Field Investigation of the Accident Involving an Ilyushin IL-76 Transport Aircraft in East Timor

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Author Biographies:

Simon Barter graduated from RMIT with qualifications in Metallurgical Science, Surface Finishing and Corrosion Control. While at DSTO he has been involved with the metallurgical investigation of aircraft structures and components from many different aircraft types. His involvement in the investigation of numerous aircraft accidents has been the highlight of this work, having completed the Cranfield Aviation Safety Centre Aircraft Accident Investigation course. He now works in the Structural Integrity area undertaking research into fatigue and fracture in high strength alloys and aircraft accident investigation techniques, and is a member of the DSTO Aircraft Accident Investigation Committee.

Lorris Molent graduated from the RMIT with a Bachelor of Engineering (Aeronautical). While at DSTO he has worked in the fields of aircraft structural integrity, structural mechanics, structural and fatigue testing, advanced bonded repair, aircraft vulnerability and aircraft accident investigation. He has over 100 publications in these technical areas and is a qualified aircraft accident investigator. He has been attached to both the Australian Civil Aviation Department and the US Navy (NAVAIR) in Washington D.C. as an airworthiness engineer. Mr Molent currently leads the Combat Aircraft Structural Integrity activities in DSTO, and manages F/A-18 Structural Integrity as well as the FT46 International Follow-On Structural Test Project’s (IFOSTP) full-scale F/A-18 aft fuselage fatigue test.

Phil Robertson is a Senior Transport Safety Investigator with the Australian Transport Safety Bureau. Phil led the Australian investigation team during the onsite investigation of the IL-76 accident at Baucau, Timor-Leste, and was responsible for compiling the accident report. He holds an Air Transport Pilot (Aeroplane) Licence, and has command type-ratings on B727 and B737 transport category aircraft. Before joining the ATSB, Phil worked in the regulatory environment in the Middle East as a flight operations inspector, where his duties included responsibility for investigating accidents and incidents involving State-registered aircraft. Before that, Phil worked as an airline pilot in Australia.
Squadron Leader Thompson joined the Australian Defence Force in 1979. Following initial employment as a clearance diver he graduated as a pilot in 1985. He has flown fixed and rotary wing aircraft with the Navy, Army and Air Force, including the CT4, Macchi, Squirrel, Wessex, Bell 206, HS748 and Seahawk. In 2000 Squadron Leader Thompson completed aircraft accident investigator training with the United States Air Force. Employed for four years at the Directorate of Flying Safety as an Air Safety Investigator, his primary area of responsibility was Defence transport aircraft. During his tour as an investigator he participated in four major investigations and conducted several safety reviews of Squadrons including detached units in the Middle East.

Squadron Leader Fox joined the Australian Defence Force in 1987. He studied for 3 years at the Australian Defence Force Academy and attained a Bachelor of Science in Political studies. He completed RAAF Pilot Course in 1991 and has had operational tours flying Falcon 900, Boeing 737-BBJ, P-3C Orions and instructed ab-initio pilots on the PC-9. In Aug 2000 Squadron Leader Fox completed the United States Navy Aviation Safety Officer’s course and commenced a 3½ year post at the Directorate of Flying Safety as an Air Safety Investigator. He has participated in a number of accident and incident investigations.

Squadron Leader Geoff Kimmins joined the Royal Australian Air Force in 1977 as a technician trainee. On graduation he worked on Macchi, Caribou and Iroquois aircraft. He was a part of the Tactical Air Support Force and took part in numerous tactical field exercises. In the mid eighties, a desk job beckoned at RAAF Logistics Command. Following commissioning as an Engineering Officer in 1990, he served variously at a tactical support unit, 84WG with Air Lift Group and Headquarters Air Command. He was able to complete the full maintenance circle on the Caribou Aircraft as the Senior Engineering Officer at 38 Squadron. He was trained as an Air Safety Investigator in 2002 and has spent over two years and numerous investigations at the Defence Flying Safety Directorate.
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Abstract

On 31st January 2003 at 0621 UTC (1521 local time), an Ilyushin 76TD, registered RDPL-34141, impacted the ground near Caicido village during an approach to runway 14 at Cakung Airport, Baucau, Timor-Leste. The aircraft was destroyed and the wreckage lay about 2 km to the northwest of the airport. The Lao PDR-operated aircraft departed Macau International Airport, Macau, and was on an international non-scheduled cargo flight to Baucau. Air traffic services were not available at Baucau at the time of the occurrence and none of the six onboard the aircraft, which was carrying about 31 tonnes of telecommunications equipment, survived.

The East Timor government requested assistance from Australia. Members from the Australian Transport Safety Bureau (ATSB) and the Directorate of Flying Safety (DFS) responded. At the request of DFS two DSTO officers also assisted the team. This small team consisting of less than ten persons at any time undertook a detailed investigation of a large transport accident in difficult circumstances, involving interaction with several nations, to produce a successful outcome. This was achieved by; the use of technological field tools, having significant onsite engineering and materials expertise and using international cooperation in the analysis of data collected. This paper will outline the on-site engineering and materials wreckage evaluation, wreckage mapping, flight reconstruction, difficulties in investigating third world registered charter operations and will discuss some of the issues that arose during the early part of the investigation.

1 Introduction

On 31 January 2003, an Ilyushin 76TD aircraft impacted the ground during an approach to land on runway 14 at Cakung Airport, Baucau, Timor-Leste (East Timor).

Within a few hours of the occurrence, the government of East Timor requested Australia to provide assistance with the accident investigation. Australia agreed to assist, and assigned the Australian Transport Safety Bureau (ATSB) to conduct the investigation for and on behalf of Timor-Leste, and in accordance with the SARPS of Annex 13 to the Chicago Convention [1].

This paper will outline the on-site engineering and materials wreckage evaluation, wreckage mapping, flight reconstruction, difficulties in investigating third world registered charter operations and will discuss some of the issues that arose during the early part of the investigation. Further details can be found at references [2, 3].

1.1 History of flight

On 31 January 2003 at 0621 UTC (1521 local time), an Ilyushin 76TD, registered RDPL34141, impacted terrain near Caicido village during an approach to land on runway 14 at Cakung Airport, Baucau, Timor-Leste (East Timor). The impact site was about 1 NM (2 km) to the northwest of the aerodrome. The accident site is depicted in Figure 1.

The Lao PDR-registered aircraft departed Macau International Airport, Macau 5 hours 29 minutes earlier, at 0052 UTC, and was on an international non-scheduled cargo flight to Baucau. There were 2 pilots, 1 flight engineer, 1 navigator, and 2 loadmasters on board, and the aircraft was carrying a cargo of about 31 tonnes of telecommunications equipment.
The aircraft departed Macau about 9 hours behind schedule because of noise restrictions on the departure of Stage II aircraft from Macau. The crew rested in a hotel during the stopover in Macau, while the two loadmasters remained on board the aircraft to supervise the loading of the cargo.

Witnesses at Cakung Airport, Baucau at the time of the occurrence estimated the cloud base to be about 1,000 ft (305m) above ground level (AGL), and visibility to be about 1,500 m (0.8NM).

The lowest safe altitude (LSALT) for the last route segment of the flight between Ambon and Baucau was 4,500ft (1,372m) AMSL. Instrument approach and landing procedures were available for runways 14 and 32 at Baucau, using the Baucau non-directional beacon (NDB). The aircraft was fitted with equipment to allow the crew to conduct an NDB approach. The approved approach plates for those procedures were available on request from the Civil Aviation Division (CAD), Timor-Leste. Approach plates for the runway 14 and 32 Baucau NDB procedures were also published by Jeppesen Sanderson, Inc. (Jeppesen) and the Royal Australian Air Force (RAAF). Each version of the runway 14 NDB procedure depicted the inbound track of the procedure as being 146 degrees magnetic, and the minimum descent altitude for landing on runway 14 as 2,260ft (688m) AMSL. That was equivalent to a height of 531ft (162m) AGL. The threshold elevation for runway 14 was annotated on each version of the charts as 1,729ft (527m) AMSL.

