Banjul Accord Group

Accident Investigation Agency (BAGAIA)

AIRCRAFT ACCIDENT REPORT

CVK/2017/07/29/F

Accident Investigation Report

Report of the Accident involving CAVOK Airlines CVK 7087 AN-74TK-100 Aircraft registered UR-CKC which occurred at Sao Tome International Airport, Sao Tome on 29th July, 2017

Approved and published by the Commissioner under authority of the Council of Ministers.

This report was produced by the Banjul Accord Group Accident Investigation Agency (BAGAIA).

The report is based upon the investigation carried out by Banjul Accord Group Accident Investigation Agency. The State of Occurrence, Sao Tome & Principe delegated the entire investigation to BAGAIA, being the Regional Accident Investigation Authority, in line with Section 5.1 of Annex 13 to the Convention on International Civil Aviation. Nigeria as a member state of BAGAIA, was requested to conduct the investigation on its behalf.

In accordance with Annex 13, it is not the purpose of Aircraft Accident/Serious Incident Investigations to apportion blame or liability.

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As BAGAIA believes that safety information is of great value if it is passed on for use of others, readers are encouraged to copy or reprint for further distribution, acknowledging BAGAIA as the source.

Recommendations in this Report are addressed to the Institut National de l'Aviation Civile (INAC), Sao Tome, Ukraine Civil Aviation Authority and CAVOK AIR, LLC, Ukraine.

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GLOSSARY OF ABBREVIATIONS USED IN THIS REPORT

AFM	Airplane Flight Manual
AGL	Above Ground Level
AIP	Aeronautical Information Publication
APFDS	Auto Pilot Flight Director System
ASD	Accelerate Stop Distance
ASDA	Accelerate Stop Distance Available
ATC	Air Traffic Controller
ATPL	Airline Transport Pilot Licence
ATIS	Automatic Terminal Information Service
BAGAIA	Banjul Accord Group Accident Investigation Agency
BKN	Broken (Cloud)
CANPA	Constant Angle Non Precision Approach
CDL	Configuration Deviation List
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder
DME	Distance Measuring Equipment
EASA	European Aviation Safety Agency
ECAM	Electronic Centralised Aircraft Monitor
EGPWS	Enhanced Ground Proximity Warning System
EICAS	Engine Indication and Crew Alerting System
EMAS	Engineered Materials Arresting System
ETOPS	Extended Twin-Engine Operations

FAA	Federal Aviation Administration
FAF	Final Approach Fix
FDR	Flight Data Recorder
FE	Flight Engineer
FL	Flight Level
FLCH	Flight Level Change
FMS	Flexible Manufacturing System
FO	First Officer
GPS	Global Positioning System
ICAO	International Civil Aviation Organisation
IF	Intermediate Fix
IFA	Initial Approach Fix
ILS	Instrument Landing System
INAC	Instituto Nacional de Aviacao Civil (National Civil Aviation Authority of STP)
MAP	Missed Approach Point
MDA	Minimum Decent Altitude
MEL	Minimum Equipment List
MET	Meteorological
MHZ	Mega Hertz
MSA	Minimum Safe Altitude
MTOW	Maximum Take-off Weight
N/A	Not Applicable
NAA	National Aviation Authority

NADP	Noise Abatement Departure Procedure
ND	Navigational Display
NOTAM	Notice To Airmen
OM	Outer Marker
PF	Pilot Flying
PM	Pilot Monitoring
PNF	Pilot Not Flying
QFE	Query Flight Elevation
QNH	Query Navigation Height
RAAS	Runway Awareness and Advisory
RESA	Runway End Safety Area
RTO	Rejected Take-Off
RVR	Runway Visual Range
RWY	Runway
SARPs	Standard and Recommended Practices
SID	Standard Instrument Departure
SMGCS	Surface Movement Guidance and Control System
SOP	Standard Operating Procedure
STAR	Standard Terminal Arrival
TDZE	Touch Down Zone Elevation
THC	Tetrahydrocannabinol
TOD	Take-off Distance
TODA	Take-off Distance Available
TOR	Take-off Run

UTC	Universal Time Coordinated
VDP	Visual Decent Point
VHF	Very High Frequency
VNAV	Vertical Navigation
VOR	Very High Frequency Omni Directional Range

Aircraft Accident Report No.:	CVK/2017/07/29/F
Name and Address of Owner:	Swift Solution FZC P.O. Box 8753, SAIF Zone, Sharjah, United Arab Emirates
Operator/Lessee:	CAVOK Air LLC, UKRAINE
Aircraft Type and Model:	Antonov AN-74TK-100
Manufacturer:	Kharkiv State Aircraft Production Enterprise
Date of Manufacture:	20th May, 1992
Serial No.:	36547095905
Registration:	UR-CKC
Location:	Sao Tome International Airport
Date and Time:	29th July, 2017 at about 0907hrs
	All times in this report are local time, equivalent to UTC unless otherwise stated.

SYNOPSIS

On 29thJuly, 2017 at about 0905hrs, an Antonov aircraft Model AN-74 TK-100, flight CVK 7087, registered UR-CKC, owned by SWIFT SOLUTION FZC and operated by CAVOK Airlines LLC overran runway 29 during a rejected take off at Sao Tome International Airport. The Captain, the First Officer, the Flight Engineer and 2 maintenance Engineers on board were rescued unhurt except the Flight Navigator who sustained an injury to his left foot and some minor bruises. The intended non-scheduled return flight to Accra was initiated in accordance with appropriate regulations. Visual meteorological conditions prevailed, and an instrument flight rules flight plan was filed.

The safety issues discussed in this report focused on rejected take-offs and rejected take-off procedures; compliance with SOP, other related checklists and manuals, flight crew training for RTO scenarios; flight crew performance, including the captain's action to initiate a RTO after V_1, and CRM.

Recommendations in this Report are addressed to the Institut National de l'Aviation Civile (INAC), Sao Tome, Ukraine Civil Aviation Authority and CAVOK AIR, LLC, Ukraine.

1.0 FACTUAL INFORMATION

1.1 History of the Flight

On 29th July, 2017 at about 0905hrs, an Antonov aircraft Model AN-74TK-100, flight CVK7087, registration UR-CKC, owned by SWIFT SOLUTION FZC and operated by CAVOK Airlines LLC was departing Sao Tome International Airport to Kotoka International Airport, Accra, for positioning with six crew on board. The flight was on an Instrument Flight Rule (IFR) flight plan and Visual Meteorological Conditions prevailed. The aircraft exited runway 29 during a rejected take off. The Flight Navigator sustained an injury and the aircraft was destroyed.

On 28th July, 2017 at 0225hrs the aircraft arrived Sao Tome International Airport from Stavanger (Norway), via Luxemburg and Ghardaia (Algeria) as a Cargo flight. On 29th July, 2017 at about 0800hrs, the crew of CVK 7087 comprising the Captain, the First Officer, the Flight Engineer, the Flight Navigator and 2 Maintenance Engineers arrived the airport and commenced the flight preparation; pre-flight inspection, determination of weight and balance, computation of performance and take-off speeds. The crew received flight briefing/weather information and refuelled the aircraft with an uplift of 5,700kg.

At 0850hrs, the crew requested engine start-up clearance from Sao Tome Tower and it was approved. After completing the engine start procedures, engine parameter indications on both engines were normal. Appropriate checklist was completed and taxi clearance was requested by the crew.

Sao Tome Tower initially cleared CVK 7087 to taxi on runway (RWY) 11 as favoured by the prevailing wind. However, the crew requested RWY 29 for departure. This request was approved by the Tower and the aircraft re-cleared to taxi to RWY 29 for departure. Sao Tome Tower did not provide the flight crew with the information about possible presence of birds at the aerodrome, in particular, on the runway.

At 0905hrs, the aircraft began the take-off roll. The First Officer was the Pilot Flying (PF) while the Captain was the Pilot Monitoring (PM). The engines and systems parameters were reported to be normal.

According to the Captain, "In the first half of the take-off run from the runway, from five to six eagles got off the ground of the runway and flew dangerously close to the aircraft". He then requested the Flight Engineer to check if the flood lights were ON and to monitor the engine parameters. The crew asserted that they observed a rising and narrowing runway as the aircarft accelerated to a speed of 180 km/hr. They stated further: "At a speed of 180 km/hr, ahead, a flock of eagles, which were not seen before this moment began to get off the ground from the runway." The Captain took control of the aircraft and decided, after assessing the situation within 4 seconds that the best option for the crew was to discontinue the take-off.

At that moment, the crew heard a bang, which they suggested could be a bird strike. This was followed by aural and visual indications on the annunciator panel such as “Left Engine Failure”, “Dangerous Vibration”, and “Take-off is prohibited” and the Captain immediately initiated a rejected take-off and instructed the Flight Engineer to deploy thrust reversers. The rejected take-off was initiated about 5 seconds after sighting the birds, at a speed of 220km/h. According to the Captain, his decision was necessitated by the consideration of losing multiple engines due to bird strike if the take-off continued.

The Captain said he pressed the brake pedals completely immediately after initiating the rejected take-off, subsequently he assessed the braking action as not effective and he used the emergency braking at a speed of about 130 km/h. On realizing that the aircraft would not stop within the remaining available runway length (about 272.3m) coupled with the presence of a ravine at the end, the captain intentionally veered to the right in order to extend the runway stopping distance and also avoid the ravine. The aircraft exited the runway at a speed of approximately 76 km/h. As the aircraft’s speed decayed to 60 km/h and just before the aircraft exited the runway, the Captain instructed the Flight Engineer to close the fuel emergency shutoff cock. The aircraft travelled a distance of about 95m from the exit point before plunging into the ravine. In the process, the forward fuselage separated from the bulkhead located immediately after the cockpit section. The aircraft came to rest at a location with coordinates: N002° 2' 51'' and E006° 42'07''. The accident occurred in daylight at about 0905hrs.

1.2 Injuries to Persons

Injuries	**Crew**	**Passengers**	**Total in the aircraft**	**Others**
Fatal	Nil	Nil	Nil	Not Applicable
Serious	Nil	Nil	Nil	Not Applicable
Minor	1	Nil	1	Not Applicable
None	5	Nil	5	Not Applicable
Total	6	Nil	6	Not Applicable

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

Nil.

1.5 Personnel Information

1.5.1 Captain

Nationality: Ukraine

Gender:	Male
Age:	59 years
Licence Number:	ATPL TA No. 002430
Licence Validity:	9th June, 2018
Aircraft Rating:	AN-74
Instrument Rating:	ILS
Instrument Rating validity:	30th December, 2017
Licence Proficiency Check validity:	17th July, 2018
Operator Proficiency Check validity:	14th January, 2018
Annual Line Check validity:	15th July, 2018
Medical Validity:	9th December, 2017
SEP/CRM:	20th January, 2017
Total Flying Experience (All types):	12,847hrs
On Type:	986hrs
Last 90 days:	146hrs
Last 28 days:	62hrs
Last 24 hrs:	Nil

1.5.2 First Officer

Nationality:	Ukraine
Gender:	Male
Age:	48 years
Licence Number:	ATPL TA No. 007254

Licence Validity:	21st November, 2017
Aircraft Rating:	AN-74
Instrument Rating:	ILS
Instrument Rating validity:	30th December, 2017
Licence Proficiency Check validity:	12th December, 2017
Operator Proficiency Check validity:	25th January, 2018
Annual Line Check validity:	1st December, 2017
Medical Validity:	21st November, 2017
SEP/CRM:	3rd November, 2016
Total Flying Experience (All types):	5,389hrs
On Type:	618hrs
Last 90 days:	146hrs
Last 28 days:	62hrs
Last 24 hrs:	Nil

1.5.3 Flight Engineer

Nationality:	Ukraine
Gender:	Male
Age:	56 years
Licence Number:	FE No. 000011
Licence Validity:	8th June, 2018
Aircraft Rating:	AN-74
Operator Proficiency Check validity:	29th December, 2017

Medical Validity:	8th December, 2017
SEP/CRM:	21st November, 2016
Total Flying Experience (All types):	17,301hrs
On Type:	4,479hrs
Last 90 days:	146hrs
Last 28 days:	62hrs
Last 24 hrs:	Nil

1.5.4 Navigator

Nationality:	Ukraine
Gender:	Male
Age:	57 years
Licence Number:	FN No. 000530
Licence Validity:	20th March, 2018
Aircraft Rating:	AN-74
Operator Proficiency Check validity:	23rd February, 2018
Medical Validity:	20th September, 2017
Total Flying Experience:	11,974hrs
On Type:	286hrs
Last 90 days:	81hrs
Last 28 days:	62hrs
Last 24 hrs:	Nil

1.5.5 Airframe & Powerplant Engineer

Nationality:	Ukraine
Gender:	Male
Age:	36 years
Licence Number:	AMLUA.66.1588
Licence Validity:	27th August, 2020
Aircraft Rating:	AN-74

1.5.6 Avionics Engineer

Nationality:	Ukraine
Gender:	Male
Age:	34 years
Licence Number:	AMLUA.66.1203
Licence Validity:	23rd October, 2019
Aircraft Ratings:	AN-12, AN-140, AN-24, AN-74 & YAK 40

1.6 Aircraft Information

1.6.1 General Information

Type:	AN-74TK-100
Serial Number:	365.470.95.905
Manufacturer:	Kharkiv State Aircraft Production Enterprise

Year of Manufacture:	1992
Total Airframe time:	5104.47hrs
C of A Validity:	27th November, 2017
Category:	Transport (Cargo)
Certificate of Registration:	Issued 3rd April, 2017 valid till 31st December, 2019

1.6.2 Engines

Number 1:

Type:	D-36, Series 2A
Manufacturer:	JSC Motor Sich, Zaporizhzhia, Ukraine
Serial No:	708036412A005
Time Since New:	5211 hours
Cycles:	1933

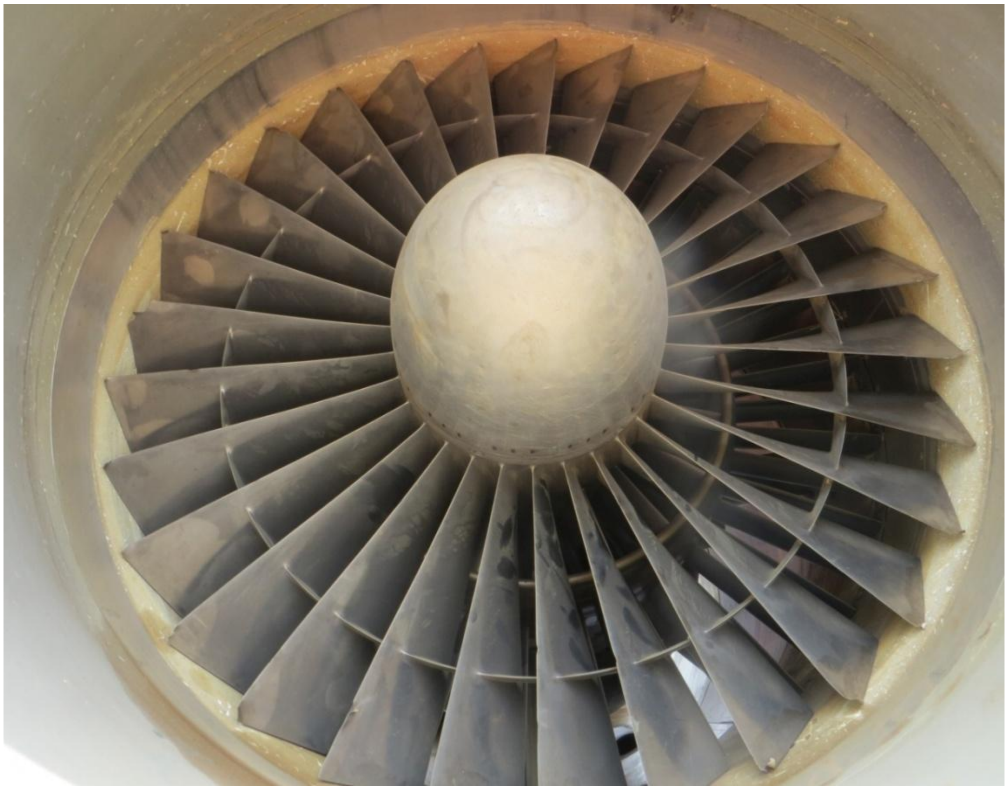

Figure 1: Picture showing engine number 1 air intake/nacelle

Number 2:

Type:	D-36, Series 2A
Manufacturer:	JSC Motor Sich, Zaporizhzhia, Ukraine
Serial Number:	708036312A006
Time Since New:	5211 hours
Cycles:	1932

Figure 2: Picture showing engine number 2 air intake/nacelle

1.7 Meteorological Information

The following weather information was obtained from the MET office in Sao Tome International Airport and was available to the crew.

