CANADIAN FORCES
FLIGHT SAFETY INVESTIGATION REPORT (FSIR)

FINAL REPORT

FILE NUMBER: 1010-CC130327 (DFS 2-2-3)
DATE OF REPORT: 3 November 2005

AIRCRAFT TYPE: CC130 Hercules
DATE/TIME: 290505Z July 2003
LOCATION: Kabul Area
CATEGORY: "E" Category Incident (Accident Potential)

SYNOPSIS

The incident crew made a navigation error during a low-level egress out of Kabul and elected to turn into a wide valley in order to regain track. Initially, the crew felt that this valley's profile was shallow enough to complete a safe climb and ridge crossing to exit the valley. However, it soon became evident that the aircraft did not have the climb performance to clear the valley's surrounding ridges. A zoom climb, during which the airspeed decayed to 160 knots indicated airspeed (KIAS), was attempted but the crew realized that the ridge could still not be cleared. It appeared as though there was adequate room on the right side of the aircraft to complete a normal 180-degree turn. Bank angle and G were increased 1/3 of the way through the turn when it became evident that a ridgeline, not previously seen, had become the controlling obstacle. The aircraft entered a stall buffet two thirds of the way through the turn. Aircraft G was reduced and the nose was lowered to stop the buffet. This resulted in an 18 degree nose down attitude with a relatively high rate of descent. The turn was continued and the controlling obstacle was cleared on the left side of the aircraft. The aircraft stopped its descent, wings level, at approximately 250 feet above ground (AGL). The aircraft proceeded to its destination without further incident.

TABLE OF CONTENTS

1. FACTUAL INFORMATION

1.1 History of the Flight

The incident crew consisted of an Aircraft Commander (AC) in the left seat, the First Officer (FO) in the right seat, a Navigator (Nav), Flight Engineer (FE), and two Loadmasters. The incident flight took off from Kabul International Airport (OAKB) on 29 July 2003 at 0505Z (0935L) via a planned low-level tactical departure. The crew planned to transit from Kabul to waypoint #4 (see Annex A) at 200 feet minimum safe distance (MSD is minimum safe distance above obstacles) in order to avoid any potential threat from small arms and Man Portable Air Defence System (MANPADS).

The crew passed waypoint #1 without incident. At waypoint #2 a 75? heading change to the right was required to place the aircraft on the proper track towards waypoint #3. However, the AC, who was flying the aircraft at the time, continued the turn beyond the required heading change. The FO voiced his concerns about the aircraft's position after about 120? of heading change. The AC rolled the aircraft level after approximately 180? of heading change, by which time the aircraft was heading back towards Kabul.

At this point the crew recognised that they were off track and planned to rejoin their planned route by entering a valley on their left and climbing to a minimum safe altitude of at least 12,000 feet above sea level (ASL) in order to cross the ridge along the edge of the valley. The crew soon realized that they would be unable to climb to the minimum safe altitude, or even clear the ridge. The AC decided to carry out a 180? right turn to exit the valley and entered a 30º bank turn.

Approximately 60? into the turn around manoeuvre, the crew became aware of a previously unseen finger ridge. Because of its height and proximity, this ridge immediately became a controlling obstacle, effectively reducing the amount of available manoeuvring space. To compensate, the AC increased the bank angle to approximately 80?, with coordinated G-loading, until the stall buffet was encountered, at which time backpressure and bank angle were reduced. This resulted in an 18 degree nose down attitude with a relatively high rate of descent. The turn was continued and the controlling obstacle was cleared on the left side of the aircraft. The aircraft stopped its descent wings level, and cleared the ridge at approximately 250 feet AGL. The crew exited the valley without further incident and proceeded to their destination.

1.2 Injuries to Personnel

Nil.

1.3 Damage to Aircraft

There was no damage to the aircraft. The solid-state flight data recorder (FDR) had no record of any aircraft structural load limit exceedances.

1.4 Collateral Damage

Nil.

1.5 Personnel Information

The incident crew arrived in theatre on 10 July 2003. The crewmembers began flying operations on 13 July 2003, and by the time of the incident they had each accumulated approximately 50 flying hours. The exception was the FE, who arrived in theatre 2 days prior to the incident and had only 10 flying hours during the previous 30 days.