The Jeppesen aerodrome chart depicted the threshold of runway 14 as being about 0.9NM (1,700m) southeast of the NDB. The Jeppesen runway 14 and 32 NDB approach plates also depicted the runway in that position, relative to the NDB. During the investigation the actual threshold of runway 14 was found to be about 1.35NM (2,500m) northwest of where it was depicted on those charts. The runway heading for runway 14 at Baucau was depicted as 135 degrees magnetic on the aerodrome chart issued by CAD. It was also depicted as 135 degrees magnetic on the Jeppesen aerodrome chart. Following the accident, the runway was surveyed and the actual runway heading was determined to be 139 degrees magnetic.

Air traffic services (ATS) were not provided to the occurrence aircraft at Baucau. A notice to airmen (NOTAM) valid at the time of the occurrence, advised that ATS were only available for aircraft conducting United Nations troop rotations at Baucau. At 0540UTC, the ATS staff at Baucau received advice from ATS in Brisbane, Australia, that the aircraft's revised arrival time was 0610UTC. At 0553UTC, the crew contacted Baucau ATS. The controller at Baucau advised the crew that ATS was not available, and that landing would be at their discretion, which they acknowledged.

According to the cockpit voice recorder (CVR), the crew set the aircraft altimeter sub-scales to 714 mm of mercury (Hg) as the aircraft was descending through 2,400m (7,784ft) on approach to Baucau. That altimeter sub-scale setting was equivalent to 952.8 hectopascals (hPa). The crew positioned the aircraft to overfly runway 14, and after observing the runway below them, they flew the aircraft on a heading of 135 degrees magnetic before climbing to a height of 500m (1,640ft) AGL and positioning on a left downwind leg for runway 14. The crew was unable to visually sight the runway during the downwind leg, but discussed passing 4 to 5km (2.1NM to2.7 NM) laterally abeam runway “.135.”. The crew then positioned the aircraft for an approach to runway 14, using the onboard navigation equipment. However, the aircraft overflew the runway before the crew expected it, and a landing could not be achieved from this approach. The crew again climbed the aircraft to 500m (1,640ft) AGL, and with reference to the onboard navigation equipment, they repositioned the aircraft for another approach to runway 14. When the aircraft was on final approach, the crew descended the aircraft. According to the CVR, at about 2km (1NM) from the aerodrome, the crew realised that the aircraft was too low on the approach. The FDR data revealed that the aircraft pitch attitude was then increased, however, the thrust lever angles remained unchanged. Three seconds later the aircraft impacted the ground.

Witnesses at the aerodrome reported seeing (and photographing) the aircraft overfly the aerodrome twice before its impact with the ground. Witnesses also reported that:

- the aircraft landing gear was not extended as it overflew the aerodrome on the first occasion;
- the aircraft landing gear was extended during the second approach (Figure 2), but the aircraft appeared too high to be able to land, and discontinued the landing approach;
- the weather at the time was overcast with a low cloud base;
- a few minutes after the aircraft's second overflight, they heard an explosion to the northwest of the aerodrome shortly after 1520 local time, and saw flames and smoke in that vicinity, and
- Three residents from Caicido village each observed the aircraft suddenly emerge from low cloud close to the ground just before its impact with trees. One of the residents was standing near the trees at the time. Another of the residents was blown to the ground by jet blast from the aircraft as it flew by just before the impact.
The weather conditions at the accident site were described as low misty cloud with light rain, with a visibility from 200 to 300m. At 0740 UTC, several fires were reported to have still been burning within the wreckage, one of which was described as being a “...major fire that was flaming bright white.”.

1.2 Inquires/damage to aircraft/property/fire/survival aspects
Impact forces and the post-impact fire destroyed the aircraft, and all six persons on board were killed. The accident was deemed un-survivable. The investigation was unable to determine the individual total levels of experience on the IL-76 TD aircraft type for the pilot in command, co-pilot, flight engineer or flight navigator. An IL-76 TD type rating was entered in each of those flight crewmember’s Russian flight crew licences, and all had held those type ratings for at least 10 years.

During the impact sequence, the right wingtip of the aircraft struck a partially constructed house to the left of the centreline of the wreckage trail, about 190 m from the first impact point. The house, which was occupied at the time by its owner, was severely damaged. The owner of the house was physically uninjured by the impact. Crops near the wreckage trail were also damaged from a combination of turbine fuel, which sprayed from the aircraft fuel tanks as they ruptured during the impact sequence, and from the post-impact fire.

2 Investigatory Response
Shortly after the occurrence of the accident and the request for aid to Australia from the Timor-Leste government, a team of Australian investigators was assembled and dispatched to Baucau. The accident investigation team (AIT) consisted of members from the Australian Transport Safety Bureau (ATSB) and the Directorate of Flying Safety (DFS). At the request of DFS two Defence Science and Technology Organisation (DSTO) officers were seconded to assist the team by supplying scientific investigatory support on site including mapping the wreckage site and the wreckage distribution, and conducting an assessment of the mechanical condition of the aircraft prior to impact and to assess the nature of the post-impact break-up.

The Australian AIT arrived to commence the investigation on 2 February 2003. The United Nations Mission In Support of East Timor (UNMISET) provided logistical support and the Baucau airport managers (PAE) provided a secure room for the team to operate from. The Australian AIT compromised one ATSB officer: Mr P. Robertson, two operations investigators and one engineering investigator from DFS and two structural and materials scientists/investigators from DSTO. To this team a liaison officer from UNMISET was attached and gave invaluable support to the investigation team in the form of supplies of water, arranging accommodation and medical aid, and numerous other administration tasks.

The Timor-Leste Department of Civil Aviation also supplied one officer as investigatory support, however his experience in aircraft accident investigation was limited.

It was agreed that the head of the AIT would be the secretary of the Timor-Leste Department of Civil Aviation and the Australian team would report through this channel. Mr Robertson was appointed by the State as the accredited representative whilst the remaining team members were to be advisors to the accredited representative in accordance with ICAO Annex 13, sections 5.23 and 5.2.4 [1]. Several days later, members from the civilian aviation organisation from the aircraft’s country of registration (Laos) arrived, as did the Russian operators and owners of the aircraft. As specified by ICAO Annex 13, the Laotians officially joined the AIT whilst the Russians were provided controlled access to the incident site. The Laotians and Russians aided in the understanding of the organisational aspects of the pre-flight registration of the aircraft, crew, and the maintenance and ownership records of the aircraft, which were found to be complex since the aircraft had been owned and leased by several entities during its life.

The place of the occurrence was at Cakung Airport, Baucau. Although Baucau is the second largest city in Timor-Leste, its facilities compared to even small towns in developed counties were very limited. The infrastructure that is often relied on to aid an investigation of large transport accident was not available and the field investigators had to be largely self-reliant.

The Australian AIT was a relevantly small team for the investigation of such an accident in difficult conditions involving several countries, with very limited local support and an aircraft foreign to the investigators experience. This case became a test of international collaboration in accident investigation and the leveraging of investigatory techniques by the use of robust advanced technology in field investigation.

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2.1 Aircraft Information and Description

Upon arrival in Baucau the AIT had very little information regarding the IL-76 aircraft. What information that was available consisted of aircraft dimensional drawings and a photo of the sister aircraft to the one involved in the accident (Figure 3 and Figure 4). A further source of data were resources found on the Internet that gave some information of the aircraft type, and details of this and other accidents as reported in the media. Among many, some of the websites where such information is available for a wide range of aircraft are: http://www.airdisaster.com and http://aviation-safety.net/database, for accident information, http://www.airliners.net/search/photo, for photos and http://www.aeronautics.ru/archive/vvs/il76-01.htm for IL76 specific information. Subsequently further detailed information became available from the owners and state of registry as well papers found in the wreckage, and from the inspection of, and discussions with the pilots of, another Ilyushin passenger transport that arrived at Cakung Airport for UN troop rotations during the investigation.

