory stabilized approach and G/A criteria were not available to ensure the safest possible mission outcome. Symptoms, including task saturation, channelized attention, normalized deviancy and an un-optimized authority gradient, were manifest in the cockpit and went unchecked. As a result, sound decision-making processes were displaced and the aircraft was unwittingly flown to the edge of its performance envelope. Once landed, degraded situational awareness and crew limitations compromised timely implementation of ideal coping mechanisms and the aircraft’s performance envelope was breached.

3. CONCLUSIONS

3.1 Findings

3.1.1 An ineffectively executed PAR contributed to the aircraft being out of position at the threshold.

3.1.2 The decision to continue the approach was made without full consideration of crew experience limitations.

3.1.3 There was a mindset amongst some of the crew to accept deviation from normal landing procedures.

3.1.4 An un-optimized authority gradient existed which precluded some of the crew from voicing concern regarding the decision to continue the approach.

3.1.5 Task saturation associated with flying the aircraft channelized the FO's attention and supplanted consideration of the G/A option.

3.1.6 There was no operational imperative to justify landing long or for compromising the prescribed AOI directives for a normal landing.

3.1.7 Landing long contradicted the pilots' agreement to use the threshold as the aim point and did not contribute to the essential development of the FO's G/P and aim point control.

3.1.8 The crew briefed a 'bolter point' that did not satisfy landing performance requirements.

3.1.9 The crew did not identify that the normal landing scenario had essentially evolved into a maximum effort-landing scenario that they were not situated to undertake.

3.1.10 The aircraft landed with sufficient runway remaining to accommodate stopping.

3.1.11 The aircraft landed at the edge of its performance envelope, which necessitated immediate and full input of deceleration mechanisms.

3.1.12 The pilots' misperception of the immediacy of the situation and limited experience recall precluded immediate and full input of deceleration mechanisms, placing the aircraft outside its performance envelope.

3.1.13 The slow response of the number one propeller to reach beta precipitated the onset of the directional control problem.

3.1.14 The crew maintained directional control, averting runway lateral departure.

3.1.15 Prescribed deceleration inputs were consciously abated during the effort to maintain directional control.

3.1.16 The slow response of the number one propeller did not render the aircraft unserviceable.

3.1.17 The OTU did not provide the FO with adequate actual or simulator training to prepare him for austere aerodrome or heavy landing operations.

3.1.18 The appropriate landing data was not included on the TOLD card.

3.1.19 There are currently no standards established to assess crew proficiency in PMA approach procedures.

3.1.20 The current requirement to conduct a PMA is based solely on the environmental risk element. The PMA selection criterion does not incorporate other risk elements, such as crew inexperience, aircraft parameters or aerodrome factors, into the determination process.

3.1.21 The SMM did not provide the crew with sufficient stabilized approach or G/A criteria to minimize approach and landing risks.

3.1.22 The PA was unfamiliar with the initial aeromedical response required following a flight safety occurrence, particularly the mandated toxicology investigation of personnel involved.

3.1.23 The supplied toxicology kit (MSTU and associated documentation) was incomplete.

3.2 Cause Factor

The incident was caused when the crew did not exercise the available option to execute a G/A to mitigate the risk associated with a long landing.

3.3 Contributing Factors

3.3.1 The CC130 SMM did not provide stabilized approach or objective G/A criteria for all types and phases of approaches. Without the benefit of clearly defined criteria, the crew's awareness that they were not on the ideal flight path throughout their visual transition to landing was not translated into effective behaviour to mitigate the risk. Additionally, without regulatory G/A criteria, the requirement to conduct a G/A remained optional for the crew, allowing them to select a riskier alternative of continuing the landing.

3.3.2 The crew did not identify that the normal landing scenario had essentially evolved into a maximum effort-landing scenario that they were not situated to undertake.

3.3.3 Although effective in maintaining directional control, CC130 deceleration mechanisms were not employed in accordance with the AOI, placing the aircraft outside its performance envelope and precipitating runway overrun.

4. PREVENTIVE MEASURES

4.1 Preventive Measures Taken

4.1.1 8 ACCS Standards personnel briefed all PAR Controllers on this occurrence and provided additional training to increase Controller effectiveness.

4.1.2 The Aerospace Medical Authority has commenced development of a revised syllabus of the Flight Surgeons Course that will provide some health care providers, including PAs, enhanced aeromedical preparedness training. This will ensure PAs who work on independent duty in remote locations, such as CFS Alert, have the requisite toolset to provide aeromedical support to CF flying operations.

4.2 Preventive Measures Recommended

It is recommended that:

4.2.1 The Operational Airworthiness Authority (OAA) develops a training module, incorporating lessons learned from this occurrence, to use in HPMA initial and continuation training.

4.2.2 The OAA amends CC130 pilot ab-initio and continuation training to ensure pilots can successfully integrate crew and aircraft limitations associated with CC130 normal and maximum effort landing performance into routine flight operations.

4.2.3 The OAA develops a PMA proficiency standard in the CC130 pilot community.

4.2.4 The OAA provides clear direction as to when a PMA shall be flown that encompasses broad risk determination.

4.2.5 The OAA provides regulatory stabilized approach and G/A criteria for all types and phases of approaches.

4.2.6 The OAA ensures the standard governing TOLD card completion is upheld.

4.3 Other Safety Concerns

4.3.1 The 1 Cdn Air Div Surgeon should ensure medical units supporting CF flying operations are in possession of a sufficient number of current, up-to-date MSTU and supporting documentation.