Position	AC	FO	Nav	FE
Rank	Capt	Capt	Capt	Sgt
Last Check Ride (valid for 2 years)	May 03	Nov 02	Feb 03	Dec 02
Flying Time - 24 hrs	4.5	4.5	4.5	4.5
Flying Time - 30 Days	57	50	50	10
Flying Time - CC130	3190	1100	940	2000
Flying Time - Total	3500	3600	1075	4350
Time on Duty in previous 24 Hrs	7.5	7.5	7.5	8.5

1.6 Aircraft Information

The aircraft was serviceable at the time of the incident, and all navigation aids were operational.

1.7 Meteorological Information

METAR OAKB 290350 33004KT 9999 FEW070 28/17 Q1016 NOSIG

METAR OAKB 290450 VRB03KT 9999 FEW070 30/16 Q1016 NOSIG

1.8 Aid to Navigation

The primary navigational tool was the standard 1:250,000-scale map with the Flight Management System (FMS) blended navigation solution of the global positioning system (GPS) and the inertial navigation system (INS) being used as a backup. The FMS was configured to show four waypoints between Kabul and the start of the instrument flying rule (IFR) corridor, which would route the aircraft back to Camp MIRAGE (see Annex A).

1.9 Communications

Aircraft communications were not a factor in this incident.

1.10 Aerodrome Information

There is no radar service at OAKB.

1.11 Flight Recorders

The solid-state FDR contained a complete record of the incident and was successfully downloaded. The Cockpit Voice Recorder (CVR) is the 30-minute type; therefore the incident was overwritten during the 4-hour transit back to base.

1.12 Wreckage and Impact Information

N/A.

1.13 Medical

No toxicology samples were obtained. The crew flew for another 4 hours after the incident, making toxicology samples moot.

1.14 Fire, Explosives Devices, and Munitions

N/A.

1.15 Survival Aspects

N/A.

1.16 Test and Research Activities

The National Research Council (NRC), using the information contained on the FDR, has produced an electronic visual recreation of the incident.

1.17 Organizational and Management Information

Canadian CC130s assigned to Op APOLLO, now Op ATHENA, were based at Camp MIRAGE (UTC +4), which was located in a Host Nation approximately four flight hours from Kabul (UTC +4.5). During the surge to get Canadian troops to Kabul, two CC130 flights were scheduled each day. For operational reasons, the appropriate command authorities had determined that troops had to arrive at Kabul between 0730 (L) and 0930 (L).

The combination of operational requirements and negotiated departure “slot times”, meant that CC130 crews had to depart Camp MIRAGE at either 0200 (L) or 0400 (L) in order to arrive in Kabul at the predetermined hour. The operation at Camp MIRAGE had just switched from daylight launches to the early morning launches at the time of the incident. This meant advanced timings of up to seven hours, a significant change of schedule to the incident crew.

2. ANALYSIS

2.1 General

The flight was duly authorised and acknowledged, and the Basic Tactical Air Transport (BTAT) crew was current. The crew involved (less the FE) had flown into Kabul on four previous occasions and were familiar with the area.

The Combat Manoeuvre Data Card was completed. This card provides the pilots with a quick cockpit reference for minimum control airspeeds under various aircraft configurations and flight profiles. The calculated minimum manoeuvre speed for 0% Flap, 60º bank was 160 KIAS.

2.2 The Aircraft

During the incident, CC-130 Aircraft Operating Instruction (AOI) bank angle limitations were exceeded, however, they did not affect the serviceability of the aircraft.

2.3 The Incident

During the low-level egress from Kabul, the crew misidentified a valley at waypoint #2. This misidentification resulted in the aircraft heading in a general direction back to Kabul. In order to regain track, the AC entered a valley to his left. After entering the valley, it became apparent to the crew that by maintaining the current aircraft flight parameters, the aircraft would not be able to climb sufficiently to clear the approaching mountains. A '"zoom" was initiated during which the airspeed decreased to 160 knots. It was then determined that the Hercules could not clear the approaching ridge so a right-hand turn was initiated, during which a previously undetected ridge became evident. The bank angle was increased to avoid the terrain. During this tightened turn the aircraft encountered stall buffet. The aircraft recovered from the 82^0 bank, 18^0 nose down attitude at approximately 250 feet AGL.