2.2 Aircraft ownership/registration/operators

With the increasing use of charter aircraft registered in third world counties to transport cargo and passengers, combined with the large number of ex-Soviet Union aircraft and aircrew on the market, extraordinarily complex ownership and responsibility arrangements have developed which make the task of investigating accidents backgrounds for aircraft maintenance, flight crew compliance and who should join in the investigation, difficult. This accident gives some insight into the complexities that may arise.

During the course of the investigation it was found that the aircraft was manufactured as an IL-76 MD variant in 1986, and was originally operated in the Ukraine. It was converted to an IL-76 TD variant in 2001. The aircraft’s owners, who were based at Sharjah in the United Arab Emirates (UAE), purchased the aircraft in July 2001 from a Ukraine-based air cargo operator. The owners registered the aircraft in the Islamic Republic of Iran, which issued the aircraft with certificates of airworthiness and registration, and in September 2001, it was leased to an Iranian company operating from Teheran.

The lease with the Iranian operator continued until December 2001. The owners then leased the aircraft to another Iranian operator that also operated from Teheran. The new lease expired in October 2002, after which the aircraft was relocated to the UAE and the Iranian registration was cancelled.

On 1 November 2002, the UAE owners leased the aircraft to a Lao PDR-based company for one year. Under the terms of the lease, the lessor was required to provide the flight crew and the loadmasters. The lease specified that the pilot in command was fully responsible for the flight safety of the aircraft. The lease also specified that the flight crew was required to comply with the legislation of the Lao PDR, and that the lease agreement was subject to the approval of the Lao PDR Department of Civil Aviation (DCA). The lessor was required to provide the flight crew with all required flight documentation, including a complete set of Jeppesen en-route navigation charts. The lease specified that the lessee would not be entitled to sublease the aircraft to a third party without the prior written consent of the lessor.

On 9 November 2002, the Lao DCA issued Air Operator Certificate (AOC) to the lessee. The AOC included information that the Lao-based company had met operator certification requirements specified in the Civil Airworthiness requirements of the Lao DCA, and was authorised to conduct commercial air transport operations.

On 18 November 2002, the Lao PDR-based company entered into an arrangement to sublease the aircraft to another company based in Cambodia. Under the terms of the proposed sublease, which was signed by both parties, the lessor would provide the aircraft flight crew to the lessee. The proposed sublease specified that the aircraft was to remain registered by the Lao PDR, and that supervision over the flight, technical and commercial operation was the lessor’s “competent authority”. The proposed sublease also specified that the lessee was to act as the lessee’s agent for the provision of necessary waybills and cargo documentation in accordance with the laws of the countries to, through, or over which the aircraft was to be flown. The lessee was also required to supervise the provision of that documentation through its representatives.

On 30 December 2002, the Lao DCA issued a letter of clarification concerning the original lease agreement, dated 1 November 2002, and the proposed sublease, dated 18 November 2002. The Lao DCA concluded the letter with the statement that the Cambodian-based operator was an operator of the aircraft owned by the Sharjah, UAE-based company.

On 20 January 2003, the Cambodian-based company executed a Cargo Transportation Agreement with a Singapore-based company for the flight from Macau to Baucau on 30 January 2003 to carry cargo. The Cambodian-based...
company was listed on the agreement as the “Carrier”, and the Singapore-based company was listed as the “Client”. The cargo manifest, however, listed the Lao-based company against the aircraft type and registration details.

On 28th of January, a request was sent to the UN in Timor-Leste for landing permission for the aircraft’s intended arrival at Baucau on 30th. CAD approved the request for landing permission. Also on that date the Singapore-based company contacted a freight-forwarding company in Dili and requested that the freight-forwarder arrange for payment of landing fees and the provision of ATS at Baucau for the occurrence flight. The freight-forwarder contacted UN Air Operations, and was given a quote for the provision of administration and security, rescue and fire fighting services, and ATS. UN Air Operations subsequently reported that freight-forwarder indicated that the only service needed at Baucau would be help with unloading the cargo. The freight-forwarder subsequently reported that it made no payments for the services needed, because “…we never received an invoice from the UN”. UNMISET subsequently reported that no one associated with the operator ever advised UNMISET of a request or a need for the provision of ATS for the aircraft at Baucau.

On 7 February, the General Director of the Lao-based company reported that the request for landing permission, dated 28 January 2003, and sent under the letterhead of his company, had been sent without his authorisation. On the 20th of March, the Chairman of the Cambodian based company advised that although both parties had signed the proposed sublease document, the Lao-based company had not received consent from the aircraft owners in the UAE to enter into the sublease. The Chairman advised that under the circumstances, the inferred sublease had not taken effect, and the Cambodian-based company had therefore acted as an intermediary between the Singapore-based company and the Lao-based company for the occurrence flight. On 21 July 2003, the Cambodian-based company advised the AIT in writing that the formalities for the proposed sublease had not been finalised at the time of the occurrence.

The site investigators recovered the aircraft’s technical log from the aircraft wreckage that indicated that the aircraft underwent an “A” check at Sharjah, UAE, at 2,312 airframe hours with no major problems reported.

3 Wreckage Examination and Analysis

The small investigation team along with the remoteness of the accident site from modern support facilities and the investigators home base meant that the investigation team had to be in part self-reliant. The data collected from the site had to be sufficient and of a quality high enough to allow a robust analysis of the accident to be made, since revisiting the site would be very difficult if not impossible once the investigators had returned to Australia. This is not dissimilar to most aircraft accident sites (if not for the same reasons) since, weather conditions can obliterate witness marks, cleaning up the wreckage is usually a priority of local authorities, or disturbance of the wreckage by unauthorised people or animals makes site evidence perishable.

To aid in the collection of as much data as possible in the shortest time, the team relied heavily on digital image capture and review of these images on site (there were no film development labs in Baucau, which would have allowed conventional film to be developed and reviewed). On-site scientific support was available in the form of the two DSTO scientists – one an aircraft structures specialist, the other a materials specialist, who collectively have expertise in mapping, failure analysis, materials toxicology, structural collapse and accident site investigation. The main data collection aids were; several high resolution digital cameras (redundancy is important), a differentially corrected mapping grade GPS unit [3,5], laser range finder with built-in inclinometer and digital compass and a lightweight laptop with mapping, image manipulation, word processing and other software to document and review witness interviews, catalogue and store documentation (including photographs) collected and backup this data to CD-Rs.

3.1 Data collection

The GPS is a satellite-based system operated by the United States Department of Defense. GPS provides an all-weather, worldwide, 24-hour service, which can be used for calculating positions and time. To make this system available to unlimited users, a passive ranging method called pseudoranging is used. The satellites are active (transmit) and the user’s units are passive (receive). The satellite transmissions enable computation of the user's position and velocity ‘relative’ to a spheroid Datum (model of the earth’s surface). Positioning accuracy is attainable from 1 cm to 100 m, depending on the type of receiver used, antenna dynamics, number and position of the satellites in view, mode of operation and the processing (error correction) techniques employed by the user.
GPS, as a military system, was initially intentionally degraded (Selective Availability (SA)) from achieving the highest positioning accuracy for a system relying on the GPS satellite data alone. The growing demand for civil use of this highly capable system has led to the SA degradation of the signal being turned off. Nevertheless the high use of the system by the civil community has resulted in other data and functions being added by the civil community to create a system that gives high, RELATIVE (to a spheroid Datum) positioning accuracy.

The GPS gives a user their position in all areas of the world. However, real world ABSOLUTE positioning is extremely complex.

The spheroid Datum used by the GPS system is the World Geodetic datum or System (WGS). The positions given by a GPS unit are referenced to this model of the earth’s surface, rather than the actual surface of the earth. The earth is in fact a very complex shape that is not easily modelled. The WGS uses the centre of the earth’s mass as its origin (geocentric) and three axes (Cartesian coordinate system) from that origin to define alignment. The WGS datum was established by using observations from satellites orbiting the earth over a long time, and is therefore quite accurate. The version promulgated in 1984 and therefore known as WGS-84 is the datum used by GPS receivers.