FORECAST

Time	**:**	**0626 UTC**
Wind	:	180/4KT
Visibility	:	>10km

Weather	:	Nil
Cloud	:	FEW 020 BKN 110
Temperature	:	24^{o}C
Dew Point	:	21^{o}C
QNH	:	1014

ACTUAL

Time	**:**	**0626 UTC**
Wind	:	190/2KT
Visibility	:	>10km
Weather	:	Nil
Cloud	:	FEW 020 BKN 110
Temperature	:	24^{o}C
Dew Point	:	21^{o}C
QNH	:	1014

The weather information passed by the Air Traffic Controller at about 0858UTC to the crew, shortly before engine start-up clearance was given, was as follows: Wind 170-04 knots, temperature 25/20, QNH 1016 while the wind value was passed as 160-08 knots at take-off clearance.

1.8 Aids to Navigation

The conditions of the navigation aids at the Sao Tome International Airport on the day of the occurrence were as follows:

Sao Tome Control and Approach (ACC & APP)	VHF 127.5 MHz	:	‘S’
Sao Tome Tower VHF 118.900 MHz		:	‘S’
Sao Tome Tower VHF 121.500 MHz (Emergency Frequency)		:	‘S’
VOR/DME 117.300		:	‘S’

1.9 Communications

There was two-way communication between the crew and the Control Tower.

1.10 Aerodrome Information

The Sao Tome International Airport with ICAO location indicator FPST has a runway designation of 11/29. Runway 29 was used for the take-off.

The surface is coated with asphalt and has a dimension, 2160m x 45m. The Aerodrome Reference Point is: $00^{o}2^{'}40^{''}$and $006^{o}42'47''$E with an elevation of 10m. Runway 29 has threshold co-ordinate of 002233.45N, 0064316.46E and elevation of 5m.

Other declared distances of RWY 29 are as follows:

RWY length - 2160m,

RWY width - 45m,

TORA - 2160m,

TODA - 2160m

ASDA - 2160m,

LDA - 2160m,

Strip - 2240m * 150m,

CWY - 60m

RESA - Not available,

Stopway - Not available.

There is ravine at the end of the RWY 29 in addition to a major road adjacent to the airport's perimeter fence.

Runway inspection is usually carried out by the airport fire service personnel before any landing or take-off. At 0720hrs on the day of the accident, the runway was inspected for departure of STP Airways, STP 508.

Aeronautical Information Publication on the aerodrome is that "Birds may at times flock on the grass around the runway. If large concentrations of birds are seen on or near aerodrome, pilots of aircraft will be so informed by ATS." As part of its wild life control programme, the airport authority uses a 12-gauge firearm for elimination of animals while it employs scarecrow and a 12-guage shot gun to scare and eliminate birds respectively.

Figure 3: Aerial view of the Aerodrome

1.11 Flight Recorders

The aircraft was equipped with both the Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) and were recovered intact from the aircraft with the following details:

Flight Data Recorder

Part Number:	ИСУЯ.794121.002 (ISUY.794121.002)
Type:	ZBN-1-3 series 3
Serial Number:	1963
Manufacturer:	"PRIBOR"SPA, JSC

Cockpit Voice Recorder

Part Number: ЛИКС.467562.001-03 (LIKS.467562.001-03)

Type: ORT (RUS – OPT)

Serial Number: 151021

Manufacturer: UkrNIIRA, JSC

Upgrade of the aircraft recorders was performed by replacing the crash-protected memory units: ZBN-1-3 by SSFDRZBN-1-3ser.3, and MARS-BM by SSCVRORT installed on 26.12.2015 by AMOUATC (Kyiv, Ukraine) under conditions of STCs DTL0164 and DTL0165 issued by SAAU to DOA PC “Stork”.

The recorders were successfully downloaded at the Scientific and Research Laboratory of the Institute of Computer Systems of the National Aviation University, Ukraine. The FDR graphical readouts are as shown in Figures 4 and 5.

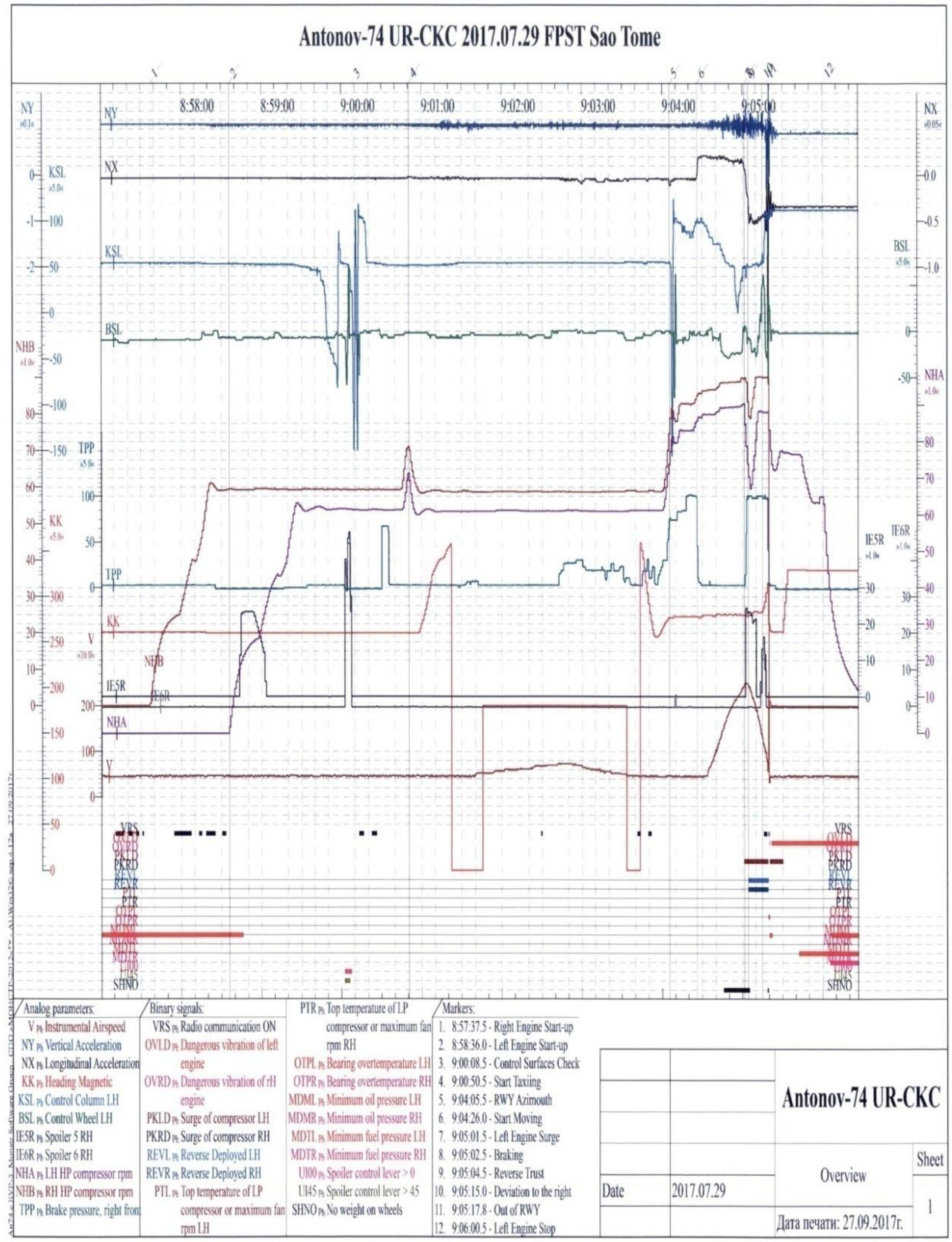

Figure 4: FDR Plot

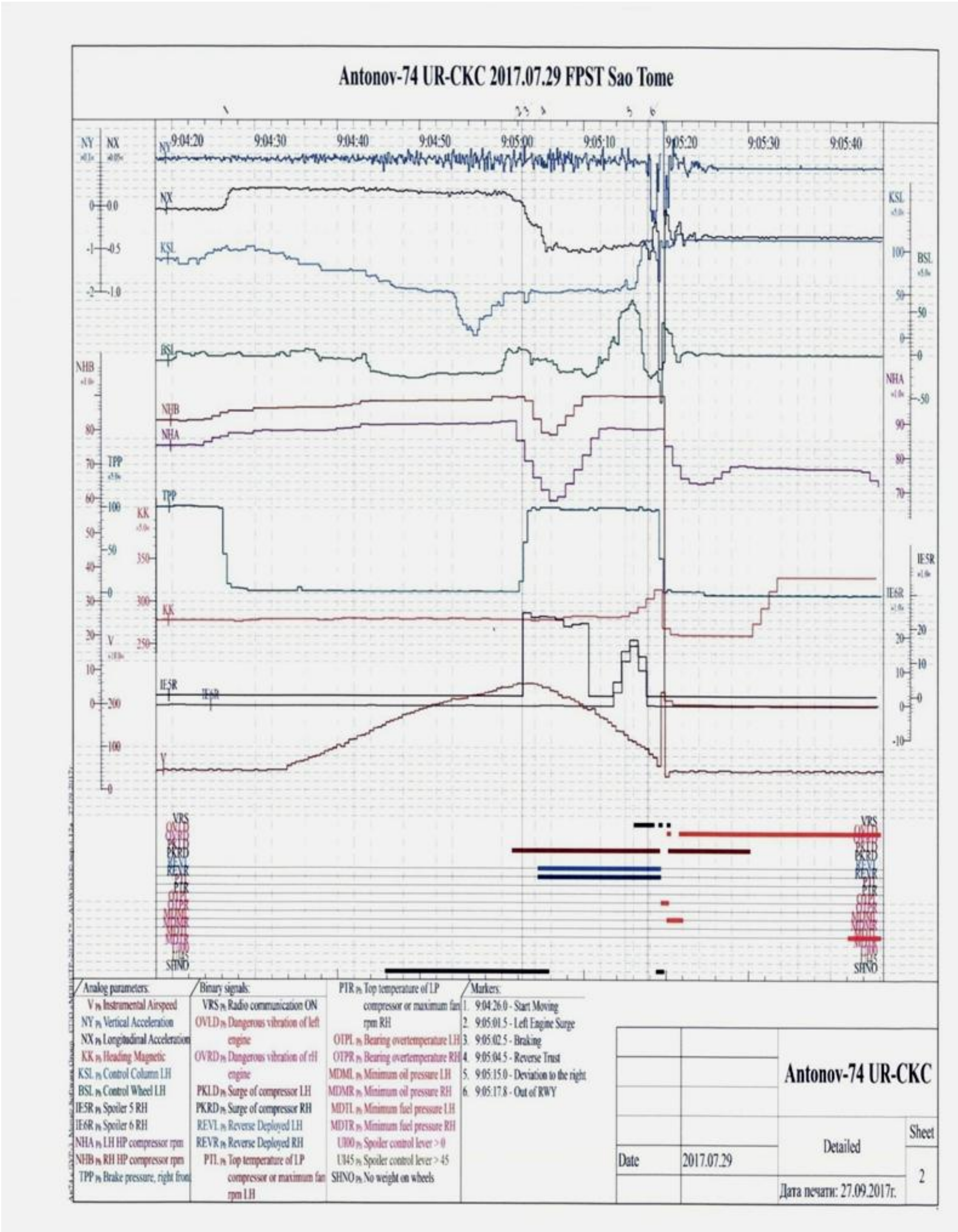

Figure 5: FDR Plot

1.12 Wreckage and Impact Information

The aircraft exited the runway at a speed of approximately 76 km/h and approximately 60m before the end of the runway. The clearway was an additional 60m in length. The aircraft plunged into the ravine and came to rest approximately 30m after the end of the clearway and 25m to the right of the clearway. The forward fuselage separated from the bulkhead located immediately after the cockpit section.

Figure 6: Picture showing the wreckage of the aircraft after the Impact

Figure 7: Picture showing the aircraft in the ravine

Figure 8: Picture showing the aircraft resting on its left side

Figure 9: Picture showing the detached portion of the left wing

1.13 Medical and Pathological Information

The Medical and Pathological report on the crew is as follows:

ANALYSIS:

The blood test results of the crew indicated the following:

1. *Ethanol (alcohol) levels for all five (5) crew members tested were within the Laboratory reference range of below 0.50 g/L);*
2. *Tetrahydrocannabinol (THC) was not detected in the blood samples of the three (3) flight crew that were tested.*

CONCLUSION

Based on the above analysis, it can be concluded that the flight crew were not operating under the influence of either Ethanol (alcohol) or Tetrahydrocannabinol (Marijuana); nor their performances impaired by these substances.

1.14 Fire

There was no post-crash fire.

1.15 Survival Aspect

The Air Traffic Controller on duty could see the aircraft exiting the runway during the take-off roll from the control tower. He immediately contacted the airport rescue and fire fighting service personnel who responded swiftly to the crash site. Foam was applied adequately on the wreckage to prevent fire outbreak before the crew were promptly rescued and immediately taken to hospital for medical attention. There was also a liveable volume for the occupants to enhance survivability.