2.4 Active Factors

2.4.1 Mission Planning

This mission was a troop-sustainment flight from Camp MIRAGE to Kabul and return, with a one hour turn-around in Kabul. There had been numerous and consistent intelligence reports that detailed the existence of MANPADs in the vicinity of Kabul. The transit from Camp MIRAGE to Kabul was uneventful, as was the turn-around in Kabul. Based on the level of the expected threat, the crew elected to depart Kabul via a shallow tactical departure.

There are two types of tactical departures employed by CC-130 crews. These are a steep tactical departure, and a shallow tactical departure. The aircrew performing the mission determines the type of departure used. Considerations as to which type of departure to fly includes hostile activity, weather conditions, aircraft performance, and friendly inbound traffic.

A steep tactical departure consists of departing the airfield and gaining as much altitude as possible in the shortest distance. This is accomplished by either a spiral climb, or a 'zoom' climb. This type of departure is used when the main threat is from small arms fire.

A shallow tactical departure consists of departing the airfield at 200' MSD and proceeding along a random route until an enroute climb is established. This tactic is used when the threat may include Surface-to-Air Missles (SAMs) and/or Anti-Aircraft Artillery (AAA). Hazards associated with a shallow tactical departure include increased difficulty of navigation, difficulty with visual perceptions / illusions, increased task load and an increased risk of Controlled Flight Into Terrain (CFIT). These hazards are addressed in the Standard Manoeuvring Manual (SMM-2601(1)).

The crew's decision to fly a shallow tactical departure was considered a valid choice based on the current intelligence reports. Due to the increased task load associated with a shallow tactical departure, focused and detailed preparations are required. As well, a detailed route study, involving the pilots and navigator, must be included. The briefing, route, map preparation and FMS programming should be detailed enough to provide a comprehensive air picture. Finally, alternatives should be discussed that include a review of contingencies germane to the mission – in this case mountain flying awareness such as ridge crossing and box canyon procedures and optical illusion awareness.

The investigation revealed that the pre-departure preparations did not cover the above-mentioned points adequately. The crew, familiar with the area and confident in operating in the low-level environment, reduced their mission planning efforts. The map and FMS waypoint entry were limited to four low-level waypoints providing limited navigational guidance. Subsequent to the unexpected deviation from the planned route, these pre-departure deficiencies conspired to erode the incident crew's situational awareness, and significantly increase their workload.

2.4.2 Mission Execution

The departure navigation was based on a 1:250000 map using terrain features as a guide. The incident crew stated that this map scale proved difficult for them to use in mountainous areas due to a lack of detail. The FMS was programmed with four waypoints and was being used to provide general track guidance. Following passage of waypoint #2, it became apparent that the intended valley had been misidentified and the aircraft was proceeding in the wrong direction. The ''direct-to'' feature of the FMS was utilized to provide directional guidance to the initial point of the enroute segment. The FMS indicated that a left-hand turn was required, and the crew commenced a left-hand turn into a large, broad valley. The crew believed they were now heading in generally the desired direction and they were aware that they were not in the valley they had intended to transit. This second valley however, had rising terrain, and housed an unseen finger ridge. As a result of this navigational error, the crew had unknowingly placed themselves in a box canyon situation.

2.4.3 Box Canyon

Shortly after entering the second valley, the crew perceived that they could complete a ridge crossing by conducting a zoom climb. The AC raised the nose of the aircraft to exchange airspeed for altitude. As the airspeed decreased to 160 knots the crew determined that they were not going to clear the ridge. The AC had not configured the aircraft with flap 50 (CC130 terminology for half-flap) in anticipation of manoeuvring at this low airspeed. The valley appeared wide enough to conduct a normal 30º bank turn for course reversal, so the crew commenced a turn to the right. Part way through the turn, a ridge that was previously masked by shadow (an illusion known as 'Hidden Terrain', as detailed in SMM-2601(1)), was detected by the co-pilot. He directed the AC to increase bank angle. During this manoeuvre, bank angle increased to $82^{0,}$ airspeed decreased to 157 KIAS (note: 157 KIAS is below the calculated minimum manoeuvre speed for 0% Flap, 60º bank) and the aircraft subsequently entered stall buffet. During the stall recovery procedure the nose was lowered to 18^{0} below the horizon. The aircraft was recovered from this procedure at approximately 250' AGL.