The GPS system used for the accident mapping allows a user-defined library of features, which are usually referred to as Features or Themes to be loading into the hand held data logger. The details to be collected in the field (position, notes etc.), about each logged item are called Attributes. A “pen-based” ruggedised data logger is connected to the GPS/communications receiver, and is capable of logging many positions along with simple notes and other details about the item being logged such as the identifiers of any digital pictures that are taken at the time.

The library loaded into the data logger is known as the Data Dictionary. Typically, the Data Dictionary will include all the feature categories that are to be located and mapped. These are separated into point, line or area features. General features (not belonging to any of the other categories) with point, line or area shapes are automatically included in the Data Dictionary to cover features not included in the rest of the Dictionary. These are listed as Point generic, Line generic and Area generic respectively.

Data Dictionaries should be tailored to particular accidents, as the decisions made when choosing the features for inclusion in the Dictionary will affect the display and flexibility of the maps produced. While the data can be manipulated after the event, a good dictionary will save a lot of time in data manipulation during analysis. Since this accident was in many ways unique (large Russian four engine transport at a site that was remote from Australia) alterations to the data dictionary were carried out from time-to-time during data collection to aid in the presentation of items mapped. Maps were produced and reviewed at the end of each session in the field to assess the progress of the data collection and to aid in the assessment of the developing scenarios.

The software used to control the data logger and generate the data dictionaries will also display the data as simple maps in real time on the data logger display. To further manipulate the data and to join other data to the GPS and notes collected in the field, a more powerful software GIS (Geographical Information System) package is used. This package was used during the site examination at the end of each session. All of the maps presented in this paper have been produced with that GIS package.

A Data Dictionary for this accident was prepared using the data logger software after an initial inspection of the accident site. It was subsequently modified during field use. The Dictionary had the Features listed in Table 1. During data collection, the data are stored with a number of attributes for each position mapped. These included: GPS position time and date; height; position shape (point, line or area); feature name; data file; number of fixes taken for this data point; standard deviation between fixes taken for a data point; and other user defined attributes.

### 3.2 Site examination preparation

Prior to examination of the wreckage appropriate preparation measures had to be taken because of the difficult conditions expected at the site. The team took sufficient personal protective equipment to carry out the site examination, water had to be sourced from the UN, French ration packs were supplied by the UN, and equipment to be used at the site had to be tested and set-up for the site work. In particular, reliance on the differentially corrected GPS unit meant that a correction service for the area had to be obtained and the correction accuracy tested. This was assessed by mapping items around the airfield such as the tower and local roads etc. and checking their positions each day. Previous experience with mapping aircraft accident sites had found that even if the maps do not add greatly to the outcome of the investigation, the process concentrates the investigators on the detail of the wreckage and forces close scrutiny of items that may become important in the post-site investigation analysis, and as such mapping by this method has been found to be an invaluable aid in several accident investigations.
GPS correction was supplied by OmniSTAR who supply world wide coverage from 60° north to 60° south using fixed base-station in various positions situated around the world, and supplying the correction signals via satellite communications. The GPS unit used had an inbuilt receiver designed to receive these correction signals and calculate the corrected position on the fly (Differentially corrected GPS: DGPS). This service normally supplied a sub-metre accuracy ideal for the mapping of aircraft wreckage.

### Table 1. Data Dictionary used for the Investigation of the IL-76 Accident at Baucau.

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<tr>
<th>Item classification (pre-site)</th>
<th>Feature type</th>
<th>User defined attribute collected</th>
<th>Actual feature name used (site)</th>
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<td>Generic Point</td>
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<td>Nose Landing gear</td>
<td>Point</td>
<td>Photo No., Note</td>
<td>NLG</td>
</tr>
<tr>
<td>Ground marks</td>
<td>Line</td>
<td>Photo No., Note</td>
<td>Ground marks</td>
</tr>
<tr>
<td>Ground marks</td>
<td>Point</td>
<td>Photo No., Note</td>
<td>Ground marks</td>
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<tr>
<td>Instruments</td>
<td>Point</td>
<td>Photo No., Note</td>
<td>Instruments</td>
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<tr>
<td>Actuators</td>
<td>Point</td>
<td>Photo No., Note</td>
<td>Actuators</td>
</tr>
<tr>
<td>Tower</td>
<td>Point</td>
<td></td>
<td>Tower</td>
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</table>

Note: The software produces a separate attribute name for each attribute taken.

### 3.3 Site examination

The Timor-Leste police with the aid of UN police were maintaining site security, and this proved mostly effective, although the police on site spent a notable amount of time ‘kicking tin’.

On arriving at the wreckage site, the following tasks were initiated by the engineering team:

- Inspect site, and site security, establish site safety concerns, clear or make safe any hazards identified.
- Form an examination strategy based on the initial inspection.
- Develop a data dictionary for the site mapping so that initial analysis can be achieved.
- Map reference items such as fences, road etc.
- Commence detailed site examination and mapping while looking for; aircraft extremities, all engines, control surface configuration, instruments, FDR and CVR etc.

From the initial examination, it was concluded that the wreckage path (130° magnetic) was approximately aligned with the heading of runway 14 (Figure 5) (i.e. the aircraft had approached from this direction).

In general two people were involved with the mapping process (see Figure 6). Integral to the process was the logging of items (point, line or area), cataloguing them appropriately (e.g. left hand wing skin, lying inverted), digitally photographing the items and referencing the data logged with the appropriate photograph number.

During the wreckage mapping, apart from the moving map produced in the data logger, more complete interim maps were produced and updated on a laptop PC in the AIT office. Viewing these maps gave the investigating team the confidence to proceed with other tasks, and to make changes to the mapping requirements as required, therefore making far greater use of the available time and resources. Sufficient data were collected over four days of mapping in weather that varied from clear skies to tropical downpours.
Several problems were encountered during the mapping of the IL76 wreckage, mostly related to variation in the accuracy of the unit. The location of the site was very remote from the nearest correction stations (Darwin: about 660km away and Denpasar: about 700km away) with the result that in the event that storms built up during the day at Baucau the error increased, sometimes in an erratic manner. This was most notable when locations previously mapped were “displaced” by several metres the next day when compared to the positions previously logged and presented on the moving map of the data logger. This was always associated with large thunderstorms over large quadrants of the sky. To alleviate this, offset corrections were entered while logging new items where nearby previously logged items were available so that local relative accuracy could be maintained. This could be carried out since on the first day of mapping the weather was clear and a large number of key items scattered widely over the accident site had been mapped, and the displacements between these key items and the items subsequently being mapped were relatively short, and the offset did not drift very quickly. Upgrading the DGPS receiver to a dual frequency unit or a unit that also uses the Russian GPS satellite array to improve accuracy could reduce weather related problems such as this. Alternately a second unit could have been set up locally at a fixed known point and its signal could have been used to calculate the local corrections required to correct the roving units readings. Such systems are commercially available and give excellent relative accuracy and allow operation without remote correction signals being required.

On the second day of mapping the correction signal, while correctly acquired initially, could not be maintained for more than a few minutes. This was found to be the result of the correction supplier erroneously turning off the activation for the receiver. The signal was restored for the next mapping session while those items logged without correction were manually corrected using offsets to the key items.

Battery problems were encountered which resulted in the correction signal being lost. It was eventually found that of the six 12V lead acid camcorder batteries taken to Baucau two would not hold a charge and caused unpredictable DGPS operation. Generally with the increasing use of battery-powered technology as an aid to investigators in the field, considerable attention needs to be given to reliable lightweight and high power density batteries and reliable fast chargers. Purpose manufactured lithium-ion batteries have now replaced most of the batteries used during this investigation.

3.4 Flight recorders

The FDR and CVRs were recovered on the first day of on-site examination. The aircraft was fitted with one FDR, two CVRs, and a quick access recorder (QAR). The FDR and CVRs were recovered from the rear fuselage section in the wreckage. The QAR was recovered from the cockpit wreckage area. The impact forces extensively damaged the QAR, and no flight data could be recovered from it.