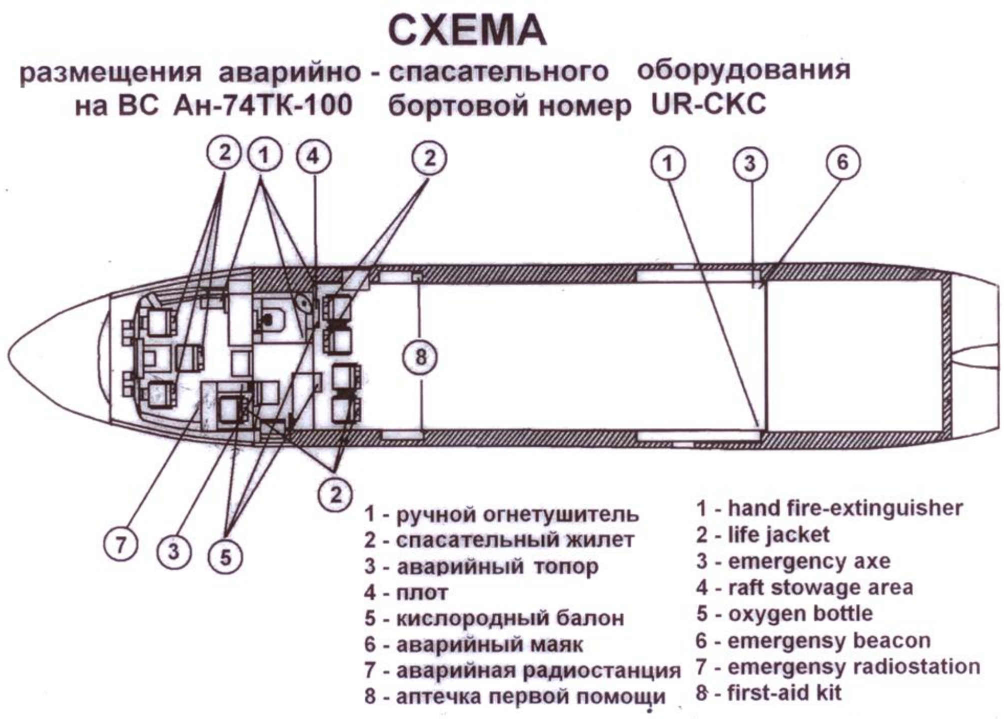

Figure 10: Cabin layout diagram

1.16 Test and Research

1.16.1 Feather Specimen Examination

Fragments of bird feathers recovered from various locations of the left engine and photograph of a dead bird on the runway were sent to Institute of Zoology at the National Academy of Sciences in Ukraine for ornithological examination. The report suggested that the fragments correspond to the juvenile specimen of diurnal carnivorous bird of Falconiformes of the Hawk Family (Accipitridae) – CommonHoney Buzzard, Pernis apivorusL.

The detailed report of the test is attached in Appendix1.

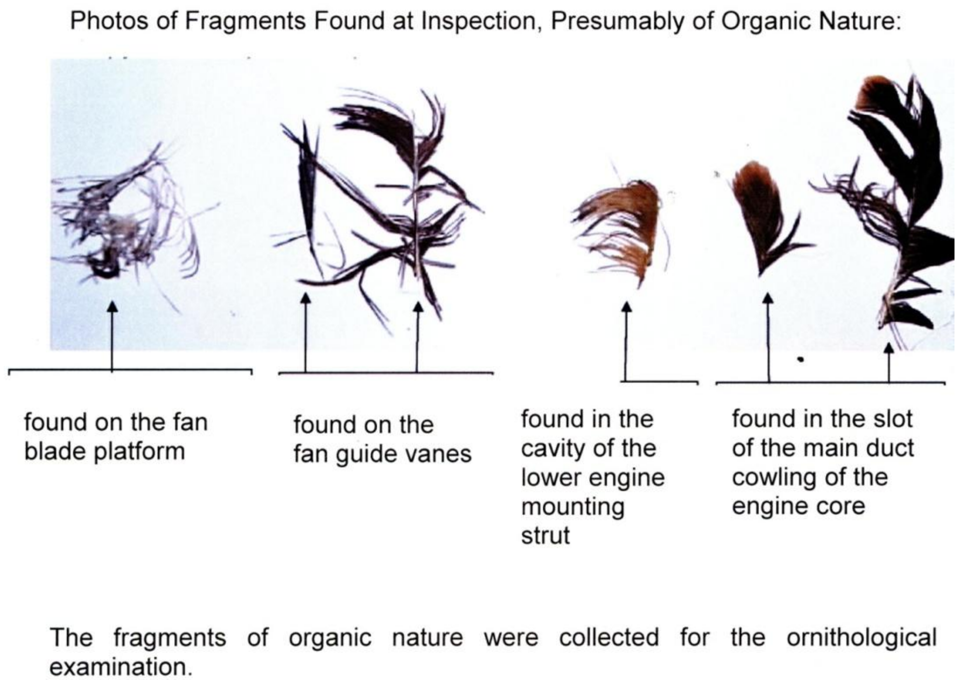

Figure 11: Feather Specimen found at different locations on the left engine

1.16.2 Fuel Sample Test and Analysis

Fuel sample taken from the incident aircraft was sent to a laboratory for analysis. The result obtained for the tests conducted were consistent with the characteristics of a normal Jet fuel and values of the parameters were within the prescribed limits. See Appendix 2 for details.

1.17 Organisational and Management Information

1.17.1 The Operator

"CAVOK AIR" is a Limited Liability Company (Airline) established in 2011 and based in Ukraine. It started operations on 26th April, 2012 and has an Air Operators Certificate. The main operations of the airline are:

- Air cargo transportation
- Dangerous goods and special cargo transportation
- Cargo charter operations with 24H flight watch
- Planning and flight support
- Obtaining diplomatic and special permits

The CAVOK Air fleet includes 7 Antonov An–12B and 1 Antonov An-74TK-100 involved in the accident.

1.17.1.1 Extract from Aircraft Operations Manual (Part B)

3.2 ACTION IN COMPLEX SITUATIONS

3.2.1 Engine failure

3.2.1.1 General notes.

Symptoms of engine failure:

1. Turn and bank of the airplane to the side of faulty engine.
2. Warning annunciator LEFT ENG-FAIL (RIGHT ENG-FAIL) illuminates.
3. Intermittent buzzer warning sounds in the headphones of the crew members.

4. Engine rotational speed loss.

3.2.1.3 Engine failure at take-off run (V>V1)

Continue take-off, for this:

- Keep the aircraft from turning and rolling using rudder pedals, ailerons deflecting.
- Carry out the lifting of nose landing gear at the 175...225 km/h speed
- Provide the incidence angle 7...8^{o} using automatic pilot control (APC) (2...3^{o} in pitch)
- After aircraft lift off provide roll to 3^{o} to the operating engine side. No performing slip C (slip indicating ball shall be declined at ¼ diameter to rolling side)
- Pull up the aircraft to climbing with the simultaneous increase of the speed up to 205...245 km/h

1.17.2 National Institute of Civil Aviation (INAC)

National Institute of Civil Aviation otherwise known in Portuguese language as Instituto Nacional de Aviação Civil (INAC) is the civil aviation regulatory authority of Sao Tome and Principe. It is one of the departments in the Ministry of Infrastructures, Natural Resources and Environment. INAC is concerned with the following main competencies:

- Cooperation with international organization on Civil Aviation.
- Agreements on air transport and other Civil Aviation matters.
- Permission for entry, exit and transit of aircraft.
- Certification and supervision of Airport and Aircraft management and Operation agencies.
- Certification and Supervision of flight operations.
- Airworthiness Certification of Aircraft maintenance.
- General planning, approval and licensing of air navigation facilities.
- ATS Supervision.

- Airspace regulation, navigation and air traffic services and procedures supervision.
- Approval and supervision of aeronautical training establishment
- Aeronautical Information Services Authority of appeal in matters of Civil Aviation
- Licensing of Aeronautical Personnel.

Sao Tome and Principe Civil Aviation Regulations has part 14 (Aerodrome Certification and Operation) and part 17 (Air Traffic Service Certification and Operation). The National Law, regulation and requirements has been in force since January, 2009.

1.17.2.1 Extracts from INAC Regulations

1.17.2.1.1 STPCAR PART 14 - Aerodrome Certification and Operation

14. D – AERODROME WILDLIFE PLANNING AND MANAGEMENT

14.10. D.05 APPLICABILITY

Subject to paragraph (b), this subsection applies to aerodromes

(1) that, within the preceding calendar year, had 2800 movements of operating aircraft;

(2) that are located in a built-up area and that in the opinion of the Authority should be certified in the public interest and to enhance the safe operation of the aerodrome;

(3) that have a waste disposal facility within 5 km of the geometric centre of the aerodrome;

(4) that had an incident where a turbine-powered aircraft collided with wildlife other than a bird and suffered damage, collided with more than one bird or ingested a bird through an engine; or

(5) where the presence of wildlife hazards, including those referred to in NI: 14.10.D.05, has been observed in an aerodrome flight pattern or movement area.

Subsection 14.10.D.15 applies to all aerodromes.

14.10. D.10 WILDLIFE STRIKES

The operator of an aerodrome shall keep records of all wildlife strikes at the aerodrome, including those reported by

(1) Pilots;

(2) Ground personnel; and

(3) Aircraft maintenance personnel when they identify damage to an aircraft as having been caused by wildlife strike.

Wildlife remains that are found within 60 meters of a runway or an airside pavement area are presumed to be a wildlife strike unless another cause of death is identified.

The operator of an aerodrome shall submit a written and dated report to the Authority

(1) for each wildlife strike, within 30 days of its occurrence; or

(2) for all wildlife strikes that occur in a calendar year, before March 1 of the following calendar year.

1.17.3 Airport Operator

Sao Tome and Principe National Airports and Air Safety Corporation otherwise known in Portuguese language as Empresa Nacionalde Aeroportose Segurança Aérea (ENASA) is the Operator of Sao Tome International Airport (FPST/TMS).

1.17.4 State Aviation Administration of Ukraine

State Aviation Administration of Ukraine is an agency of the Ukrainian government under the Ministry of Infrastructure responsible for civil aviation. It regulates all aspect of civil aviation in Ukraine. The head office is located in Kiev.

1.17.5 Kharkiv State Aircraft Production Enterprise

Kharkiv State Aircraft Production Enterprise was founded in 1926. Since that time, the company has been producing different types of aircraft, civil and military, including combat trainer MiG-15УТИ, Tu-104 (the first jet airliner of the USSR), and Tu-134, which formed the basis of fleet of Aeroflot and many other airlines.

The incident aircraft, AN-74TK-100 was manufactured by the company in 1992. It is one of the three subsidiaries of the state-owned Antonov Aviation Concern. The other two subsidiaries being: State Civil Aviation Enterprise Plant 410 and the Antonov Company itself - which builds Ukraine's "An-" aircraft and operates "Antonov Airlines."

1.18 Additional Information

1.18.1 Bird Strike

A bird strike is strictly defined as a collision between a bird and an aircraft which is in flight or on a take-off or landing roll. The term is often expanded to cover other wildlife strikes with bats or ground animals.

Bird Strike is common and can be a significant threat to aircraft safety. For smaller aircraft, significant damage may be caused to the aircraft structure and all aircraft, especially jet-engine ones, are vulnerable to the loss of thrust which can follow the ingestion of birds into engine air intakes. This has resulted in a number of fatal accidents.

Bird strikes may occur during any phase of flight but are most likely during the take-off, initial climb, approach and landing phases due to the greater numbers of birds in flight at lower levels. Since most birds fly mainly during the day, most bird strikes occur in daylight hours as well.

1.18.1.1 Effects

The nature of aircraft damage from bird strikes, which is significant enough to create a high risk to continued safe flight, differs according to the size of aircraft. Small, propeller-driven aircraft are most likely to experience the hazardous effects of strikes as structural damage, such as the penetration of flight deck windscreens or damage to control surfaces or the empennage. Larger jet-engine aircraft are most likely to experience the hazardous effects of strikes as the consequences of engine ingestion. Partial or complete loss of control may be the secondary result of either small aircraft structural impact or large aircraft jet engine ingestion. Loss of flight instrument function can be caused by impact effects on the Pitot-Static System air intakes which can cause dependent instrument readings to become erroneous.

Complete Engine failure or serious power loss, even on only one engine, may be critical during the take-off phase for aircraft which are not certificated to 'Performance A' standards. In the case of bird ingestion into more than one engine, all aircraft are vulnerable to loss of control. Such hazardous ingestion is infrequent but may result from the penetration of a large flock of medium sized birds or an encounter with a smaller number of very large ones.

In some cases, especially with smaller fixed wing aircraft and helicopters, windscreen penetration may result in injury to pilots or other persons on board and has sometimes led to loss of control.

Although relatively rare, a higher altitude bird strike to a pressurized aircraft can cause structural damage to the aircraft hull which, in turn, can lead to rapid depressurization. A more likely cause of difficulty is impact damage to extended landing gear assemblies in flight, which can lead to sufficient malfunction of brakes or nose gear steering systems to cause directional control problems during a subsequent landing roll. A relatively common but avoidable significant consequence of a bird strike on the take-off roll is a rejected take-off decision which is either made after V_1 or which is followed by a delayed or incomplete response and which leads to a runway excursion off the departure end of the runway.

1.18.1.2 Mitigation

The primary defence against hazardous bird strikes stems from the requirements for continued safe flight after strikes which are included in the airworthiness requirements of the **Aircraft Type** and **Aircraft Engine Type Certification** processes. However, these requirements are not a complete protection and are also mainly focused on large fixed wing transport aircraft. The relevant design requirements for smaller fixed wing aircraft and helicopters are very limited.

The opportunities to mitigate the risk of hazardous bird strikes in the first place are centred on airports, because this is where the greatest overall volume of conflict occurs, and because this is where management and control of the hazard is most easily achieved. However, there are two problems with this approach:

1. The airport-centred bird strike risk is rarely confined to the perimeter of any particular airport
2. Many of the most hazardous strike encounters such as those with large flocking birds take place so far from the airport that the airport operating authority will often have little real influence over the circumstances.

Therefore, establishing and monitoring levels of bird activity is important, and a critical part of this process includes the recording of bird strikes at the local level. This then provides the opportunity to build up a larger database and to share the information.

Guidance on effective measures for establishing whether or not birds, on or near an aerodrome, constitute a potential hazard to aircraft operations, and on methods for discouraging their presence, is given in the ICAO Airport Services Manual, Part 3. Further detail is provided in a number of State-published documents which are useful beyond their jurisdictions.

1.18.1.3 Factors Influencing Birds Activities at Airports Vicinity

- Habitat features, including open areas of grass and water as well as shrubs and trees, provide food and roosting sites for birds. Even transient water accumulation on uneven pavements can be a significant bird attractant.
- Landfill and other waste disposal sites often attract large numbers of birds if they are not carefully managed.
- Some types of agricultural activity, on or in the vicinity of an airport, may attract birds.
- Migrating birds often follow well-defined flight paths in considerable numbers. This can create a hazard if the flight paths are near an airport.
- Airports in coastal locations often have a much higher level of un-managed bird activity than do inland airports.
- Most airports contain considerable areas of grass within their perimeters. Since even dry grass can be attractive as a loitering area for birds by day or night, appropriate grass management policies, especially the grass height maintained, can be very important.

1.18.1.4 Solution

- Habitat management, including reduction or elimination of trees, shrubs and other plants which provide food, shelter or roosting sites for birds.
- Netting or draining of streams, routinely wet grassland and areas of standing water.
- Prevention of transient formation of such areas after heavy rainfall.
- Aerodrome grass management appropriate to the prevalent species and the degree of risk that they pose.
- Liaison with local authorities to ensure that landfill waste disposal sites are not operated so as to create an aircraft hazard.
- Liaison with local farmers to limit the attraction of birds to fields.
- Use of bird scaring techniques such as:
    - Broadcast of bird distress signals;

- Firing of pyrotechnic bird-scaring cartridges.
- Tactical detection of large flocking birds using specialized ground-based radar equipment.

1.18.2 Bird Strike Performance A

Modern aircraft are designed and built according to strict standards which are laid down by national and international authorities to comply with International Civil Aviation Organization (ICAO) Annex 8 (Airworthiness). In Europe, aircraft design must also comply with European Aviation Safety Agency (EASA) standards.

Aircraft manufacturers publish full details of aircraft performance in the Airplane Flight Manual (AFM), together with the approved aircraft operating techniques necessary to achieve AFM performance.

Aircraft must be able to operate safely throughout their flight regime in such a way that a safe outcome will result from specified malfunctions (e.g. power unit failure), occurring at any point throughout the flight range.