The SMM-2601(1) provides guidance in warning crews of the need to anticipate a box canyon encounter when operating in mountainous terrain, and to plan accordingly. The minimum radius turn for the CC130 is achieved at the stall speed for 45º bank angle with flap 50 configured. The incident crew did not configure the aircraft flaps in anticipation of, or while conducting, low-speed manoeuvring in mountainous terrain. This oversight precipitated the need for the pilot to overbank the aircraft when confronted unexpectedly with a controlling obstacle, resulting in stall buffet encounter and subsequent near CFIT during the stall recovery procedure.

2.5 Latent Factors

2.5.1 Fatigue

Like any other crew involved in various deployments, CC130 crews on deployment may suffer from fatigue issues. Fatigue can be classified into two distinct types. Generally, the initial fatigue suffered is acute fatigue. Acute fatigue is derived from extended crew days combined with change in time zones. A typical deployment from 8 Wing Trenton to Camp MIRAGE takes approximately 22 hours, and crosses nine time zones. This type of fatigue generally lasts nine days; one day per time zone crossed. The second type of fatigue stems from an extended period of inadequate sleep and will manifest itself as chronic fatigue. Over a period of time this fatigue can accumulate to the point where cognitive performance is affected.

A study entitled "Fatigue Assessment in Camp Mirage CC130 Aircrew", dated February 2004, describes these phenomena in detail. The study recommended that to combat long-term sleep deprivation, more rest opportunities should be given between missions. Additionally, it proposes a number of pragmatic ways / options of dealing with fatigue including the use of pharmacological intervention.

Prior to the incident mission, the crew was provided with a lengthier crew rest period than prescribed in applicable orders. This provision alone, however, did not ensure that some crew members were not suffering from fatigue. It was determined by the investigation team that the FE, having arrived in theatre less than 48 hours prior to the incident mission, was suffering from acute fatigue. Other crew members had been in theatre long enough to have their circadian rhythms reset, however, as evidenced in the chart below, they were carrying a sleep debt.

Position	AC	FO	Nav	FE
Accrued sleep 24 hrs before incident	4	2	12	4.5
Accrued sleep 48 hrs before incident	9	8	22	7.5

This chronic fatigue suffered by the crew cannot be attributed to any one factor. Aircrew testimonial evidence suggests however, that adequate quality sleep had been compromised due to individuals experiencing difficulty in adapting to the conditions of camp life. Additionally, the change in timing to an early morning launch necessitated that the crew readily re-adjust their circadian rhythm. These factors resulted in insufficient sleep attainment by most of the crew. Both pilots stated that they were cognizant of fatigue issues within the crew.

2.5.2 Mission Imperative Perception and Risk Acceptance

Although obtaining insufficient sleep prior to the mission, the crew did not exercise their option of calling a ''time-out''. The pilots both testified that this option was not considered due to the definite pressure to get the job done. This apparent mission imperative perception was prevalent amongst Camp MIRAGE aircrew. Camp MIRAGE leadership emphasized an operational imperative and this may have created a mindset in aircrew to push personal limits, thus unwittingly promoting skewed decision-making processes. Case in point, the aircrew took it upon themselves to accept the elevated level of risk associated with flying fatigued, and flew the mission. The crew did not advise their Chain of Command of their fatigued state in an effort to seek other risk mitigation strategies. The mission imperative perception was a key issue cited by the Flight Safety Survey conducted by 1 Canadian Air Division (1 Cdn Air Div) at Camp MIRAGE in December 2003.

2.5.3 Training

It is notable that although task-saturated and fatigued, the AC's reaction when his aircraft entered stall buffet was immediate and effective. This is indicative of effective basic training. Pilots are taught stall recognition and recovery, from ab initio through to type training, until reaction becomes rote. This training intensity is completely necessary due to the time-critical nature of stalls. A parallel can be drawn with the insidious nature of mountain flying. Training intensity needs to be proportionate to the increased risks of operating in mountainous terrain. At the time of this incident, mountain flying training was limited to a maximum of two low-level mountain routes flown during the BTAT course, and there was no recurrency training. The incident crew thus had limited

training in this environment. As a result, navigation skills, ridge crossing proficiency, box canyon awareness and optical illusion awareness, proved inadequate.