The casings of the FDR and CVR storage units were sooted from the post-impact fire, but revealed no evidence of heat or structural damage since the recorders had been found in a relatively undamaged section of the tail of the aircraft (Figure 7). Examination of the recorded data revealed that the FDR had operated normally until impact. The parameters recorded by the FDR included:

- lateral acceleration, vertical acceleration (‘g’), rudder position, elevator position, magnetic heading, roll, stabiliser position in degrees, pitch angle in degrees, angle of attack in degrees, barometric altitude in metres,
- with reference to a standard sea level pressure datum of 760 mm Hg (1,013.2 hPa), radio altitude in metres,
- GPWS activation, indicated airspeed in km/hour, thrust lever angles for each engine, N2 for each engine,
- EGT for each engine, wing slat extension, landing gear activation, autopilot pitch engagement, autopilot roll engagement.

On advice from the Australian Accredited Representative, CAD forwarded the FDR and CVRs to the Russian Interstate Aviation Committee, Air Transport Accident Investigation Commission (CIS) (IAC) for readout and analysis.

The wire-recording medium in one of the CVRs was dislodged from the recorder spools in that unit, and provided no useful data. The other cockpit voice recorder provided good quality audio information for the descent and approaches to Baucau. This recorder was a single-channel recorder, and combined all onboard audio channels into one recorded channel. It operated in an automatic ‘auto-start’ mode, and the recording media only moved and recorded acoustical and time data if the flight crew operated the intercom or the radio transmitter keys. The system incorporated disengaging delay of about 15 seconds between when the intercom or the radio transmitter keys were released, and when the recording media stopped. The aircraft was not fitted with a ‘hot mic’ system that provided acoustical data to the CVR. Additionally, the CVR was not equipped with a cockpit area microphone (CAM). Both ‘hot mic’ and CAM systems provide a CVR with the capacity to capture flight crew communications and acoustical signals relating to the operation of the aircraft. Those signals improve the ability to analyse the activities of a flight.
crew and the operation of the aircraft in the period leading up to an occurrence. Both ‘hot mic’ and CAM are most effective when the CVR is continuously recording acoustical data. Without a CAM, the CVR on the occurrence aircraft was not able to record the flight deck aural environment as required under the standard described in 2.1.1.b) of Attachment B to Annex 6 Part I to the Chicago Convention.

Readout of recorded flight crew conversations was obtained for the final 40 minutes of the flight. The CVR transcript was prepared by the IAC, and was a translation from the Russian language to the English language. From the CVR, it was evident that the pilot in command was the handling pilot for the flight. The IAC reported that because the time intervals between the flight crew conversations recorded on the CVR during the second landing approach were less than 10 seconds, any audible warnings generated by the radio altimeter system and the GPWS would have been recorded on the CVR. However, none were evident.

The recorded flight data provided by the CIS IAC were also used as one of the inputs in to a generic flight visualization program (Graphic Replay Software: GRS) developed by DSTO (Figure 8). Other inputs were: wind direction and strength, a topographical map as a render on the ground surface, the wreckage mapping information and the positions of the runway as depicted by the on-site mapping and in the Jeppesen approach plate.

The evaluated pressure altitude varied slightly from the ‘smoothed’ true pressure altitude derived from the variable recorded barometric altitude data. The impact point was 495 m (1,625 ft) above the 760 mm Hg (1,013.2 hPa) datum. The evaluated pressure altitude at impact was 609 m (1,998 ft), indicating a discrepancy of 114 m (374 ft) between the recorded barometric data and the evaluated pressure data.

3.5 Wreckage

The wreckage trail was aligned on a track of about 130 degrees magnetic. The aircraft began to break-up immediately after impact. It also slewed about 5 degrees to the left during the break-up sequence, as is evident in Figure 9. Despite the destruction of the aircraft during the break-up sequence, all extremities of the airframe were located. The four engine cores were also located. They were relatively intact, and each revealed damage consistent with engine rotation while delivering power.

The post-occurrence examination of airframe and engine parts revealed no evidence of in-flight break-up or mechanical failure. There was also no evidence of any pre-impact explosion or fire. All meltage within the wreckage displayed evidence of a vertical flow in relation to the ground, which suggested that the individual metallic structures were in a static state when they were exposed to the heat source that resulted in the melting process. While there was evidence of sooting and ash on the wreckage, there was no evidence of slipstream effect to indicate that fire had occurred before impact.

The engine cores and accessories were mostly intact, however each engine fan assembly had separated from its respective engine, and fan blades were spread throughout the accident site suggesting that the engines were operating at the time of the impact.

The post-occurrence technical examination of the engine fan blades found in the wreckage did not display any evidence of bird strike or blending repairs. It was not possible to determine whether the engines had sustained any foreign object damage before impact because of the significant damage resulting during from the impact sequence. The FDR EGT and N2 plots revealed no apparent aircraft engine anomalies during the descent into Baucau or during the approach sequences.

The slat and flap assemblies that had remained attached to primary wing structure were in the extended position. The flap tracks were lubricated, and displayed no evidence of significant wear. The screw jack and actuator positions were consistent with the wing high lift devices having been extended at the time of impact. No slat or flap abnormalities could be found which would have suggested a problem during the approach sequences.

All landing gear assemblies were found in the extended position, and no landing gear abnormalities were evident during the approach sequences.

4 Wreckage map

The data collected in the field with the DGPS mapping system were presented in a number of different formats to show particular wreckage patterns as part of the analysis of the aircraft break-up. The team also used the equipment
to map the runway and other features of interest (see Figure 1). After five days about 900 items of wreckage were mapped covering the airfield, and the main wreckage site (Figure 10). These maps were highly flexible allowing separation of specific types of wreckage as shown in Figure 11, which shows the relative location of engine parts compared to the main wreckage.

A comparison between the position of the runway and the reference point as shown on the WPEC Jeppesen Baucau chart (30 Aug 2002) was made and it was found that when measured with the DGPS (WGS84) the runway was displaced from the position presented in the chart. Figure 12 depicts the extent of this displacement, which occurred in latitude, longitude and (also) height. Included in this Figure is the RAAF plate for comparison. The difference in height, between the charts and the DGPS, can probably be explained since it appears that the WGS84 model is incorrect at Baucau by about 140 feet (i.e. the shore was found to be shown as about 140 feet on the WGS84 Datum of the DGPS) so that the elevations quoted on the chart are about correct when measured above sea level and incorrect if assumed to be WGS84 compliant. The airport reference point (ARP) could not be found in the position noted in the chart, although a survey marker was found near the southern end of the runway, which was thought could be the ARP.

Many (approximately 300) of the items plotted at the crash site were categorised and photographed. Within the first few days, coupled with the examination of physical witness marks, the maps allowed a plausible incident scenario to be developed. A brief summary of the impact and wreckage analysis follows.

### 4.1 Summary of the impact and aircraft break-up

The aircraft’s impact and disintegration is thought to have followed the following sequence based on the evidence gathered during the wreckage and site examination, and mapping:

One landing gear bogie contacted the slightly rising ground before a clump of trees leaving the distinct witness scar found in the ground. This scar was on a heading of approximately 130° magnetic. Measurements of the ground witness marks clearly indicated that a main landing gear bogie produced them. The impressions in the ground suggested that the attitude of the aircraft was slightly nose-up. This is supported by the absence of any other marking suggesting that another bogie had contacted the ground. This is also supported by the wheel marks ending some distance before the trees; it is possible that the aircraft had begun to climb prior to the left wing contacting the trees. The dry stonewall running across the imaginary continuation of the wheel marks also had only one impact region (four indentations consistent with the four wheels of a main landing gear bogie could clearly be seen in the top of the wall) consistent with an undercarriage bogie, but slightly to the right of the initial wheel track. This suggested that the aircraft had its left wing slightly up at tree impact. The distance from the centre line of the wheel marks to the most distant damaged tree trunk was about 22m, while another tree, undamaged, was about 27m from this track. Since the distance from the centre line of the left and right bogies to the left wing tip is 22.4m and 28.2m respectively (see Figure 3) it is likely that the left hand (rear, since the nose was up) bogie had produced the witness mark on the ground (given that the aircraft had not drifted laterally).