1.18.2.1 Take-off and Landing Performance

The maximum aircraft mass at take-off is the maximum mass calculated for the aircraft type, the runway elevation, length, slope and braking action, and the prevailing weather conditions such that the aircraft can:

- Maintain specified minimum rates of climb after take-off with full power and with one power unit inoperative;
- If a power unit failure is detected during the take-off run, either:
    - abandon the take-off and stop within the runway length; or,

- continue the take-off, clearing all obstacles during the climb-out path by a specified margin.

- Continue with the flight with one engine inoperative, either returning to the departure airfield, the destination, or a specified alternate airfield clearing all terrain en-route by specified margins.
- Land safely at the departure airfield, the destination or the specified alternate airfield.

The correct operating technique requires the aircraft to be flown at specified configurations[1], power settings and speeds corresponding to the actual aircraft mass throughout the take-off, initial climb, approach and landing.

1.18.2.2 En-route Performance

The manufacturer specifies the maximum operating altitude when full power is available and also when operating with one or more engines inoperative. Climb, cruise and descent data is also published for one or more operating techniques and for all permissible altitudes and temperatures. Data comprises power settings, indicated air speed or Mach No, true air speed and fuel consumption.

1.18.3 Bird Strike Certification Standards

Although the great majority of reported bird strikes have little or no effect on continued safe flight, a small number of encounters, usually with flocks of birds and especially flocks of large birds, can damage aircraft or their engines so badly that they cannot continue to fly.

Current aircraft certification standards therefore include requirements to demonstrate both airframe and engine resistance to bird impact. The standards which apply are those in place at the

[1]Configuration refers to the number of power units operating, whether flaps, landing gear or speed brakes are extended

time of introduction of a new aircraft type or engine. Experience of Accident and Incidents has led to progressively tougher requirements although, as with most certification standards, with arrangement under which later derivatives of an initial aircraft type design can be manufactured under variations to the original Type Certificate; thereby avoiding the more complex procedures involved in gaining approval under a completely new Type Certificate. This implies that new requirements are not retrospectively applied to aircraft and engines that have been in-service. The Standards established by both the FAA and EASA are essentially similar but are not yet fully harmonized. However, new aircraft and engine types have to meet both standards so that more demanding of each applies in each instance. Assurance that certification standards have been met is achieved by various means including ground testing using dead birds, of specified weights and quantities, at representative impact speeds.

1.18.3.1 Bird Impact Forces

For any given impact, the most important determinant of damage potential is the speed of impact. This is because the kinetic energy, which has to be absorbed by the airframe or within the engine, is the product of mass and the square of the speed. Clearly, the speed of the aircraft, rather than that of the bird, makes up nearly all of the closing speed of impact so that, except for very small aircraft, aircraft speeds are directly proportional to the damage potential for collision with a particular object. Civil aircraft speeds are generally at their lowest where most birds are found - near the ground - but increase progressively with altitude until the bird hazard disappears at somewhere above Flight Level (FL) 200. What has been convincingly demonstrated from incident data analysis is that, although the number of recorded bird impacts reduces rapidly with altitude, the greater the altitude, the greater the proportion of bird strikes which produce major damage.

Apart from speed, a number of factors have been identified as influencing the damage a bird impact can cause. These are all considered during the design of both aircraft and engines in an attempt to understand the robustness of structures and engines to bird impact from first principles as well as to prepare to meet certification standards. They include, with the most common simplifying assumptions shown in parenthesis:

- Bird weight
- Bird density
- Bird rigidity (deformation by 50% of its shape)
- Angle of impact (90 degrees)
- Impact surface shape (flat)
- Impact surface rigidity (no deformity)

It is also important to understand that the kinetic energy which is absorbed by an airframe during an impact is 'converted' into an effective force on that airframe based upon the distance over which the impact is 'delivered'. This notional distance is the product of the various simplifying assumptions listed above. The only additional assumption required to calculate impact force is that mass = weight.

Structural damage is, therefore, proportional to impact force rather than the quantity of kinetic energy absorbed. The forces are large, however the order of magnitude and their concentration over a very small area means that there is little prospect of 'hardening' any engine or airframe to completely resist such a force and certification standards tend to address the containment of the effects of bird impacts.

1.18.3.2 Engine Certification Standards

Current standards, for both multiple and single bird engine ingestions into a single fixed wing aircraft engine, exist in equivalent form in 14 CFR Part 33-77 and in EASA Airworthiness Code CS-E 800 ’Bird Strike and Ingestion’. The basic requirements for engine ingestion were revised in 2000 to take account of both evidence of an increase in the size of birds impacting aircraft and issues raised by the development of very large inlet, high bypass ratio, engines. The requirements, to be demonstrated by testing, are, in outline, now as follows:

- That at a typical initial climb speed and take-off thrust, ingestion of a single bird of maximum weight between 1.8kg and 3.65kg dependent upon engine inlet area shall not cause an engine to catch fire, suffer uncontained failure or become impossible to shut down and shall enable at least 50% thrust to be obtained for at least 14 minutes after ingestion. These requirements to be met with no thrust lever movement on an affected engine until at least 15 seconds of post impact have elapsed.

- That at a typical initial climb speed and take-off thrust, ingestion of a single bird of maximum weight 1.35kg shall not cause a sustained thrust or power loss of more than 25%, shall not require engine shut down within 5 minutes and shall not result in hazardous engine condition.

- That at a typical initial climb speed and take-off thrust, simultaneous ingestion of up to 7 medium sized birds of various sizes between weight 0.35kg and weight 1.15kg, with the number and size depending upon the engine inlet area, shall not cause the engine to suddenly and completely fail and it shall continue to deliver usable but slowly decreasing minimum thrust over a period of 20 minutes after ingestion. [Engines with inlet sizes of less than 0.2 m^2 (300 square inches) only have to meet the standard for a single bird of this weight]

- That at a typical initial climb speed and take-off thrust, simultaneous ingestion of up to 16 small sized birds of weight 0.85kg, with the number dependent upon the engine inlet area, shall not cause the engine to suddenly and completely fail and it shall continue to deliver usable but slowly decreasing minimum thrust over a period of 20 minutes after ingestion.

The following failure definitions apply to the Engine for bird strike certification:

(1) An Engine Failure in which the only consequence is partial or complete loss of thrustor power (and associated Engine services) from the Engine must be regarded as a Minor Engine Effect.

(2) The following effects must be regarded as Hazardous Engine Effects:

i. Non-containment of high-energy debris,
ii. Concentration of toxic products in the Engine bleed air for the cabin sufficient to incapacitate crew or passengers,
iii. Significant thrust in the opposite direction to that commanded by the pilot,
iv. Uncontrolled fire,
v. Failure of the Engine mount system leading to inadvertent Engine separation,
vi. Release of the propeller by the Engine, if applicable,
vii. Complete inability to shut the Engine down.

(3) An effect falling between those covered in (1) and (2) must be regarded as a Major Engine Effect.

1.18.3.3 Airframe Certification Standards

Current standards for the impact of a single bird with a large aircraft airframe exist in both 14 CFR Part 25-571 and in EASA CS-25.631 as design requirements for which means of compliance are provided. This means that an airplane must be capable of continued safe flight and landing after hitting a 1.8 kg bird at the more critical of:

- V_c (cruise speed) at mean sea level or
- 85% of V_c at 8000 feet altitude.

The FAA (only) has an additional requirement under 14 CFR Part 25-631 that an airplane must be capable of continued safe flight and a subsequent normal landing after the empennage structure has been impacted by an 3.6 kg bird at cruise speed (V_c) at mean sea level.

In addition, both EASA CS-25 and 14 CFR Part 25 require that:

- Windshield integrity after single bird impact requires that the inner ply must be non-splintering and the panes directly in front of the pilots must withstand, without penetration, a 1.8 kg bird at cruise speed at mean sea level
- Pitot-tubes must be far enough apart to preclude damage from a single bird impact

Under EASA CS-23.775 and 14 CFR Part 23.775, smaller aircraft are required only to have limited windshield integrity; a demonstrated single bird impact resistance of up to 0.91 kg at maximum approach flap speed and at least one pane with sufficient forward vision remaining to allow continued safe flight.

1.18.4 Airport Bird Hazard Management

Since aircraft bird strike hazard is greatest at low altitudes (because that is where bird activity is most heavily concentrated) and at or near airports (because that is where the greatest concentration of aircraft is found), much of the focus on bird hazard management is on airports.

Operators of aircraft have a reasonable expectation that any bird hazard which may exist at an airport that they utilize will be controlled to a level which eliminates exceptional risk. Many States have detailed guidelines and compliance procedures to ensure that their airports achieve this but, despite the existence of related ICAO SARPs, there is no uniformity of achieved standards.

1.18.4.1 Principles of Effective Risk Management

The extent of a bird hazard at any particular airport location is widely variable. While there are many potential solutions and strategies available, not all are necessarily relevant to the particular circumstances of a specific airport. The most important action, upon which any risk management strategy must be founded, is knowing the nature of the (unmanaged) hazard. This may vary by time of day and seasonally and must be related to the likely pattern of aircraft movements. Once a risk management plan is in place, it must be recognized that it is still necessary to monitor proactively for any detectable change in the assumptions upon which the plan was based. This is necessary in order to try and avoid complete reliance upon the reaction to an increase in the level of a recorded hazard as the trigger for any modification to the plan.

As with all risk management, an SMS approach to risk management is essential. The activity must be founded on accountability, co-operation between stakeholders, proper documentation and an effective review procedure. All this needs to be facilitated by human and financial resources compatible with the task.

1.18.4.2 Components of Risk Management

One aspect of risk management similar for all airports, is maintaining a reliable record of the hazard remaining despite the implementation of the risk management plan. In respect of actual bird strikes to aircraft, this is a requirement included in ICAO SARPs. Liaison with Operators is likely to be necessary to ensure full data capture and to exclude double counting. It is also important to keep records of changes to the risk mitigation actions in place under the risk management plan, so that the effects on the level of residual hazard recorded can be monitored.

It is likely that airports will need the services of specialist advisers to assist in the initial preparation and ongoing review of the risk management plan.

Many of the 'tools' at the disposal of airport operators will find at least some place in any risk management plan but not necessarily to the same degree. These are essentially considered in three categories:

I. **Airport Habitat Management** - grass and surface water (including transient accumulations) management, exclusion of roosting opportunities in buildings and trees within the airport perimeter

II. **Airport Locality Habitat Review** (i.e. that area beyond the airport perimeter where bird attractants or related bird activity have the potential to directly affect the operational safety of aircraft using the airport).

III. **Active on-airport control systems** - bird activity monitoring, bird deterrence methods, ATC alerting channels. The selection of a balance of appropriate risk management methods will depend not only on the apparent effectiveness of deterrence of birds, but often on an understanding of any particular reasons why given species are present.

1.18.4.3 Operators Checklist for Bird Strike Hazard Management

1. Aircraft operators should be given specific, timely and reliable information which will allow them to adapt their flight schedules in order to ensure the safety of their aircraft, just as they would do to mitigate other hazards such as wind shear, icing, and volcanic ash.

2. Operators are to always have access to up to date bird strike rates for each airport. Operators may use their own data if movements are sufficient, or may use that for all airport movements if movements are not sufficient. Where high relative rates are identified, operators should ensure that further investigation of the circumstances is carried out with the assistance of the airport operator.

3. Operators should ensure that flight crew are properly informed about known bird hazards which may affect them before commencing their flights, whether such information is published in AIPs, NOTAMs or BIRDTAMs (where available), or has been directly determined by the Operator. (Unless a specific effort is made to facilitate this, the pressures of time during pre-flight briefings has often resulted in such awareness not being gained).

4. Operators should ensure that flight crew are provided with appropriate guidance on response to the hazard. Particular attention should be given to engine ingestion for both the short final case (do not attempt a go around) and the take-off roll case (do not attempt

a rejected take off at high speed unless it is positively assessed that it is unlikely that it will be possible to get safely airborne.) Tactical mitigation of unexpected bird hazard is an important element of risk management , many accidents and serious incidents have resulted from inappropriate flight crew responses to bird encounters.

5. Ensure that flight crew make reports on all actual or suspected bird strikes and any instances of observed bird activity which they consider could have been hazardous. It is important that flight crew have sufficient familiarity with bird species to recognize and record at least species groups and that, when reporting actual or suspected engine ingestion of birds, they record any observed engine thrust or torque fluctuations which might have been associated with an ingestion event.

6. Have unequivocal guidelines in place for appropriate levels of maintenance inspection after any flight during which actual or suspected bird strike has occurred, especially if engine ingestion is or may be involved. These should be founded upon an operating culture which achieves a flight crew entry in the aircraft Technical Log after any such occurrence and clear procedures on the necessary authority to clear or defer such an entry.

7. Even if there are no applicable ATC speed restrictions, apply a Company Maximum Speed below FL100 / 10000 feet for both climb and descent. This will ensure that damage from any impact with the larger birds that increasingly predominate at higher altitudes is minimized

8. If a particular airport, used by pure jet engine aircraft, is identified as having an above average risk of bird strike during initial climb then consideration should be given to introducing an SOP for that airport to fly the ICAO Noise Abatement Departure Procedure1 (NADP 1). This will minimize the probability of strikes at low level where bird density is highest because of the high climb rate and will also minimize the extent of any damage if birds are ingested due to the minimum climb speed.

1.18.5 Engine Compressor Surge

1.18.5.1 Compressor Stall

A compressor stall is a local disruption of the airflow in a gas turbine or turbocharger compressor. It is related to **compressor surge** which is a complete disruption of the flow through the compressor. Stalls range in severity from a momentary power drop (occurring so quickly it is barely registered on engine instruments) to a complete loss of compression (surge) necessitating a reduction in the fuel flow to the engine.

Stall was a common problem on early jet engines with simple aerodynamics and manual or mechanical fuel control units, but has been virtually eliminated by better design and the use of hydro mechanical and electronic control systems such as Full Authority Digital Engine Controls. Modern compressors are carefully designed and controlled to avoid or limit stall within an engine's operating range.

Figure 12: Picture showing Airflow separating from an aerofoil at a high angle of attack, as occurs during stall.

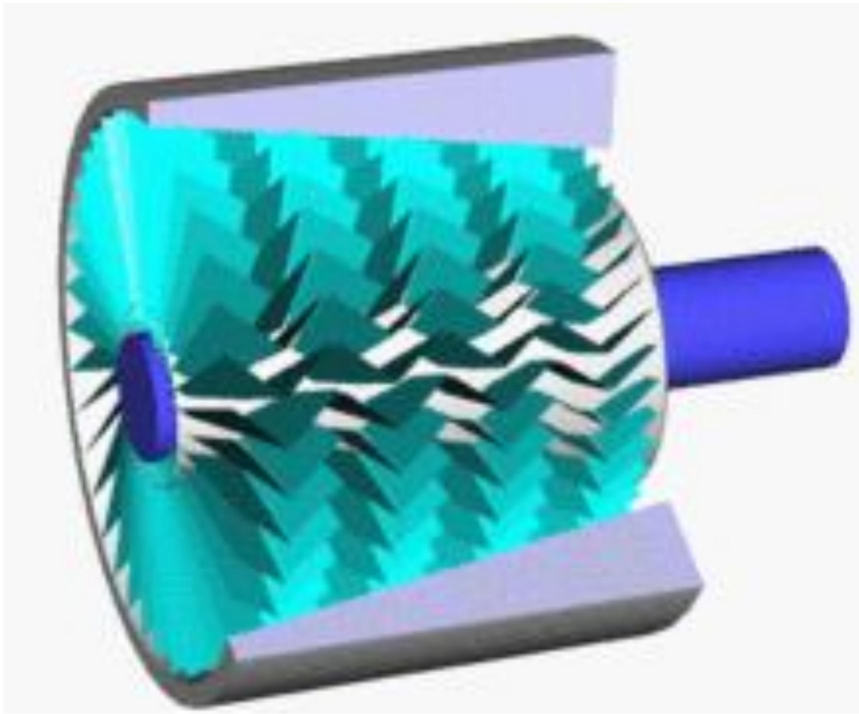

Figure 13: A picture of an axial compressor showing both the stator and rotor blades

1.18.5.2 Types of Compressor Surge

There are two types of compressor stall:

1. **Rotating stall**

Rotating stall is a local disruption of airflow within the compressor which continues to provide compressed air but with reduced effectiveness. Rotating stall arises when a small proportion of the airfoil experiences airfoil stall disrupting the local airflow without destabilizing the compressor. The stalled airfoils create pockets of relatively stagnant air (referred to as *stall cells*) which, rather than moving in the flow direction, rotate around the circumference of the compressor. The stall cells rotate with the rotor blades but at 50% to 70% of their speed, affecting subsequent airfoils around the rotor as each encounters the stall cell. Propagation of the instability around the flow path annulus is driven by stall cell blockage causing an incidence spike on the adjacent blade. The adjacent blade stalls as a result of the incidence spike, thus causing stall cell "rotation" around the rotor. Stable local stalls can also occur which are axi-symmetric, covering the complete circumference of the compressor disc but only a portion of its radial plane, with the remainder of the face of the compressor continuing to pass normal flow.