4.3.2 The OAA should consider the extent to which the recommendations of this report with respect to PMA, stabilized approach and G/A criteria can or should apply to other fleets.

4.3.3 The CF is very dependent upon voluntary reporting to identify emerging hazards and trends. Yet, voluntary reporting has clear limitations in identifying behavioral issues among aircrew, such as the normalized deviation cited in this report. Implementing the preventive measures of paragraph 4.2 above will do little good if means to monitor adherence to them is lacking. The CF needs to adopt a flight data monitoring regime to capture and analyze critical data on a routine basis to better identify emerging trends prior to occurrences, instead of investigating accidents after the fact. The AIA will undertake to coordinate the development of a flight data monitoring policy, in conjunction with the OAA and the TAA, for consideration by the AA.

4.4 DFS Remarks

This occurrence falls into the broad category of an approach and landing accident (ALA) (although in this case the damage was minor). The destruction of the Air France Airbus 340 at Pearson International Airport in 2005 is an example of a similar occurrence. The Flight Safety Foundation made a study of ALAs in 1999, and concluded that unless changes occurred in the air transport industry, there would be an increase from 14 to 23 fatal approach and landing accidents annually by 2010. From its study results, the Flight Safety Foundation made several important recommendations to reduce the incidence of approach and landing accidents, and some of these recommendations resonate in this report. Specifically, the Flight Safety Foundation recommended that air transport operators establish explicit definitions of conditions requiring a timely go-around, and clear definitions of acceptable stabilized approach criteria. Not surprisingly, this report also advocates such actions.

However, we also need to consider the circumstances by which this occurrence came to our attention. The aircraft got stuck in the snow, which made it pretty obvious that not all had gone well during the approach and landing. That the outcome was not worse is purely a matter of luck. Unfortunately, we do not know how many other Hercules have landed long and fast at Alert, or other locations, but simply managed to stop before sliding off the end of the runway. We do know that crewmembers aboard the occurrence aircraft had experienced other long landings at Alert, to the extent that they felt no discomfort with the position of this particular aircraft on landing. These previous events had not been the subject of Flight Safety incident reports, even though, as this case makes evident, accident potential definitely existed. This situation points to a serious flaw in our system of hazard identification and rectification – it relies too heavily upon voluntary reporting. A quick glance at our statistics for personnel cause factors tells the tale: the percentage of personnel cause factors attributed to aircrew for air incidents falls well short of the percentage assigned as a result of accidents. This is because a hazardous incident in the air can easily go unreported, as often the crew will be the only witnesses to the event. To be fair to aircrew, the assessment of whether an incident has accident potential is highly subjective, and in fact, such incidents may pass un-noticed or might not be perceived as report-worthy. An accident or serious incident, though, is quite evident to one and all and results in an in-depth investigation. Such investigation invariably leads to the assignment of several personnel-related cause factors, which accounts for the discrepancy cited above. As a result, we are not really seeing the true extent of the hazards encountered by our aircrew during their missions, and this hinders our efforts at prevention.

This brings me back to the Flight Safety Foundation study. A further recommendation of the study was to institute programs of flight data monitoring as a way to identify system deficiencies. Most airlines, and several air forces, use some type of flight data monitoring to collect data that can identify trends or specific problem areas with flight operations so that preventive action can occur before an accident or serious incident results. Such programs go beyond what can be achieved by voluntary reporting schemes, and, if properly implemented, enjoy widespread support among users. The CF needs to move towards automated data collection and analysis, which is now the world-standard, if we expect to achieve higher levels of risk reduction and safety in military aviation operations. None of the preventive measures at paragraph 4.2 needed to wait for a serious occurrence to trigger their formulation and implementation; yet, that is precisely the case. Our goal has to be to become more proactive, and less reactive, and we must find the means to achieve it.

C.R. Shelley
Colonel
Director of Flight Safety

Photographs

Photo 1: Runway departure

Photo 2: Commencement of extraction efforts

List Of Abbreviations

AC	Aircraft Commander
ACCS	8 Air Communication And Control Squadron
AGL	Above Ground Level
AOI	Aircraft Operating Instructions
CFS	Canadian Forces Station
CVR	Cockpit Voice Recorder
DH	Decision Height
FPM	Feet Per Minute
FDR	Flight Data Recorder
FE	Flight Engineer
FO	First Officer
G/A	Go-Around
GI	Ground Idle
G/P	Glidepath
GPI	Ground Point of Intercept
G/S	Glideslope
KIAS	Knots Indicated Airspeed
KTS	Knots
LM	Loadmaster
MSTU	Medical Specimen Transport Unit
NAV	Navigator
NM	Nautical Mile
NRC	National Research Counsel
OAA	Operational Airworthiness Authority
OTU	Operational Training Unit
PA	Physician's Assistant
PAR	Precision Approach Radar
PMA	Pilot Monitored Approach
RCR	Runway Condition Reading
SMM	Standard Manoeuvre Manual
SM	Statute Miles
TCH	Threshold Crossing Height
TOLD	Take-off and Landing Data