Given that the left hand bogie had contacted the ground, then the distance between it and the trees to the left, when it became abreast of the trees on an imaginary continuation of the wheel marks (11m), referred to as T1, indicates that the left wing had struck the tree just outboard of the starboard outboard engine pylon (Figure 13). The most distant damaged tree, T3, would thus have struck approximately 1 m from the wing tip. This was consistent with a piece of the outboard aileron, being found directly under the trees and with pieces of an engine fan being found from these trees forward along the wreckage path.

Assuming that the left hand bogie had contacted the ground first, then it must be speculated that the pilot (or co-pilot) upon seeing the trees initiated a bank to the right (and probably a simultaneous pull-up), thus causing the slightly upward left hand wing to leave the observed impact damage to the trees. The attitude deduced from the observations would have had to be attained in the 41m between the bogie leaving the ground and the aircraft impacting the trees1. The bank to the right would also suggest that the wall was impacted by the right hand bogie (thus positioning the impact approximately 2m from the initial bogie track, to the right of this track).

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1 Given a typical landing speed for this aircraft of approximately 300km/hr, then the rate of roll (from a few degrees left wing down to a few degrees left wing up) is considered achievable.
The height above the ground in the tree cuts was approximately 7m. Given that the wheel impacts to the fence were about 1m above the ground then this distance is consistent with the left wing having caused the tree damage.

The wing impact damage caused its internal fuel to be sprayed forward. The fuel chemical damage caused the foliage in the vicinity to be ‘browned’.

The impact damage to the left wing (including the loss of the high lift devices i.e. flaps and slats, and possibly severe damage to the wing box resulting in the wing outboard of the outer engine beginning to bend upwards) would have reduced its lift producing capability, and with the right hand wing producing lift the aircraft would have proceeded to roll to the left. Since the trees were substantial (about 0.5m diameter in the impact regions) then a sudden violent yaw towards the left would also have occurred. During this roll and yaw, it is considered likely that the aft-most fuselage section partially separated from the main body of the aircraft. The roll would also have resulted in the forward fuselage contacting either the ground, vegetation and or one of the stone walls (a nearby stone wall had been extensively damaged by impact) momentarily as evidenced by pieces of lower cockpit window and wiper blade not far down track from the impact trees. The roll would also have caused the damaged left hand wing to contact the ground as witnessed by a piece of wing tip skin found forward of the impacted trees. It is suggested that this may have caused the wing to fold up (just outboard of the outboard engine) had it not already started to do so, losing several ribs in the process. At this point the aircraft is effectively rolling about the “folded” left hand wing. The yaw also swung the final debris trail slightly to the left of the initial ground mark direction.

By the time that the right wing tip hit the house on the left side of the debris trail the wing (and most of the aircraft) was inverted (the several large pieces found were all inverted) and had yayed somewhat from its original heading. A standby attitude indicator recovered in this vicinity supports this proposition. With the aircraft still yawing, the left wing tip (red) light contacted the ground close by (23m laterally). This is consistent with the outer left wing section having folded over the inner section as described above, thus positioning the red light approximately 23 m from the green light. Forward and to the right of this region, significant pieces of the left hand outer wing were found. In Figure 14 a scaled IL-76 image has been placed on a map of the ‘initial tree impact to house area’ to show the possible positions of the aircraft during this part of the impact sequence.

Just after the house impact the aircraft crossed a large area of serrated-like coral ridges that were perpendicular to the path of the aircraft (consisting of extremely hard limestone) and could be likened to an enormous “cheese-grater”, Figure 15. As the inverted forward fuselage and cockpit contacted the ground heavily here it probably separated from the remaining fuselage due to failure of the regions initially damaged during the tree impacts and ground contact that occurred earlier. As this section traversed this area it was shredded into relative small fragments leaving most of the cockpit items to the left of the centre line of the track.

During the travel through this section the damaged wing with its fuel leaking is now yawed roughly parallel to the wreckage path, thus restricting the fire damage to the centre of the wreckage trail. This yawing motion and fire trail is evident from Figure 9.

The remaining wing sections and centre-to-rear fuselage continued the yawing motion until coming to rest generally facing towards the initial impact point. The wings were inverted at this point, and had yayed through 180° or more. Most of the cargo was thrown forward and to the left of this region (Figure 16). The remaining right hand wing section was notably longer than the left, consistent with the left hand wing damage described earlier. Three of the four main landing gear bogies located in this region and were relatively undamaged, also suggesting that the aircraft travelled to its final resting place inverted.

The aft section containing the horizontal T-tail must have separated from the remaining fuselage before coming to rest. This was evident since only the leading edge of the vertical tail had impact markings (scraping marks - Figure 19). Had it been together with the rest of the fuselage in its normal position, when the aircraft became inverted far greater damage would have occurred.

Since the aircraft wings spent much of the ground travel inverted, and the fan sections of the engines had absorbed most of the impact damage noted to each of the engines, it is considered that the engines had sufficient time to spool down from their landing thrust power level accounting for the relative low level of damage to their cores.
5 Discussion

The investigation [2] determined that the flight crew’s compliance with procedures was not at a level to ensure the safe operation of the aircraft. Before the flight crew commenced the descent into Baucau, the pilot in command briefed them that he would conduct a non-precision instrument approach at Baucau, with reference to the Baucau NDB.

The flight instruments fitted in the occurrence aircraft provided readings of height, speed and distance in metric units. The pilot in command’s briefing included information on the relevant heights for the missed approach procedure expressed in feet, and not in their metric equivalents. None of the other crewmembers commented on that fact. The CVR data revealed that the pilot in command did not refer to the source of data that he used for the briefing on the intended NDB approach at Baucau. The pilot in command’s arrival briefing also contained no information or discussion on the:

- planned altimeter subscale settings for the descent to Baucau
- applicable minimum sector altitude (MSA) within 10 NM (18 km) of the Baucau NDB; the MSA was 9,300 ft (2,834 m) above mean sea level (AMSL)
- commencement altitude for the runway 14 NDB approach at Baucau, which was 5,500 ft (1,676 m) AMSL
- lowest safe altitude (LSALT) for the last route sector into Baucau, which was 4,500 ft (1,372 m) AMSL
- applicable minimum descent altitude (height) (MDA(H)) for the approach
- expected weather at Baucau
- Baucau NOTAMs.

The CVR data revealed that none of the other crewmembers commented on the omission of this critical information. As a result, the arrival briefing was not effective.

Controlled airspace was established at Baucau, but ATS at Baucau was only available for UN aircraft on UN troop rotation days. The NOTAMs for Baucau included that information. The occurrence aircraft was not engaged in UN troop rotation operations, and no troop rotations took place during the aircraft’s approach to Baucau. When the aircraft was about 300 km from Baucau, the pilot in command instructed the co-pilot to call Baucau ATS. Over the next 23 minutes, the co-pilot called Baucau Tower 25 times, but received no response to those calls. The flight navigator then called Baucau Tower. A controller, who was present at Baucau aerodrome at the time, but not on operational duty, advised the flight crew that ATS was not available and that landing would be at the discretion of the flight crew. The flight navigator acknowledged the controller’s advice, but did not seek information from the controller about the prevailing weather at the aerodrome. That was a missed opportunity for the flight crew to obtain updated information on the weather at Baucau. Had the flight crew sought and received that information, it may have provided them with an improved situational awareness of the prevailing weather. During the descent in Timor-Leste airspace, none of the flight crew monitored the Timor Common High frequency of 123.45 MHz while the aircraft was above 10,000 ft (3,048 m). They also did not monitor the Timor Common Low frequency of 127.1 MHz while the aircraft was below 10,000 ft, or broadcast their intentions and traffic information on that frequency. Therefore, the flight crew had no assurance that there was no conflicting traffic. The flight crew’s disregard of the requirement for traffic information broadcasts within Timor-Leste airspace increased the potential risk of an in-flight collision. The pilot in command diverted the aircraft from the published inbound track to the Baucau NDB, and descended the aircraft below the published 10 NM MSA. He continued descending the aircraft through the commencement altitude for the published non-precision instrument approach for runway 14, and through the LSALT. None of the other crewmembers commented that the pilot in command had breached those relevant safety heights. The Baucau NOTAMs included information that instrument approach charts for Baucau were available from the CAD of the Ministry of Transport, Communication and Public Works, Timor-Leste. However, the investigation determined that the flight crew used Jeppesen instrument and approach charts, and not the CAD-issued charts. As the aircraft approached Baucau, the flight crew decided to conduct an over-flight of the aerodrome before making a landing approach, and during the over-flight, the flight crew realized that the runway was not where they expected it to be. The investigation determined that the flight crew did not conduct the over-flight of the aerodrome, or either of the landing approaches, with reference to the Baucau NDB. The flight crew used selected data from their instrument approach charts for Baucau to formulate a user-defined non-precision approach using the onboard GPS. That user-defined procedure was a non-approved procedure. It deviated from normal practice, bypassed all the safety criteria and risk treatments built into the design of the published precision approach procedures, and increased the risk of a controlled flight into terrain (CFIT) accident. The flight navigator provided the pilot in command with distance to run and lateral offset distance from the runway centreline during the over-flight and the first landing approach. The flight navigator’s reference to distance and lateral offset during those manoeuvres...
corresponded to the position of the aircraft in relation to the threshold of runway 14 as depicted on the Jeppesen charts. The navigation data provided by the flight navigator was therefore accurate in terms of where he expected the threshold of runway 14 to be, based on the Jeppesen charts. However, erroneous data on the Jeppesen charts meant that it was inaccurate in terms of where the threshold of runway 14 was actually located. The flight crew’s inappropriate reliance on that data therefore increased the risk of a CFIT event.