A rotational stall may be momentary, resulting from an external disturbance, or may be steady as the compressor finds a working equilibrium between stalled and unstalled areas. Local stalls substantially reduce the efficiency of the compressor and increase the structural loads on the aerofoils encountering stall cells in the region affected. In many cases however, the compressor aerofoils are critically loaded without capacity to absorb the disturbance to normal airflow such that the original stall cells affect neighbouring regions and the stalled region rapidly grows to become a complete compressor stall. And the second part is individual stall

2. **Axi-symmetric stall or compressor surge**

Axi-symmetric stall, more commonly known as **compressor surge**; or **pressure surge**, is a complete breakdown in compression resulting in a reversal of flow and the violent expulsion of previously compressed air out through the engine intake, due to the compressor's inability to continue working against the already-compressed air behind it. The compressor either experiences conditions which exceed the limit of its pressure rise capabilities or is highly loaded such that it does not have the capacity to absorb a momentary disturbance, creating a rotational stall which can propagate in less than a second to include the entire compressor.

The compressor will recover to normal flow once the engine pressure ratio reduces to a level at which the compressor is capable of sustaining stable airflow. If, however, the conditions that induced the stall remain, the return of stable airflow will reproduce the conditions at the time of surge and the process will repeat. Such a "locked-in" or self-reproducing stall is particularly dangerous, with very high levels of vibration causing accelerated engine wear and possible damage, even the total destruction of the engine.

1.18.5.3 Causes

A compressor will only pump air in a stable manner up to a certain pressure ratio. Beyond this value the flow will break down and become unstable. This occurs at what is known as the surge line on a compressor map. The complete engine is designed to keep the compressor operating a small distance below the surge pressure ratio on what is known as the operating line on a compressor map. The distance between the two lines is known as the surge margin on a compressor map. Various things can occur during the operation of the engine to lower the surge pressure ratio or raise the operating pressure ratio. When the two coincide there is no longer any surge margin and a compressor stage can stall or the complete compressor can surge as explained in preceding sections.

1.18.5.4 Factors which erode compressor surge margin

The following, if severe enough, can cause stalling or surging.

- Ingestion of foreign objects which results in damage, as well as sand and dirt erosion, can lower the surge line.
- Dirt build-up in the compressor and wear that increases compressor tip clearances or seal leakages all tend to raise the operating line.
- Complete loss of surge margin with violent surging can occur with a bird strike. Taxiing on the ground, taking off, low level flying (military) and approaching to land all take place where bird strikes are a hazard. When a bird is ingested by a compressor the resultant blockage and aerofoil damage causes compressor surging. Examples of debris on a runway or aircraft carrier flight deck that can cause damage are pieces of tire rubber, litter and nuts and bolts. A specific example is a metal piece which dropped from another plane. Runways and aircraft carrier flight decks are cleaned frequently in an attempt to preclude ingestion of foreign objects.

- Aircraft operation outside its design envelope; e.g., extreme flight manoeuvres resulting in airflow separations within the engine intake, flight in icing conditions where ice can build up in the intake or compressor, flight at excessive altitudes.

- Engine operation outside its flight manual procedures; e.g., on early jet engines abrupt throttle movements (slam acceleration) when pilot's notes specified slow throttle movements. The excessive over fueling raised the operating line until it met the surge line. (Fuel control capability extended to automatically limit the over fuelling to prevent surging).

- Turbulent or hot airflow into the engine intake, e.g. use of reverse thrust at low forward speed, resulting in re-ingestion of hot turbulent air or, for military aircraft, ingestion of hot exhaust gases from missile firing.

- Hot gases from gun firing which may produce inlet distortion.

1.18.5.5 Effects

Compressor axially-symmetric stalls, or compressor surges, are immediately identifiable because they produce one or more extremely loud bangs from the engine. Reports of jets of flame emanating from the engine are common during this type of compressor stall. These stalls may be accompanied by an increased exhaust gas temperature, an increase in rotor speed due to the large reduction in work done by the stalled compressor and – in the case of multi-engine aircraft yawing in the direction of the affected engine due to the loss of thrust. Severe stresses occur within the engine and aircraft, particularly from the intense aerodynamic buffeting within the compressor.

1.18.5.6 Response and Recovery

The appropriate response to compressor stalls varies according to the engine type and situation, but usually consists of immediately and steadily decreasing thrust on the affected engine. While modern engines with advanced control units can avoid many causes of stall, jet aircraft pilots must continue to take this into account when dropping airspeed or increasing throttle.

1.18.6 Engine Failure during Take-Off

In the early days of jet engine powered transport aircraft, engine failures, in all phases of flight, were a fairly frequent occurrence. Statistics from the 1960's indicate that failures resulting in in-flight shutdowns occurred at an approximate rate of 40 per 100,000 flight hours (or 1 per 2,500 flight hours). This rate is the equivalent of every engine failing once every year. By contrast, the failure rate of the engines installed on current generation aircraft have a failure rate of less than 1 per 100,000 flight hours.

Infrequent as this might seem, engines do fail and a failure during take-off has very serious safety of flight implications. The aerodynamic effects of the failure and the immediate actions by the flight crew, which are necessary to ensure an acceptable outcome, are similar to those in a light, twin engine aircraft. However, unlike their smaller cousins, the certification criteria for multi-engine transport category jet aircraft require that the aircraft be capable of achieving a specified minimum climb rate, which will ensure obstacle clearance, should an engine failure occur on take-off.

Regulatory Requirements

The National Aviation Authority (NAA) for each sovereign state is responsible for issuing an aircraft type certificate, in accordance with the guidance provided in the ICAO Standards and Recommended Practices (SARPS), for aircraft that are registered within its jurisdiction. While the SARPS provide the agreed minimum requirements for type certification, each NAA has the right to insist that additional criteria be satisfied before an aircraft type certificate will be issued.

Within the European Union, type certificates are issued by the European Aviation Safety Agency (EASA).

Aircraft Type Certification

There are many safety and performance requirements that must be met before an aircraft will be issued a type certificate. For multi-engine, transport category jet aircraft, minimum runway requirements that allow the safe rejection or continuation of a take-off in the event of a failure and the ability to comply with minimum specified engine out climb gradients and obstacle clearance criteria are both critically important.

Minimum Runway Requirements

Regulatory criteria for minimum runway requirements encompass multiple calculations inclusive of Take-off Distance (TOD), Take-off Run (TOR) and Accelerate Stop Distance (ASD). The most limiting of these criteria, based on aircraft weight and prevailing atmospheric conditions, defines the minimum runway required for take-off. Note that, depending upon the regulations under which the aircraft certification is granted, these distances may have to take into consideration the runway distance lost during line-up.

Figure 14: An Illustration of defined runway distances

Take-off Distance (TOD)

The Take-off Distance on a **dry runway** is the greater of the following values:

- Distance covered from the brake release to a point at which the aircraft is 35 feet above the take-off surface, assuming the failure of the critical engine at V_{EF} (Engine Failure Speed) and recognized at V_1
- 115% of the distance covered from brake release to a point at which the aircraft is 35 feet above the take-off surface, assuming all engines operating

The Take-off Distance on a **wet runway** is the greater of:

- Take-off Distance on a dry runway (see above)
- Distance covered from brake release to a point at which the aircraft is 15 feet above the take-off surface, ensuring that the V_2 speed can be achieved before the airplane is 35 feet above the take-off surface, assuming failure of the critical engine at V_{EF} and recognized at V_1

Take-off Distance must not exceed the Take-off Distance Available (TODA), with a clearway distance not to exceed half of the TODA

Take-off Run (TOR)

Take-off Run (TOR) calculations incorporate the operational advantage of a designated clearway when one is present on the departure runway. If no clearway exists, TOR = TOD.

When a clearway exists, the Take-off Run on a **dry runway** is the greater of the following values:

- Distance covered from brake release to a point equidistant between the point at which V_{LOF} (Lift-off Speed) is reached and the point at which the aircraft is 35 feet above the take-off surface, assuming failure of the critical engine at V_{EF} and recognized at V_1

- 115% of the distance covered from brake release to a point equidistant between the point at which V_{LOF} is reached and the point at which the aircraft is 35 feet above the take-off surface, assuming all engines operating

When a clearway exists, the Take-off Run on a **wet runway** is the greater of:

- Take-off Distance (TOD) wet runway

- 115 % of the distance covered from brake release to a point equidistant between the points at which V_{LOF} is reached and the point at which the aircraft is 35 feet above the take-off surface, assuming all engines operating.

Take-off Run must not exceed Take-off Run Available (TORA)

Accelerate Stop Distance (ASD)

Accelerate Stop Distance calculations assume the following:

- Delay between V_{EF} and V_1 = 1 second
- ASD is determined with the wheel brakes at the fully worn limit of their allowable wear range
- reverse thrust is not considered for a dry runway distance determination, it can be used for wet runway calculations

The Accelerate Stop Distance on a **dry runway** is the greater of the following values:

- Sum of the distances necessary to:

1. Accelerate the airplane with all engines operating to V_{EF}
2. Accelerate from V_{EF} to V_1 (assumes that engine fails at V_{EF} and first action to reject is taken at V_1)
3. Come to a full stop

4. Plus an additional distance equivalent to 2 seconds at constant V_1 speed

- Sum of the distances necessary to:

1. Accelerate the airplane with all engines operating to V_1 (assumes that first stopping actions are taken at V_1)
2. With all engines still operating come to a full stop
3. Plus an additional distance equivalent to 2 seconds at constant V_1 speed

The Accelerate Stop Distance on a **wet runway** is the greatest of:

- ASD on a dry runway (see above)
- Sum of the distances on a **wet runway** necessary to:

1. Accelerate the airplane with all engines operating to V_{EF}
2. Accelerate from V_{EF} to V_1 (assumes that engine fails at V_{EF} and first action to reject is taken at V_1)
3. Come to a full stop
4. Plus an additional distance equivalent to 2 seconds at constant V_1 speed

- Sum of the distances on a **wet runway** necessary to:

1. Accelerate the airplane with all engines operating to V_1 (assumes that first stopping actions are taken at V_1)
2. With all engines still operating come to a full stop
3. Plus an additional distance equivalent to 2 seconds at constant V_1 speed

Note: Depending upon the criteria under which the aircraft was certified, the additional 2 seconds distance equivalent might not be required.

Accelerate Stop Distance must not exceed the Accelerate Stop Distance Available (ASDA)

Loss of Runway Length during line up

Declared distances such as TORA and ASDA are based on measurements from the runway threshold. However, unless the aircraft enters the runway from a point prior to the threshold, it is not possible to use the full length of the runway. Aircraft typically enter the take-off runway from an intersecting taxiway. The aeroplane must then be turned to align it on the runway in the direction of take-off. In some cases, it may be necessary to backtrack on the runway and turn through 180° before the take-off run can be initiated. FAA regulations do not explicitly require airplane operators to take into account the runway distance used to align the aero plane on the runway for take-off. However, EASA regulations require that the applicable distance be taken into consideration. When required, the TODA and TORA must be reduced by the distance from the runway threshold to the main landing gear and ASDA reduced by the distance from the threshold to the nose gear. Manufacturers will provide minimum line up distances required for both 90° and 180° turns.

Some Operators provide data which takes loss of runway length during line up into account. All crews must be familiar with the assumptions made in the production of their own company's data.

Effects of Engine Failure

On the Runway

If a multi-engine aircraft suffers an engine failure during the take-off roll, the aircraft will yaw towards the failed engine. If the airspeed at the time of the failure is at or above $V_{\text{minimum control ground}}$ (V_{mcg}), directional control on the runway can be maintained utilizing only aerodynamic controls. At a speed below V_{mcg}, directional control will not be possible unless thrust on the operating engine(s) is (are) also reduced. In any event, if the airspeed at the time that the failure is recognized is less than V_1, the take-off must be rejected.

Flight Crew Actions

During pre-flight preparation:

- Using the Electronic Flight Bag or the appropriate performance charts, determine the maximum take-off weight (MTOW) for the runway in use, anticipated atmospheric conditions and intended aircraft configuration
- Confirm that actual aircraft weight does not exceed the calculated maximum allowable weight
- Complete performance calculations to determine speeds and thrust settings (inclusive of reduced thrust criteria where appropriate or applicable)
- Review and brief the Emergency Turn procedure inclusive of routing, turns and turn altitudes, acceleration altitude and safe altitudes

During the take-off roll:

- Use appropriate line up technique to ensure charted runway length is available
- Apply thrust using manufacturer's recommended procedures
- Confirm actual thrust meets or exceeds calculated thrust
- In the event of an engine failure prior to V_1, reject the take-off
    - ADVISE Air Traffic Control (ATC) that the take-off has been rejected using appropriate emergency communication protocols

In the event of an engine failure after V_1:

- Establish and maintain directional control with appropriate rudder input
- Rotate at V_r and establish a climb speed of V_2

- If the failure occurs after the aircraft is airborne, a climb speed of between V_2 and V_2 + 10 is acceptable

- Utilise appropriate aileron input to maintain wings level. At, or near, $V_{minimum\ control\ air}$ (V_{mca}), as much as a 5° bank away from the dead engine may be required

- When safely airborne and established in a positive climb, retract the landing gear
    - ***Establish or maintain the Emergency Turn routing***

- Initiate ECAM / EICAS / Emergency Checklist procedures as per manufacturer and Company policy
    - ***Establish or maintain the Emergency Turn routing***

- Maintain V_2 and take-off thrust until reaching acceleration altitude. Acceleration altitude will be the highest of 400' AGL, Emergency Turn procedure published acceleration altitude or Company standard acceleration altitude
    - ***Establish or maintain the Emergency Turn routing***

- At acceleration altitude, maintain take-off thrust, level the aircraft (see note below) and accelerate to V_{FS} retracting flaps on schedule.
    - ***Establish or maintain the Emergency Turn routing***

- Once in clean configuration, maintain V_{FS}, resume climb and reduce thrust to maximum continuous
    - ***Establish or maintain the Emergency Turn routing***

- ADVISE ATC using appropriate emergency communication protocols
    - note that if the Emergency Turn profile has or will result in a departure from the cleared routing, ATC should be notified as soon as it is practical to do so

- Reaching a safe altitude, comply with any enroute climb requirements, complete any appropriate emergency or QRH checklists, determine plan of action (diversion or recovery) and advise ATC

Note: The acceleration profiles utilized by VNAV and FLCH modes do not necessarily command the aircraft to fly level at Acceleration altitude in the event of an engine failure. With all engines operating, VNAV & FLCH will use the algorithm 60% climb, 40% acceleration. In the event of an engine failure, the algorithm is reversed with 40% climb, 60% acceleration. As a consequence, at light weights the APFDS may command a climb during the acceleration phase.