3. CONCLUSIONS

3.1 Findings

3.1.1 The level of recurrency training received by the crew insufficiently prepared them for the demands required during low-level mountain-flying. (2.5.3)

3.1.2 The incident crew was fatigued prior to mission start. (2.5.1)

3.1.3 The crew's apparent mission imperative perception influenced their decision to accept the increased risk of flying fatigued rather than calling a 'time-out'. (2.5.2)

3.1.4 The crew did not advise the Chain of Command of their fatigued state in an effort to seek out other risk mitigation strategies. (2.5.2)

3.1.5 The incident crew did not plan, brief and prepare an effective tactical route departing Kabul. (2.4.1)

3.1.6 The incident crew found the standard 1:250000 map scale difficult to use in mountainous areas due to lack of details. (2.4.2)

3.1.7 The incident crew did not execute an effective tactical route departing Kabul. (2.4.2) (2.5.3)

3.1.8 The pilot did not configure the aircraft flaps in anticipation of, or while conducting, low-speed manoeuvring in mountainous terrain. (2.4.3) (2.5.3)

3.2 Causes and Contributing Factors

3.2.1 The mountain flying recurrency training received by the crew was inadequate. (3.1.1) (3.1.6) (3.1.7) (3.1.8)

3.2.2 The crew did not adequately prepare for their mission. (3.1.5)

3.2.3 The crew flew their mission in a fatigued state. (3.1.2) (3.1.3)

3.2.4 The crew did not advise the Chain of Command of their fatigued state. (3.1.4)

4. SAFETY MEASURES

4.1 Safety Measures Taken

4.1.1 The map supply at Camp MIRAGE has been expanded to include 1:100,000-scale maps, to augment the original supply of 1:250,000-scale maps. This will provide aircrew with better options for planning and executing tactical missions. (3.1.6)

4.1.2 Defence Research and Development Canada, Toronto, has conducted an in-depth sleep/fatigue study on the CC130 aircrew at Camp MIRAGE in order

to determine their overall fatigue, health and stress levels. Recommendations were made with the aim of mitigating these factors to the greatest extent possible. (3.1.2)

4.1.3 Subsequent to this incident, the 1 Cdn Air Div Orders addressing mountain flying currency have been amended. Crews are now required to complete recurrency training, every 120 days, on box canyon procedures. This consists of a pilot aircraft handling exercise vice crew mountain proficiency training, as there is no directive that this training be conducted in mountainous terrain. (3.1.1)

4.2 Further Safety Measures Recommended

It is recommended that:

4.2.1 The Air Force develops a pharmacological policy aimed at mitigating the risks associated with fatigue. (3.1.2)

4.2.2 The Air Force examine the concept of developing a tactical risk assessment process. (3.1.3) (3.1.4)

4.2.3 1 Cdn Air Div reassess mountain flying recurrency training and consider the inclusion of other aspects of mountain flying, such as low-level navigation and ridge crossings. A training needs analysis, to address the suitability of conducting recurrency training in non-designated mountainous areas as is currently accepted for box canyon procedures, warrants consideration. (3.1.1) (3.1.7) (3.1.8)

4.3 Other Safety Concerns

Nil.

4.4 DFS COMMENTS

The crew involved in this incident are to be commended for reporting this occurrence. Their professionalism in bringing this situation to light allowed us to identify several valuable lessons that can be applied to the tactical transport and other CF aircraft communities. In addition, NRC used the downloaded FDR information to produce an animation of this incident that was used in the DFS 2003/2004 annual briefing. This video graphically demonstrated to a wide audience of CF personnel how a series of seemingly innocuous events led to a near disaster.