Had the flight crew followed the non-precision runway 14 NDB approach procedure as published on either the CAD or Jeppesen charts, and not descended below the relevant MDA(H) until visual flight was assured, the position of the runway, as depicted on the Jeppesen charts would have been irrelevant. Although the runway would not have appeared where the flight crew expected it to be at the MDA(H), in visual meteorological conditions (VMC) a safe approach could have been conducted to the actual threshold of runway 14. Alternatively, if a visual approach could not be made from the relevant MDA(H), a safe missed approach could have been conducted by following the published missed approach procedures. During the over-flight and the subsequent (first) landing approach, the flight crew realised that the runway was not where they expected it to be as it was depicted on the Jeppesen charts. The pilot in command discontinued the landing approach, and the flight navigator stated that he would apply a 4 km correction to position the aircraft for a second landing approach to where he thought the runway was located. By applying the 4 km correction, the flight navigator was providing the pilot in command with inaccurate data, and resulted in the aircraft being repositioned towards a point about 1.65 km (0.88 NM) northwest of the actual position of the threshold of runway 14. That incorrect data substantially increased the hazards of the user-defined approach procedure, and the risk of a CFIT event at that stage of the flight increased to a high degree. The flight crew did not appear to identify the hazards associated with the intended improvised approach procedure, and were therefore not in a position to manage the associated risks.

As the aircraft turned on to the final approach heading during the second landing approach, the flight navigator stated that the aircraft was high on the approach profile, based on his assumption of the location of the threshold of runway 14. The pilot in command increased the rate of descent of the aircraft to about 18 m/sec (3,543 fpm), and stated ‘Increased’. None of the other crewmembers commented on the high rate of descent, or drew the pilot in command’s attention to the fact that the approach was unstabilised at that point. The risk of a CFIT event is diminished by a stabilised approach, and the high descent rate in close proximity to terrain at that stage of the flight increased the risk of a CFIT event to the point where impact with terrain was almost certain. The CVR data provided no evidence that the flight crew was monitoring the increasing risk and evaluating whether to discontinue the approach to treat that risk. The flight engineer misinterpreted the pilot in command’s statement ‘Increased’ to be an instruction for him to increase the engine thrust, and he advanced the thrust levers. It took about 2 seconds for the pilot in command to realise that engine thrust had been increased, and he reacted by calling ‘No, I increased vertical speed’ and reduced the engine thrust. The flight engineer’s action in increasing engine thrust was a significant distraction to the pilot in command at that stage of the flight, and probably diverted his attention from the primary task of flying the aircraft to restoring the thrust to the proper setting.

At about the same time, the aircraft descended through 162 m, which was the published MDH for a straight-in landing on the runway 14 NDB approach. Neither the pilot in command nor the co-pilot appeared to notice that the aircraft had descended through the MDH, and it is probable that both were distracted by the flight engineer’s erroneous action. The risk of a CFIT event is diminished if an approach is flown no lower than the published MDA(H) of an instrument approach procedure until visual flight can be assured and maintained. At that stage of the flight, descent below the MDH in instrument meteorological conditions (IMC) at a high rate of descent meant that the risk of a CFIT event had increased to an unacceptably high level and could not be treated. Impact with terrain was almost certain from that point onwards.

The high rate of descent continued unchecked until slightly less than 2 seconds before impact. It is probable that the pilot in command and the co-pilot were each unaware of the high rate of descent, because neither was monitoring the flight instruments while they were looking ahead of the aircraft and trying to establish visual contact with the ground. Just before impact the co-pilot urgently expressed concern that impact with terrain seemed certain. In response the pilot in command applied back elevator to increase the aircraft pitch attitude, without simultaneously increasing the engine thrust. Consequently, the pilot in command’s attempt to avoid impact with terrain was unsuccessful because of the inertia of the aircraft and its close proximity to terrain.

The aircraft’s impact with terrain was a direct consequence of the pilot in command descending the aircraft below the published minimum descent height for the runway 14 non-precision instrument approach procedure in an unstabilised manner. Furthermore, it was also as a result of poor planning by the flight crew and less than effective crew coordination. During that landing approach, the actions of the flight crew steadily increased the risk of a CFIT.
to an extreme level, yet they seemed unaware that the likelihood of impact with terrain was almost certain until shortly before it occurred.

Research conducted by an aviation industry task force, under the patronage of the ICAO, has credited the main reasons for accidents involving aeroplane hull losses to CFIT and approach-and-landing accidents. In recent years, CFIT reduction has been the focus of organisations such as ICAO and the Flight Safety Foundation (FSF). The findings of the FSF approach-and-landing accident reduction (ALAR) task force resulted in several conclusions and recommendations, and from those, the production of the FSF ALAR Tool Kit.

This paper highlights that deviations from recommended practice are a potential hazard, particularly during the approach and landing phase of flight, and increase the risk of a CFIT event. It also highlights that crew coordination is less than effective if crewmembers do not work together as an integrated team, and that support crewmembers have a duty and responsibility to ensure that the safety of a flight is not compromised by non-compliance with recommended practices.

The potentially serious to catastrophic consequences of a CFIT event remain constant, irrespective of likelihood of the event. The potential risk of CFIT can be diminished by using current technology and equipment, by implementing adequate standard operating procedures, by assessing and managing CFIT risk factors, and by developing effective crew decision-making and risk management processes.

6 Conclusions

On 31 January 2003, at 0621 UTC (1521 local time), an Ilyushin 76TD (IL-76TD) aircraft, registered RDPL-34141, impacted terrain near Caicido village during a landing approach, about 1 NM (1.87 km) to the northwest of Cakung Airport, Baucau, Timor-Leste. The pilot in command was the handling pilot during the descent and approaches at Baucau. Impact forces and a severe post-impact fire destroyed the aircraft, and the six occupants were fatally injured.

Australia agreed to assist the Timor-Leste government in the investigation of this accident, and assigned the Australian Transport Safety Bureau (ATSB) to conduct the investigation for and on behalf of Timor-Leste, and in accordance with Annex 13 to the Chicago Convention. A relatively small team comprising members of the Directorate of Flying Safety and the Defence Science and Technology Organisation conducted the major portions of the investigation. Assistance was also gained from Timor-Leste Department of Civil Aviation, United Nations Mission In Support of East Timor (UNMISET), the aircraft’s country of registration (Laos) civilian aviation organisation, the Russian operators and owners of the aircraft and the Russian Interstate Aviation Committee, Air Transport Accident Investigation Commission.