Defences

Crew members must make themselves familiar with the explanatory notes to their performance data. Better utilization of date could only be achieved by gaining an understanding of the assumptions made in the calculations.

If aircraft engines were 100% reliable, engine failure during take-off would never occur. Over the years, manufacturers have made great improvements in the reliability of their products and the failure rate of turbine engines has decreased with each generation. It is unlikely, however, that the potential for engine failure will ever be completely eliminated.

Maintenance personnel can reduce the risk of failure by ensuring that the engines are maintained to the manufacturer's recommendations. Ground crew and flight crew must ensure during their pre-flight and post flight inspections that all fluids are adequate, that there are no obvious leaks or damage and that the fuel supply is free from water or other contamination.

Flight crew/dispatch performance calculations must ensure that the aircraft can meet regulatory requirements in the event of an engine failure during the take-off.

Flight crew should have a thorough understanding of the aerodynamics of a failure and clearly understand the actions that must be taken should a failure occur.

Finally, crews must be completely familiar with their Company procedures which will always take priority.

1.18.7 Rejected Take-off (RTO)

Boeing studies indicate that approximately 75 percent of RTOs are initiated at speeds less than 148 km/h and rarely result in an accident. About 2 percent occur at speeds in excess of 222 km/h. The overruns and incidents that occur invariably stem from these high-speed events.

A take-off may be rejected for a variety of reasons, including engine failure, activation of the take-off warning horn, direction from air traffic control (ATC), blown tires, or system warnings. In contrast, the large number of take-offs that continue successfully with indications of airplane system problems, such as master caution lights or blown tires, are rarely reported outside the airline's own information system. These take-offs may result in diversions or delays, but the landings are usually uneventful. In fact, in about 55 percent of RTOs the result might have been an uneventful landing if the take-off had been continued, as stated in the Take-off Safety Training Aid published in 1992 with the endorsement of the U.S. Federal Aviation Administration (FAA).

Some of the lessons learned from studying RTO accidents and incidents include the following:

- More than half the RTO accidents and incidents reported in the past 30 years were initiated from a speed in excess of V_1.
- About one-third were reported as occurring on runways that were wet or contaminated with snow or ice.
- Only slightly more than one-fourth of the accidents and incidents actually involved any loss of engine thrust.
- Nearly one-fourth of the accidents and incidents were the result of wheel or tire failures.
- Approximately 80 percent of the overrun events were potentially avoidable by following appropriate operational practices.

In 1989 the U.S. Federal Aviation Administration (FAA) urged the aviation industry to take steps to reduce the number of overrun accidents and incidents resulting from high-speed rejected take-offs (RTO). This led to the formation of an international take-off safety task force, with members from airlines, regulatory agencies, pilot unions, and manufacturers. The task force produced nine recommendations, including the following three directly related to training:

- Develop model training practices.
- Develop model operational guidelines.
- Improve simulator fidelity.

These will improve the pilots' decision making and procedural accomplishment in case of failures during take-off.

Statistically the majority of all RTO overrun accidents occurred when the RTO was initiated at speeds above 222km/h. More than half of these accidents occurred because the RTO was initiated above V_1. One-third occurred on wet or contaminated runways. Only about 1/4 of the RTO's were initiated because of engine failures.

Analysis of statistical data revealed that 80% of the RTO accidents were avoidable. Out of these 80% more than half could have been avoided by continuing the take-off and one-seventh by correct stop techniques.

1.18.7.1 The Go/Stop Decision

In the event of an engine malfunction, the recognition of a significant abnormality, or an ATC instruction to stop the aircraft during the take-off roll, transport aircraft in Performance Category 'A' should be able to safely reject the take off if the decision to do so is made at a speed not greater than the correctly calculated decision speed (V_1).

A successful rejection should be achieved if the response is immediate and completed in accordance with prescribed procedures (SOPs). After V_1, a reject should ***only*** be considered if there is a strong reason to believe that the aircraft *will not fly*.

Depending on Operator SOPs, a call of "STOP" to reject a take-off based on stated criteria will usually be able to be made by either pilot. However, in some cases, the action following such a call will be only for the pilot in command to take, regardless of which pilot is PF.

Continuing the Take Off after V_1

Once a correctly calculated V_1 has been exceeded, the take-off must be continued and should allow the aircraft to get safely airborne and climb away. This explicitly covers the case of a single engine malfunction or failure up to V_1 provided that the prescribed crew actions in respect of that failure are correct. However, there are certain situations, where it may be found at V_r that it is simply not possible to get airborne and there is no effective solution available. In this case there is no option but to reject the take-off despite the likelihood that a runway overrun of some sort will result.

1.18.7.2 The Significance of Speed in respect of the decision to reject a take off

Most aircraft manufacturers specify an airspeed, (usually 148km/h or 185km/h) which defines the transition between the low speed and the high speed part of a take-off roll and represents a change in the expected use of a "stop" call. This speed is usually in the vicinity of the speed where directional control using the rudder becomes effective. The prescribed speed has to be called out by PM from their own airspeed indication and the call must receive a prompt response from the PF. The fact that this call also functions as a validation that both pilots have similar airspeed indications and as a pilot incapacitation check means that the determination of the speed takes all three purposes into consideration.

1.18.7.3 High Speed RTO

Whilst a successful rejection of take-off from V_1 is achievable in all but exceptional and very specific cases, it is universally recognized that the closer the speed gets to it, the greater the risk involved in a decision to stop. Therefore, once at high speed, it is usually specified that the take-off will only be rejected for major malfunctions such as an engine failure or fire or at the discretion of the pilot in command in the event that a similarly serious situation is perceived.

1.18.7.4 Low Speed RTO

Prior to the prescribed speed check call (usually 148 km/h), it is envisaged that the take-off will normally be rejected for any significant malfunction or abnormal situation. Within this lower speed range, it is likely that directional control will be largely dependent on use of the nose gear steering system. However, speeds in this range will usually be well below the applicable V_{mcg} (the speed at which sufficient rudder authority to maintain directional control) is available and so it is important for a pilot carrying out any low speed rejected take off to be ready to make any necessary control inputs to the nose gear steering system via the tiller provided**.**

1.18.7.5 Rejected Take-offs and Runway Excursions

The main reasons why runway excursions occur during rejected take offs could be one or more of the following:

- The decision to reject the take-off is made after V_1 and there is insufficient runway length left to come to a stop on it.
- The flight crew actions required to achieve a rejected take off are not carried out in a sufficiently prompt and/or comprehensive manner.
- Stopping devices are not used to their full capacity.
- Directional control is not maintained during the take-off roll.
- It is found at V_r that it is impossible to achieve rotation.

Runway Excursions arising from Rejected take offs can therefore usually be avoided if operating procedures for the loading and take off of aircraft are robust and rigorously applied. The V_1 call must be made in such a manner that the verbalization is complete as the speed is achieved.

Stopping action must be initiated promptly (within 2 seconds) of the reject decision. Stopping devices must be used to their full capability until such time that it is certain that the aircraft will stop before the end of the runway. Unless there is a clear indication that the aircraft will not fly, a reject must not be initiated after V_1.

However, for large aircraft, there is usually a significant gap between V_1 and V_r so that if, at V_r, it is found impossible to physically achieve rotation, there may be no alternative but to reject the take-off. It is this scenario, on limiting runway lengths, which accounts for many of the most serious runway excursions arising from rejected take offs.

1.18.7.6 Application of SOPs

All the relevant Flight Crew SOPs must be clearly specified and applied, particularly:

- Cross checking take off performance calculations and the corresponding setting of ASI speed bugs.
- Both flight crew must be fully satisfied that the prevailing runway surface conditions correspond to the assumptions which have been made in their take off performance calculations.
- There must be unambiguous requirements governing crew calls of abnormal conditions during the take-off roll and the degree to which the aircraft commander then has the discretion to reject or continue the take-off.
- There must be accurate calls of standard speeds during the take off by PM and a check that both principal ASIs are indicating the same figure at the designated check speed (usually 148 km/h or 185 km/h).

1.18.7.7 Simulator Training

Once robust flight crew SOPs are in place, the most effective way for an operator to ensure that flight crew are likely to respond to a rejected take off decision and its execution in the expected way is practice. This means ensuring that the plan for both initial and recurrent aircraft type simulator training and assessment includes unexpected scenarios in which a rejected take off may be the only expected response or a judgement call. Both stop/go take-off decisions and the response to stop decisions should be covered. These unexpected events should include evidence of malfunctions other than total engine failure. The ability to make prompt and rational decisions on stop-go should be trained and validated evidence of indecision should be an indication that more training is required.

1.18.7.8 Runway Excursion

A runway excursion occurs when an aircraft departs the runway in use during the take-off or landing run. The excursion may be intentional or unintentional.

- ***Types of Runway Excursion***
  - A departing aircraft fails to become airborne or successfully reject the take off before reaching the end of the designated runway.
  - A landing aircraft is unable to stop before the end of the designated runway is reached.
  - An aircraft taking off, rejecting take-off or landing departs the side of the designated runway.
- ***Effects***
  - Death or injury to persons on board the aircraft
  - Damage to the aircraft
  - Death or injury to persons not on the aircraft
  - Damage to airfield or off-airfield installations
  - Damage to other aircraft or to vehicles
  - Delay to other aircraft departing or landing due to runway obstruction due to the excursion.

- ***Defences***
  - Never deciding to reject a take-off after V_1 unless it is certain that the safety of the aircraft would be endangered if it became airborne.
  - Correct calculation of maximum operating weight, field length required and relevant critical speeds etc. based on accurately reported ambient conditions and subsequent correct input into aircraft flight systems should preclude a runway excursion under all normal and most abnormal conditions (e.g. power unit failure).

1.18.7.9 Runway End Safety Area (RESA)

Runway End Safety Areas (RESA) are a formal means to limit the consequences when aircraft overrun the end of a runway during a landing or a rejected take-off, or undershoot the intended landing runway.

They are constructed to provide a cleared and graded area which is, as far as practicable, clear of all but frangible objects. It should have a surface which will enhance the deceleration of aircraft in the overrun case but should not be such as to hinder the movement of rescue and fire fighting vehicles or any other aspect of emergency response activity.

Minor aircraft runway overruns and undershoots are a relatively frequent occurrence. Most data sources point to significant occurrences on average once a week worldwide and suggest that runway excursions overall are the fourth largest cause of airline fatalities. It has been stated by the FAA Airport Design Division that approximately 90% of runway undershoot or overruns are contained within 300 meters of the runway end. The contribution which RESAs can make to a reduction in the consequences of such over-runs has frequently been demonstrated as has the avoidable hazardous outcomes where they have not been present.

1.18.7.10 ICAO Annex 14 SARPs

ICAO SARPs relating to runways are determined according to runway length using the standard Runway Code categories. Code 1 runways are less than 800 meters long, Code 2 runways are 800-1199 metres long, Code 3 runways are 1200-1799 metres long and Code 4 runways are 1800 metres or more in length.

In all cases, the dimensions of a 'Runway Strip' are first defined as it must contain the dimensions of the designated runway surface and it should be flat, firm and free of non-frangible obstructions. For Code 3 and 4 runways, runway strips must extend at least 150 meters either side of the runway centreline and at least 60 meters beyond the end of the runway including any stop way. For Code 1 and 2 runways, the width requirement is reduced to 75 metres and for non-instrument Code 1 Runways, the length requirement is reduced to 30 metres.

ICAO RESA specifications all begin at the limit of the 'Runway Strip' not at the limit of the Runway/Stop way surface.

RESA SARPs were revised in 1999 when the then Recommended Practice of a 90 meter RESA was converted into a Standard. The current Requirement is that Code 3 and 4 runways have a RESA which extends a minimum of 90 meters beyond the runway strip and be a minimum of twice the width of the defined runway width. The additional Recommended Practice for these runway codes is that the RESA length is 240 metres or as near to this length as is practicable at a width equal to that of the graded strip. For Code 1 and 2 Runways, the Recommended Practice is for a RESA length of 120 meters with a width equal to the graded strip.

1.18.7.11 RESA Implementation

Implementation of these SARPs by State Regulators is ongoing. Many have now prescribed a period within which the ICAO Standard must be adopted and the Recommended Practices carefully considered.

In the case of the USA, the FAA Airport Design requirements specify the minimum dimensions of a 'Runway Safety Area' which includes the Runway Strip defined by ICAO. Since 2002, these requirements have included a Runway Safety Area at each end of a runway which takes account of the direction of runway use when specifying the minimum length of the runway end element. The basic standard is defined for instrument runways used by transport aircraft and any such runway with an 'approach visibility minima' of less than 1200 metres and is 300 metres for the overrun case and 180 metres for the undershoot case. It is permissible to reduce the overrun case to 180 metres if the runway has either instrument or visual vertical guidance aids and an Engineered Materials Arresting Systems (EMAS) which can stop an aircraft which leaves the end of the runway at up to 130km/h groundspeed is provided.

It can be seen that the FAA overrun requirement (300 metres) is equivalent to the ICAO RESA Recommended Practice plus the required Runway Strip (also totalling 300 metres) but that the FAA undershoot requirement (180 metres) is only slightly more than the ICAO RESA Standard plus the required runway strip (totalling 150 metres).

1.18.7.12 Beyond Runway End Safety Area

The consequences of many runway excursions, especially overruns, are made much more serious because the aircraft end up beyond the confines of the ICAO-defined Runway End Safety Area (RESA); the aircraft may be catastrophically damaged because of major obstructions or terrain changes encountered soon after this protected area has been exceeded. Suddenly down-sloping terrain and low but substantial ground obstructions, which are of no concern to aircraft in flight, may take on considerable significance in determining the damage to an aircraft following a major overrun.

Under ICAO SARPs, the recommended extent of a RESA is considerably greater than the requirement for one. However, worldwide and even in the USA, there are still large numbers of runways used by air carrier aircraft which do not yet have even the ICAO required RESA, or satisfy the more stringent ICAO Recommended Practice, or meet the equivalent (for overrun purposes) FAA 'Standard'. State AIPs do not always include specific reference to the extent of RESA provision.

The RESA for some runways is surrounded by dangerous features, usually on the runway extended centreline. Raised prior awareness of flight crew to these dangers might influence their subsequent decision to make or complete a landing rather than initiate a go around (including ones commenced as Rejected Landings). Similar considerations might influence a decision to attempt a Rejected Take Off from a speed above V_1. There is some circumstantial evidence that flight crew who do not have sufficiently detailed knowledge of significant terrain or obstacle challenges beyond the immediate confines of a runway are more likely to be involved in overruns which lead to major airframe structural damage.

Although Aerodrome Obstacle and Precision Approach Terrain Charts published in the AD section of State AIPs can identify notable terrain changes, this information is not normally transcribed to the documentation available to Flight Crew, unless it refers to terrain awareness which is relevant to safety in flight. In the case of notable non-terrain ground obstructions, these will only be recorded in an AIP - and therefore capable of transcription to flight crew documentation where they are relevant to safety in flight.