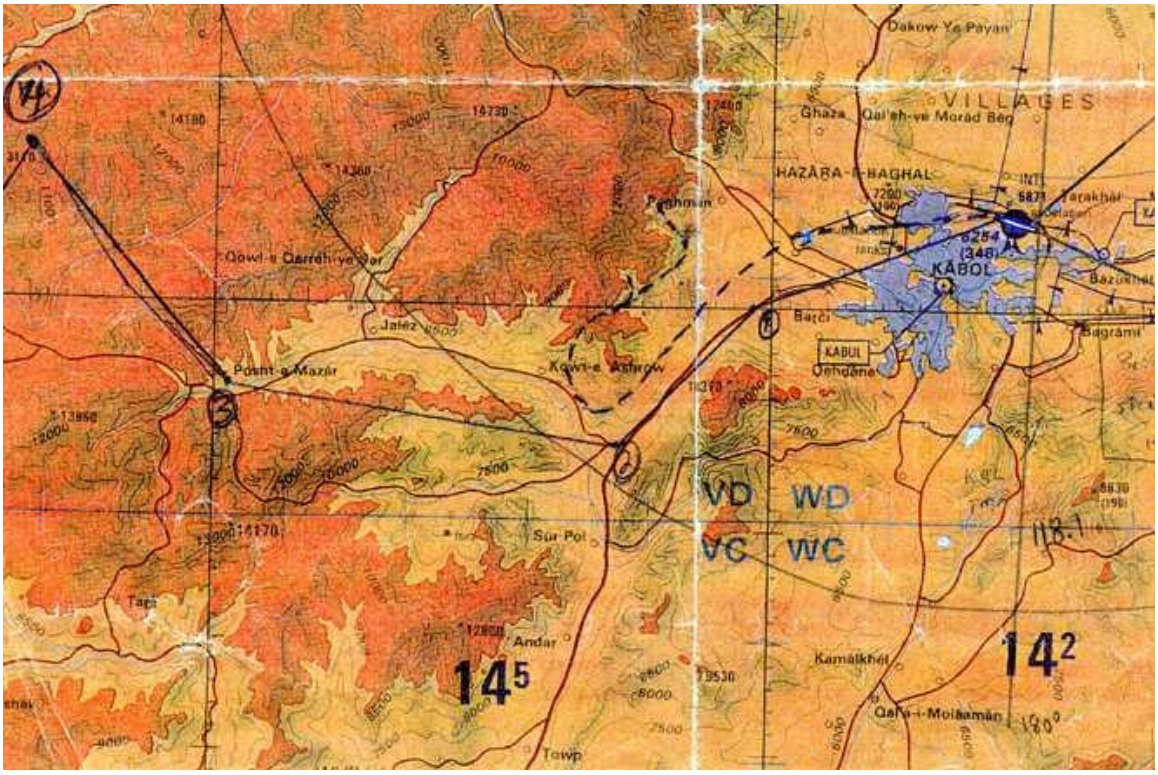
This incident highlights the requirement for the Air Force to take a serious look at personnel fatigue problems associated with aircraft operations. Although this incident involved CC-130 aircrew, other aircraft operators as well as all aircraft maintainers could benefit from this study. Commanders at all levels need to have a better understanding of this problem and the Air Force needs to investigate the possible employment of other fatigue management mechanisms, including pharmacological options, where it is deemed appropriate.

The last point that should be highlighted concerns acceptance of risk. During a lengthy discussion of this issue at the recent CF annual Flight Safety Conference, a number of concerns were raised with respect to how a tactical level risk acceptance program could be implemented. The first problem concerns the identification of the appropriate level of risk that aircraft captains can accept. Several possible systems were examined and most were found to be complex, unwieldy or so time consuming that they were impractical. In addition, it was felt that many systems could easily become overly restrictive and unnecessarily inhibit the actions of aircraft captains. Suffice it to say that this is not a simple issue. Having said that, it is one that certainly merits further study.

A.D. Hunter
Colonel
Director of Flight Safety

ANNEX A: MAP

1:250,000-scale map showing FMS waypoints and the aircraft's ground track (dashed line).



ANNEX B: LIST OF ABBREVIATIONS

AA	Aeronautics Act
AAA	Anti-Aircraft Artillery
AC	Aircraft Commander
AGL	Above Ground Level
AIA	Airworthiness Investigative Authority
AOI	Aircraft Operating Instructions
ASL	Above Seal Level
BTAT	Basic Tactical Air Transport
CFIT	Controlled Flight Into Terrain
CM	Camp Mirage
CVR	Cockpit Voice Recorder
DFS	Director of Flight Safety
FDR	Flight Data Recorder
FE	Flight Engineer
FMS	Flight Management System
FO	First Officer
FSIR	Flight Safety Investigation Report
GPS	Global Positioning System
IFR	Instrument Flying Rule
INS	Inertial Navigation System
KIAS	Knots Indicated Airspeed
MANPADS	Man Portable Air Defence System
NDHQ	National Defence Headquarters
MND	Minister of National Defence
MSD	Minimum Safe Distance
Nav	Navigator
NRC	National Research Centre

OAKB	Kabul International Airport
PDI	Parties of Direct Interest
SMM-2601	Standard Manoeuvre Manual 2601
UTC	Universal Time Constant