The use of a small team to investigate a complex incident of a large aircraft involving a remote and difficult location, limited support, and complicated international dealings was successfully completed by, in-part leveraging on new readily available technology and imbedded scientific support. Using a mapping grade GPS unit the team were able to map and categorise approximately 900 items of wreckage in only 5 days. The daily analyses of these maps allowed a plausible scenario to be developed in a timely fashion. Early mapping and witness mark investigation provided a good indication of the aircraft configuration, engine power and attitude at impact. This has lead to a understanding of the break-up sequence.

The investigation concluded that the incident was due to CFIT which occurred as the result of a combination of actions involving the crew ignoring published landing procedures in favour of an unapproved approach based on on-board navigation aids which eliminated all the risk mitigation strategies under pinning safe aviation, and calls into question the level of oversight being applied to small under-resourced charter operations out of countries with less developed governmental control over civil aviation operations than developed countries

Safety recommendations from many investigations of CFIT events and serious incidents have related to the prevention of CFIT and approach-and-landing accidents. The ATSB and CAD Timor-Leste endorse those recommendations and their implementation.
6.1 Safety Actions

6.1.1 Most significant findings.

As a result of this investigation a large number of findings and safety actions were recommended [2]. While this paper does not address the details of the investigation it is worth noting the following as the most significant findings. The safety actions recommended are also included.

1. The flight crew did not comply the published non-precision instrument approach and/or missed approach procedures at Baucau during flight in instrument meteorological conditions.
2. The flight crew conducted user-defined non-precision instrument approaches to runway 14 at Baucau during flight in instrument meteorological conditions.
3. The pilot in command permitted the aircraft to descend below the MDA(H) published on both the Jeppesen and CAD runway 14 instrument approach charts during flight in instrument meteorological conditions.
4. The flight crew did not recognise the increased likelihood and therefore risk of CFIT.
5. The flight crew did not recognise or treat that risk in a timely manner.

Safety actions recommended for:

CAD Timor-Leste

1. As a result of the recommendations made by the Australian (ATSB) Accredited Representative and his advisers to the Government of Timor-Leste on 9th February 2003, CAD issued a NOTAM that contained information that with the exception of UNMISET aircraft and aircraft operating on behalf of the UN, aircraft were not permitted to conduct NDB approaches at Baucau. The NOTAM included advice that all approaches and landings at Baucau were to be conducted in VMC, and that the Baucau NDB could only be used for homing or tracking.
2. On 10th February 2003, CAD notified Jeppesen that the location of the runway in relation to the NDB and the aerodrome reference point (ARP) was incorrectly depicted on the Jeppesen charts, and asked Jeppesen to withdraw the charts.
3. CAD issued a new NOTAM that contained information that QNH for Baucau was only available to aircraft operated by and on behalf of UNMISET during periods that ATS was available for aircraft engaged in UN troop rotations.
4. CAD issued a new NOTAM that contained information that UNMISET NDB instrument approach and landing charts for runways 14 and 32 at Baucau, and an aerodrome chart for Baucau, dated 20th February 2003, were available from UNMISET. The NOTAM included advice that the use of those charts was restricted for use only by UNMISET aircraft and aircraft operated on behalf of the UN. The NOTAM also included advice that: PREVIOUS NDB IAL CHARTS RUNWAY 14/32 [Baucau] ARE HEREBY WITHDRAWN.
5. CAD advised that it had put in place arrangements to ensure that it is the single point of contact with the Royal Australian Air Force and Jeppesen for East Timor aeronautical data to prevent the possibility of incorrect or conflicting data being used in the preparation of instrument approach and landing charts.
6. CAD advised that it has amended the existing coordination procedures between Timor-Leste and the Australian and Indonesian ATS units to ensure that:
   a. Comoro Approach would become the central point of coordination for aircraft entering Timor-Leste airspace and
   b. crews of all aircraft entering Timor-Leste airspace would be required to contact Comoro Approach on the appropriate very high frequency radio (VHF) channel, irrespective of their destination, notwithstanding that Comoro air traffic control’s responsibility was confined to the Dili control area.
7. CAD advised that with respect to CAD safety action 6, the amended procedures would ensure that Comoro ATS unit was made aware of all known aircraft entering East Timor airspace, and that by being in contact with an air traffic control (ATC) unit, aircraft crews could be provided with a level of ATS service.
8. CAD also advised that with respect to CAD safety actions 6 and 7, because of VHF range coverage, communication with Comoro Approach could not be assured if aircraft were operating at low levels, and that the amended procedures would not affect the existing TIBA arrangements until East Timor could establish its own Flight Information Service.
9. CAD advised that it was examining how Baucau QNH could be relayed to Dili so that Comoro Approach could relay that QNH to aircraft other than UNMISET aircraft or aircraft operated on behalf of the UN operating into Baucau.

10. CAD advised that preparation of the Timor-Leste aeronautical information publication (AIP) was nearing completion, and that it was intended that the AIP would contain information specifying that pilots shall not use "user-defined" GPS procedures instead of published procedures to conduct instrument approaches.

11. CAD advised that it had issued completely updated aerodrome and instrument approach and landing charts for runways 14 and 32 at Baucau in October 2003, and that those charts were in compliance with ICAO standards and recommended practices.

Jeppesen Sanderson Inc.

1. At the request of CAD Timor-Leste, Jeppesen issued Airway Manual Services Revision Letter number 5-03 on 28th February 2003 which provided details of revisions to material in the Pacific Basin edition of the manual, and included instructions that the Baucau 16-1 and 16-2 charts were to be destroyed.

United Nations Mission of Support in East Timor Air Operations

1. On 12th February 2003, UNMISET Air Operations commissioned a survey of Baucau aerodrome to establish its actual elevation above mean sea level.

2. As a result of UNMISET safety action 1, the instrument approach and landing charts for runways 14 and 32 at Baucau, and the aerodrome chart for Baucau were amended with effect 20th February 2003 and issued by UNMISET Air Operations; the charts contained information on the corrected elevations established by the survey, and were restricted for use by UNMISET and UN aircraft.

3. UNMISET advised that the UN would consider, on a case-by-case basis, providing ATS, including notification of QNH, at Baucau to aircraft on humanitarian flights, other than UNMISET aircraft or aircraft operated on behalf of the UN.

7 References


Figure 1 Map of Cakung Airport runway in relation to crash site laid over a local area topographical map.

Figure 2 The aircraft as observed during the second overflight at Baucau Airport at about 06:00:20 UTC, note the extended nose landing gear.
Figure 3  An overview of the IL-76 aircraft

Figure 4  An IL-76 aircraft (one of two operated by Euro Asia Aviation - EAA) - Courtesy EAA.
Figure 5   Looking at the accident site towards runway 14

Figure 6   Team members mapping piece of engine diffuser.
Figure 7  The FRD and CVRs as found in the wreckage. Note that these were ‘wire’ recorders.

Figure 8  Graphical Replay Image of Last Moments of Flight
Figure 9  Looking down on the second half of the wreckage trail; from the house (at the left of this Figure) to the final resting place of the main wreckage (to the right of the picture).

Figure 10  General map of the wreckage distribution.
Figure 11  Map concentrating on large wing and all engine pieces. Note only engine number 3 was positively identified from its serial plate. The identity of the other engines was estimated from their relative positions on the wing and their relative damage post accident. Engine numbering - left to right.
Figure 12  Map of runway (green) as measured by the DGPS unit, and the runway’s approximate position as indicated on the RAAF (blue) approach chart and the Jeppesen Baucau chart (red). The red dots are the DGPS measured runway thresholds and suspected ARP.
Figure 13  Overview of initial impact site
Figure 14  A scaled IL-76 drawing placed on a map of the initial impact area to show the possible positions of the aircraft during this part of the impact sequence. The yellow dot is the lower cockpit wiper blade. It is possible that impact with the nearby fence is responsible for the position in which it was found.

Figure 15  Wreckage scattered throughout the region of “coral outcrop” looking east.
Figure 16  Looking down at wing and tail sections.