The safety case for an EMAS (Engineered Materials Arresting System) has generally been made as a substitute for a fully-established RESA. Any application of EMAS to reducing the risk of occasional overrun on take-off or overrun on landing which extends beyond RESA may be problematic, unless there have been studies to define an appropriate lateral extent, taking into account the tendency to increasing divergence from the runway centreline as distance from the runway end increases.

1.18.7.13 Runway Awareness and Advisory System

The Runway Awareness and Advisory System (RAAS) is one of a number of related software enhancements available on later model Enhanced Ground Proximity Warning Systems. RAAS is designed to improve flight crew situational awareness, thereby reducing the risks of runway incursion, runway confusion and runway excursions.

Runway Awareness and Advisory System uses airport data stored in the EGPWS database, coupled with GPS and other on-board sensors, to monitor the movement of an aircraft around the airport. It provides visual/aural annunciations at critical points, such as "*Approaching Runway 29 Left* and confirmation when an aircraft is lined up on the runway prior to take-off: for example, "*On Runway 29 Right, 2,450 metres remaining*." In a scenario where a crew inadvertently lines up on a parallel taxiway and commences a take-off, an aural alert "*On Taxiway, On Taxiway*" is provided if the aircraft speed exceeds 72 km/h. On approach and after touchdown, the system continues to announce the distance to go until the end of the runway is reached.

1.18.7.14 System Description

Advisories/cautions are generated based upon the current aircraft position as compared to the location of the airport runways, which are stored within the EGPWS Runway Database.

The aural can be grouped into two categories:

- Routine Advisories (annunciations the flight crew will hear during routine operations) and
- Non-Routine Advisories/Cautions (annunciations the flight crew will seldom or perhaps never hear).

RAAS provides the flight crew with five 'routine advisories'. Three of these annunciations will be heard by the crew in normal operations, providing increased position awareness relative to the runway during taxi and flight operations. They are intended to reduce the risk of a runway incursion. The two remaining 'routine' advisories provide information about the aircraft location along the runway, and are intended to reduce the risk of overruns. The five advisories are:

- *Approaching Runway* - Airborne advisory provides the crew with awareness of which runway the aircraft is lined up with on approach.
- *Approaching Runway* - On-Ground advisory provides the flight crew with awareness of approximate runway edge being approached by the aircraft during taxi operations.
- *On Runway* - Advisory provides the crew with awareness of which runway the aircraft is lined-up with.
- *Distance Remaining* - Advisories enhance crew awareness of aircraft along-track position relative to the runway end.
- *Runway End* - Advisory is intended to improve flight crew awareness of the position of the aircraft relative to the runway end during low visibility conditions.

In addition, RAAS provides the flight crew with several 'non-routine' advisories/cautions. These annunciations are designed to enhance safety and situational awareness in specific situations not routinely encountered during normal aircraft operations. Some of the RAAS advisories include distance information. The unit of measure used for distance can be configured to be either metres or feet.

- *Approaching Short Runway* - Airborne advisory provides the crew with awareness of which runway the aircraft is lined-up with, and that the runway length available may be marginal for normal landing operations. If desired, an additional caution annunciation can be enabled which provides the crew with awareness that the issue has not been resolved when the aircraft is on final approach.
- *Insufficient Runway Length* - On-Ground advisory provides the crew with awareness of which runway the aircraft is lined-up with, and that the runway length available for take-off is less than the defined minimum take-off runway length. If desired, an additional caution annunciation can be enabled which provides the crew with awareness that the issue has not been resolved when the aircraft is on the final stage of take-off.

- *Extended Holding on Runway* - Advisory provides crew awareness of an extended holding period on the runway.
- *Taxiway Take-Off* - Advisory enhances crew awareness of excessive taxi speeds or an inadvertent take-off on a taxiway. If desired, this function can provide a caution annunciation in lieu of an advisory annunciation.
- *Distance Remaining* - Advisories provide the flight crew with position awareness during a Rejected Take-Off (RTO).
- *Taxiway Landing* - Alert provides the crew with awareness that the aircraft is not lined up with a runway at low altitudes.

Each RAAS function is independently enabled based on a customer specification and, when enabled, the RAAS functions operate automatically without any action required from the flight crew.

In addition to the aural annunciations provided, visual caution indications may be activated if the appropriate criteria are met. Visual text annunciations can also be configured so they are overlaid on the terrain display for a period of time after the warning is generated.

1.18.8 Human Decision Making

Decision making is the cognitive process of selecting a course of action from among multiple alternatives. The decision-making process produces a choice of action or an opinion that determines the decision maker's behaviour and therefore has a profound influence on task performance.

Decision making in an aeronautical environment involves any pertinent decision a pilot must make during the conduct of a flight. It includes both pre-flight go/no-go decisions as well as those made during the flight. In aeronautics, decision making is of particular importance because of the safety consequences of poor decisions.

The U.S. Federal Aviation Administration (FAA) defines *aeronautical decision making* (ADM) as follows:

ADM is a systematic approach to the mental process used by aircraft pilots to consistently determine the best course of action in response to a given set of circumstances. (FAA Advisory Circular 60-22)

This briefing note discusses:

- The concept of human decision making
- The limitations of human decision making

A companion briefing note is Decision-Making Training.

Human Decision Making

Human decision making is a complex process that is strongly dependent on the environment in which the decision must be made. We all make decisions every day, such as the choice of what to have for breakfast or which road to take when driving to work. The extent to which safety considerations enter our decision making depends on the situation. Choosing cereal or bread for breakfast involves virtually no consideration of safety. Selecting a route to drive may involve some aspects of safety but is probably primarily based on travel time and, perhaps, scenery.

Aviation is a complex, safety-critical endeavour. Many decisions made while flying can affect the lives of hundreds of people and have extraordinary economic consequences. Thus, even though some flight decisions are not strongly related to safety, it is best to view ADM as a safety-critical function.

Decision making in the aeronautical environment

Decision making in aeronautics builds upon the foundation of conventional decision making. Zsambok and Klein (1997) point out, however, that ADM is carried out in dynamic and complex environments often characterized by:

- Ill-structured problems
- An abundance of information
- Uncertainty
- Shifting, ill-defined or competing goals
- Multiple event-feedback loops
- Time constraints
- High stakes with high levels of risk
- Collaboration and task sharing among multiple players
- Organizational norms and goals that must be balanced against the decision maker's personal choices

Decisions in such a complex environment should involve the following considerations:

- A decision is not unique but, instead, is a series of multiple and interdependent decisions that are made in real time and in a continuously changing autonomous environment. (Edwards, 1962).
- A human being is not able to perceive, evaluate, understand and act on all aspects of the environment. The decision maker must simplify reality and make a decision within it. Reason (1990) calls this mechanism "bounded rationality."

- The principle of sufficiency (Amalberti, 2002) describes a decision as a continuous process in which a set of decisions is made while seeking satisfactory results to a given situation. This principle does not mean the decision involves the least cognitive effort but, rather, that the human being has achieved a satisfying response to the situation. Consequently, a successful decision is not necessarily the optimum or most rational decision. It is the decision the human being understands and knows how to apply effectively in the context of the situation.

These considerations indicate that ADM cannot be equated to a simplistic, sequential decision-making process involving:

- Cue detection
- Cue interpretation and/or integration
- Hypothesis generation and/or selection
- Action selection

While this model of decision making is attractively simple and may be sufficient to describe the everyday process, it is not adequate to describe ADM, which is best considered in the framework of a holistic model of information processing.

ADM is strongly dependent on situational awareness and the alternatives available to a pilot (Hoc and Amalberti, 1995). A pilot's level of situational awareness determines the solutions that will be considered and helps guide the choice of a response. In addition, the results of selected actions can enhance perception and understanding of the situation, which can serve as feedback to alter and improve subsequent decisions. In fact, it is clear that situational awareness, decision making and action are thoroughly intertwined (See Figure below).

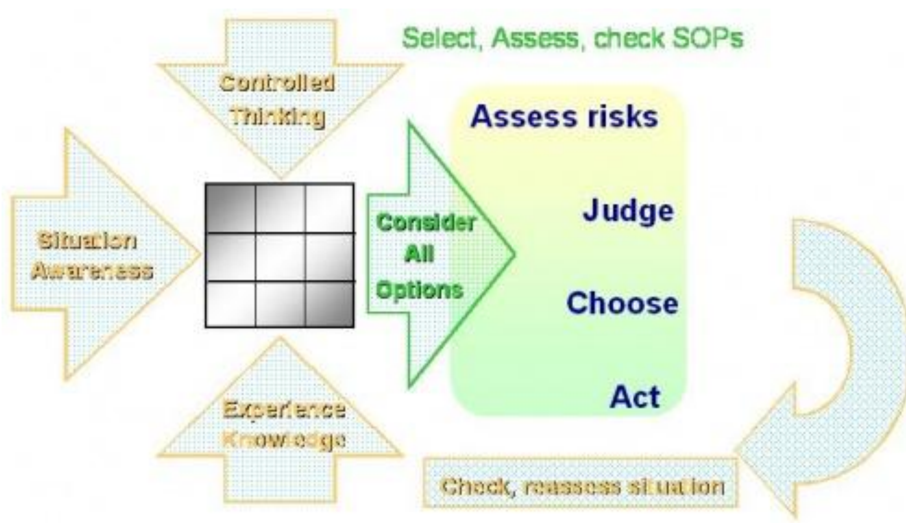

Figure 15: Decision making and information processing

Situational awareness and decision making

Situational awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status into the near future (Endsley, 1995). This definition leads to the identification of three levels of comprehension (see Figure 16).

- Level 1: perception of critical environmental cues
- Level 2: understanding the relevance and importance of those environmental cues to a person's goals
- Level 3: realistic predictions of potential future events in the system

An analysis of a pilot's cognitive task suggests that some tasks do not require a high level of continuous comprehension. Pilots can temporarily accept low or no comprehension for some tasks that are clearly not safety-critical. Situational awareness, then, must involve a pilot's ability to manage the correct levels of comprehension with regard to available mental resources and mission and task requirements. Time pressure and the pilot's goals are significant factors that contribute to comprehension level.

Figure 16: Decision making and situational awareness

The ADM process is an active process guided, in part, by the pilot's mental representation. Consequently, ADM is directly affected by the resources the pilot allocates to the Situational Awareness process shown in Figure 2. Poor comprehension may lead to an inappropriate decision even if the information needed to support the proper choice is available in the environment.

Collective decision making

Studies of decision making traditionally have focused on decisions by individuals. Commercial aviation, however, is a group or team environment — not only in the cockpit but also among the cabin crew and on the ground (e.g., maintenance, operations).

In aviation, the team represents a distributed cognitive system in which each member may affect the collective decision-making process. The leader takes a specific role in the process by assuming the responsibility for the collective decision on behalf of the team, regardless of the situation or event.

The steps for making a successful collective decision are:

- Access the same information either directly or by sharing among team members
- Build collective situational awareness and check for a common understanding
- Complete and mutually agree on goals
- Select and accept the course of action
- Execute the course of action using an approved task-sharing scheme after having planned it by defining the procedure, role and needs of each member
- Feedback results for monitoring the decision's effect
- Express any doubts and resolve them

However, as with individual decision making, the process of collective decision making can change as a function of the features of the environment in which the decision is being made (Urban, Weaver, Bowers and Rhodenizer, 1996). Factors influencing the collective decision-making process include:

- Time stress
- Workload
- Style of leadership
- Personality and mood of team members
- Ability, experience and stature or reputation of the team members
- Confidence, doubt and the social dynamic among team members

Three different team decision-making styles or processes can be defined based on the relative influences of the factors listed above:

1. **Limitations of Human Decision Making**

Some factors and/or biases can distort the way situations or goals are perceived by individuals and the team as a whole. The more a situation becomes strained, the more people tend to place confidence in subjective and personal factors, which can limit the quality of decisions, regardless of the specific decision-making process used. Knowledge of these limiting factors is important in order to avoid their use or to mitigate their consequences on safety. Three types of factors can be described:

- Risk perception and risk management
- Situational factors
- Biases

2. **Risk and decision making**

All decision alternatives entail some level of risk. The choice between alternatives is a trade-off based on the expected results for each alternative and the risk of failure to achieve these results when adopting the selected alternative. The way risk is perceived and managed can limit some choices.

Individuals tend to prefer solutions they are confident of achieving, even if the result will not be as good as might have been achieved with another, less-familiar solution. The likely solution in such situations is the best of the available alternatives that the individual or the team is actually able to implement, even if it is not the optimum solution.

1.18.9 Situational Factors

Situational factors arise from the interaction of the characteristics of the situation and those of the specific individual or team. Four types of situational factors have been identified:

Factors linked to the task

Factors inherent in a task can affect decision making. These include: degree of task complexity, time available to complete the task (time pressure), amount and flow of information, ease of access and availability of the information, conduciveness of the human-machine interface design, degree of uncertainty and clarity of the goals.

Cognitive factors

There are limits on human cognitive abilities and information processing (i.e., perception, understanding, action). Also, factors such as individual knowledge level, expertise, qualifications, fatigue and stress can influence decision making.

Motivational and personality factors

The degree of an individual's motivation as well as personality traits, attitudes, response style and the impacts of emotion or past experience and mood can profoundly influence decision making.

Psycho-social factors

Many psycho-social factors can influence the decision process for both individuals and teams. Decision making in a professional environment is subject to judgment and assessment by a third party. Concerns about image or failure and the desire to command the respect of others are psycho-social factors that can have direct impacts on the way decisions are made.

Other psycho-social factors include team collaboration mechanisms, leadership, and followership, processes of influence, stereotypes, reputation, and prominence.

Biases that influence decisions

Khaneman, Slovic and Tversky (1982) describe numerous biases that can distort the decision-making process. Biases are a particular tendency or inclination that prevents unprejudiced consideration of a question. Biases have been broadly studied in the field of decision making. The most frequent biases influencing decision making are:

- Anchoring bias: the tendency to rely too heavily, or "anchor," on one trait or piece of information
- Belief bias: the tendency to base assessments on personal beliefs
- Confirmation bias: the tendency to search for or interpret information in a way that confirms one's preconceptions
- Loss-aversion bias: the strong tendency for people to prefer avoiding losses rather than acquiring gains
- Rosy-retrospection bias: the tendency to rate past events more positively than they were actually rated when the event occurred
- Status-quo bias: the tendency to like things to stay relatively the same
- Gambler's-fallacy bias: the tendency to assume that individual random events are influenced by previous random events
- Valence effect of prediction bias: the tendency to overestimate the likelihood of good things happening and to underestimate the chance of bad things happening
- Correlation bias: the tendency to underestimate rare events and overestimate frequent events
- Recency-effect bias: the tendency to weigh recent events more heavily than earlier events
- Primacy-effect bias: the tendency to weigh initial events more heavily than subsequent events

- Fundamental attribution error bias: the tendency for people to overemphasize personality-based explanations for behaviours observed in others (but not themselves) while underemphasizing the role and power of situational influences on the same behaviour

- False consensus effect bias: the tendency for people to overestimate the degree to which others agree with them

- Projection bias: the tendency to unconsciously assume that others share the same or similar thoughts, beliefs, values or positions

- Overconfidence effect bias: the human tendency to be more confident in one's behaviours, attributes and physical characteristics than one should be

- Conformity bias: a propensity to preferentially adopt the cultural traits that are most frequent in the team. Conformity can also involve accepting the majority opinion and silencing or ignoring those who argue with the consensus.

1.18.10 Types of Error in Decision-making

Orasanu and Martin (1998) defined two basic types of decision-making errors in aviation.

The first relates to situation assessment, which involves defining the problem as well as assessing the levels of risk associated with it and the amount of time available for solving it. Once the problem is defined, a course of action must be chosen. The course of action is selected from the options available. Situation-assessment errors can be of several types: situation cues may be misinterpreted, misdiagnosed or ignored, resulting in a wrong picture; risk (threat or danger) levels may be mis assessed (Orasanu, Dismukes and Fischer, 1993); or the amount of available time may be misjudged (Orasanu and Strauch, 1994).

The second type of decision-making error identified by Orasanu and Martin involves errors in choosing a course of action. These also may be of several types. When there are specific rules to guide the decision (e.g., procedures), the appropriate response may not be retrieved from memory and applied, either because it was not known or because some contextual factor mitigated against it. If there are choices from which the decision must be made, options also may not be retrieved from memory, or only one may be retrieved when, in fact, multiple options exist. Constraints or factors that determine the adequacy of various options may not be retrieved or used in evaluating the options. Finally, the consequences of various options may not be considered. The decision maker may fail to mentally simulate the possible outcomes of each considered option. Creative decisions may be the most difficult because they involve the least support from the environment. The absence of available options means candidate solutions must be invented to fit the goals and existing conditions.

Orasanu and Martin examined cases in the U.S. National Transportation Safety Board's set of 37 "crew-caused" accidents that involved "tactical-decision errors" (NTSB, 1994). A common pattern was the crew's decision to continue with their original plan when conditions suggested that other courses of action might be more prudent. In other words, they decided to "go" in a "no-go" situation, usually in the face of ambiguous or dynamically changing conditions (e.g., continuing with a landing when it might have been more appropriate to go around). Four factors are hypothesized as possible contributors to these decision errors:

- The situations were not recognized as ones that should trigger a change of course of action, due to the ambiguity of the cues
- Risk was underestimated, possibly because a previous similar situation was successfully handled
- Goals conflicted (e.g., safety vs. productivity, mission completion or social factors)
- Consequences were not anticipated or evaluated, possibly due to some of the environmental factors or biases discussed earlier.

4.0 Key Points

The following are key points with respect to decision making:

- ADM takes place in a complex environment and requires situational awareness, relevant skills and experience
- Decision making must be considered in broad human factors and operational contexts
- The naturalistic decision-making process is greatly affected by time pressure and workload
- ADM in commercial aviation is a team process. Therefore, team dynamics can play a strong positive or negative role
- There are limitations in the human decision-making process, and exceeding these limits can result in decision error.

1.18.11 Flight Briefings

Briefings Overview

Briefings should help both the pilot flying (PF) and the pilot not flying (PNF) understand the desired sequence of events and actions, as well as the condition of the aircraft and any special hazards or circumstances involved in the planned flight sequence. To achieve the safety and efficiency benefits of good flight preparation, all crewmembers should strive for high-quality briefings.

Objectives of briefings

When conducting any briefing, the following objectives should be met:

- Define and communicate action plans and expectations under normal and abnormal conditions
- Confirm applicable task sharing (i.e., crewmembers' roles and responsibilities)
- Brief each subject area to its appropriate level of detail

- Promote questioning and feedback
- Ensure full understanding and agreement on the correct sequence of actions
- Communicate objectives to other crewmembers (cabin crew) and develop synergy
- Enhance the preparedness of the flight crew and cabin crew for facing unusual requirements or responding to unexpected conditions

The quality of the flight crew/cabin crew and flight crew take-off and approach briefings shapes crew performance throughout the flight. Pre-flight briefings should start at the dispatch office when the dispatcher gives the flight plan to the flight crew for review and the crew's final decision on the route, cruise flight level and fuel quantity.

The on-board crew formation briefing and the flight crew take-off and approach briefings should include the following:

- Crew familiarization with the departure and arrival airports and routes
- The maintenance state of the aircraft (e.g., inoperative items, recent repairs)
- Fatigue state of crewmembers (e.g., short-haul/multi-sector operations)
- Take-off, departure, approach and landing conditions (e.g., weather, runway conditions, special hazards)
- Lateral and vertical navigation, including intended use of automation
- Communications
- Status of cabin from the cabin crew
- Status of abnormal procedures as applicable (e.g., rejected take-off, diversion, missed approach/go-around)
- Review and discussion of take-off and departure hazards

Timeliness of briefings

Briefings should be conducted during low-workload periods. The take-off briefing should be conducted while the aircraft is at the gate or other parking position.

The descent preparation and the approach and go-around briefings should typically be completed 10 minutes before reaching the top-of-descent to prevent increasing workload and rushing the descent preparations.

Techniques for conducting effective briefings

The importance of briefing technique is often underestimated. The style and tone of a briefing play an important role in its effectiveness. Interactive briefings (e.g., confirming agreement and understanding by the PNF after each phase of the briefing) are more effective and productive than an uninterrupted lecture from the PF followed by: "Any questions?" Interactive briefings provide the PF and PNF with an opportunity to communicate and to check and correct each other as necessary (e. confirming the use of the correct departure and approach charts, confirming the correct setup of Nav-aids for the assigned take-off and landing runways).

The briefing itself should be based on the logical sequence of flight phases. It is important, however, to avoid the routine and formal repetition of the same points on each sector, which often becomes counterproductive because it involves no new thinking or problem solving. For example, adapting and expanding a briefing by highlighting the special aspects of an airport, the departure or approach procedure, or the prevailing weather conditions and circumstances usually result in a more lively and effective briefing.

Briefings should be conducted by speaking face-to-face, while remaining alert and vigilant in the monitoring of the aircraft and flight progress. The briefing technique of the PF should encourage effective listening to attract the PNF's attention. The briefing should therefore be conducted when the workload of the PNF is low enough to permit effective communication.

Whether anticipated or not, a significant change in an air traffic control (ATC) clearance, weather conditions, landing runway or aircraft condition requires a crew to review relevant parts of previously completed briefings. A re-briefing is almost always beneficial under these circumstances.

Take-off briefing

The take-off briefing is conducted by the pilot designated as PF for the particular flight leg. It enables the PF to inform the PNF of the planned course of actions (e.g., expectations, roles and responsibilities, unique requirements) for both normal and abnormal conditions during take-off. A full take-off briefing should be conducted during the first sector of the day. Subsequent briefings should be limited to the specific aspects of each individual airport/runway/take-off/departure condition. The take-off briefing should be guided and illustrated by referring to the applicable flight management system (FMS) pages, the paper or electronic charts and the navigation display to visualize the departure route and confirm the various data entries. Some of the important topics to review in a take-off briefing are discussed below. The important point is that a take-off briefing must be comprehensive and based on complete situational awareness gained from the available documentation and data.

ATIS

The Automatic Terminal Information Service (ATIS) is a recorded message broadcast at major airports. It provides flight crews with up-to-date information on weather, runway in use and other operational information. The ATIS message is updated whenever the situation changes significantly, with the new version designated by the next letter of the alphabet.

All pilots approaching the airport are required to monitor the ATIS and review the message, including:

- Expected take-off runway in use and standard instrument departure (SID)
- Altimeter (QNH or QFE)
- Transition altitude (if variable with QNH)
- Weather, temperature and dew point

- Wind and runway condition
- Unusual airport conditions (e.g., closed taxiways, presence of work crews)

NOTAMs

Notices to airmen (NOTAMs) provide crews with critical information that may have a direct effect on flight safety (e.g., unserviceable nav aids, change of departure routing, airspace restrictions, work in progress on taxiways and/or runways, obstructions, man-made obstacles, birds activities volcanic activity). NOTAM coverage can be national, regional, specific to one route or specific to a given airport. NOTAMs generally do not include detailed explanations and graphics. As a result, interpretation of a NOTAM can sometimes be difficult. Each pilot should therefore review applicable take-off and departure NOTAMs and discuss their possible impacts on operations with fellow crewmembers. If there is any doubt about the contents or interpretation of a NOTAM, pilots should contact the company dispatch office for clarification.

Key points

Conducting effective briefings is an essential part of flight preparation. Without proper preparation, a crew will not have the necessary situational awareness to fly at maximum effectiveness and safety. Briefings are necessary at various points in the flight from before taxiing to the departure runway through taxiing to the arrival gate.

The following summary points apply to all briefings:

- Briefings should be adapted to the specific conditions of the flight and focus on the items that are relevant for the particular take-off, departure, cruise or approach and landing.
- Briefings should be interactive and allow for dialogue between the PF, PNF and other crewmembers.
- Briefings should be conducted during low-workload periods.

- Briefings should be conducted even if the crew has completed the same flight many times in the past. Vary the briefing approach or emphasis when on familiar routes to promote thinking and to avoid doing things by habit.
- Briefings should cover procedures for unexpected events.
- Pilots should not fixate on one particular aspect of information in a briefing, as other important information may be missed.

1.18.12 CAVOK AIR Brake Assembly, Normal and Abnormal Checklists

The following CAVOK System and Checklists are pertinent to this investigation.

1. AN-74TK-100 MAIN BRAKE ASSEMBLY

The wheel system is designed to ground braking of the aircraft during taxiing or parking and ensures both simultaneous and consecutive braking of the wheels of right and left legs in the modes of main and emergency braking. Anti-skid devices minimize the potential wheel skidding ("skid") in the main braking mode.

The main braking is performed by foot control pedal application (wheel brake pressure (100+10) kgf/cm2 [(10+1) MPa)], and the emergency braking is performed by pulling the emergency braking handles (brake pressure (80+5-10) kgf/cm2 [(8+0.5-1) MPa].

The parking brake function is performed by pulling the emergency braking handles and then by locking them in partially extended position. In this case the brake pressure (63-10) kgf/cm2 [(6.3-1.0) MPa] is provided for within 48 h.

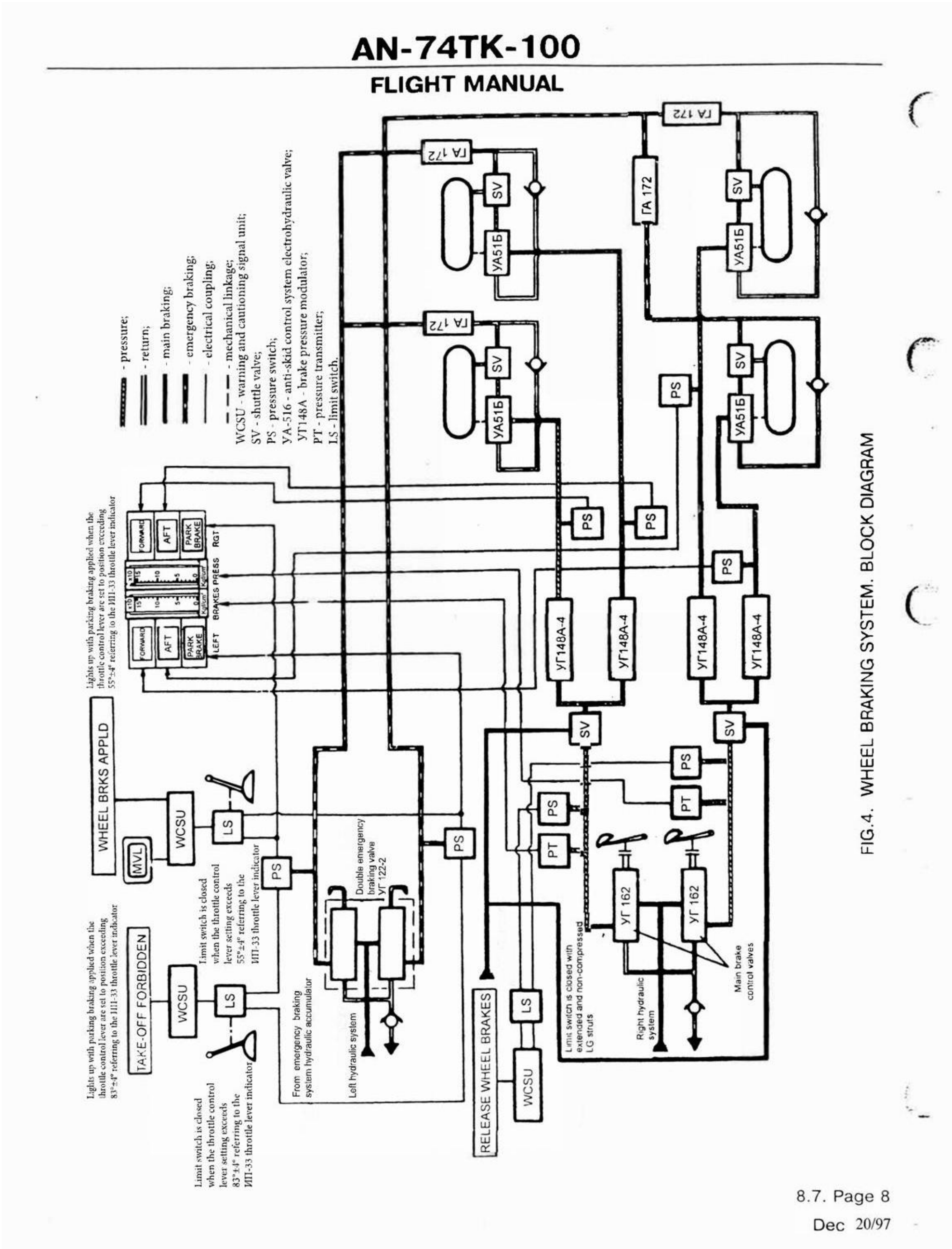

Figure 17: Schematic diagram of main brake assembly

2. AN-74TK-100 NORMAL OPERATION CHECKLIST

This checklist describes the CAVOK's "Normal Operation Procedures as follows;

- Before Starting Engines
- Before Taxiing
- During Taxiing
- At Holding Take-off Position
- At Line up Position

See Appendix 3.

3. AN-74TK-100 OPERATIONS MANUAL PART B

Chapter 3 of this manual describes the types of Engine failures and appropriate actions to be taken. The checklist is sub divided into 2 sections; they are:

- Section 2 (Normal Operations)
- Section 3 (Special Cases of Flight)
  - Section 3.2 Action in Complex Situations

    3.2.1 Engine failure

    3.2.1.1 General notes

    3.2.1.2 Engine failure at take-off ($V<V_1$)

    3.2.1.3 Engine failure at take-off run ($V>V_1$)

See Appendix 4.

4. AN-74TK-100 FLIGHT MANUAL

Chapter 5 of this manual describes in details the features and symptoms of Engine failures and actions to be taken. It is subdivided as follows:

- Section 5.1 Engine Failure

  5.1.1 General

  5.1.2 Engine failure at take-off ($V<V_1$)

  5.1.3 Engine failure during take-off ($V>V_1$)

See Appendix 5.

5. AN-74TK-100 QUICK REFERENCE HANDBOOK (QRH)

This hand book briefly describes actions to be taken by the crew in specific situations, specifically Emergency/Abnormal situations. Chapter 1 of this handbook deals with Engine failures at different phases of flight.

- Abnormal Procedures
  - 1 Engine failure
    - 1.1 General guidelines
    - 1.2 Engine failure at take-off run ($V<V_1$)
    - 1.3 Engine failure at take-off run ($V>V_1$)

See Appendix 6.

1.18.13 Definitions

1. **Rejected Take-Off**
   The situation which follows when it is decided to stop an aircraft during the take-off roll.

2. **Runway Safety Area**
   "An area symmetrical about the extended runway centre line and adjacent to the end of the strip primarily intended to reduce the risk of damage to an aero plane undershooting or overrunning the runway". [ICAO Annex 14]
3. **Runway Excursion**
   ICAO defined Runway Excursion as a veer off or overrun off the runway surface (ICAO).

4. Decision Speed (V_1)

V_1 is the Decision speed (sometimes referred to as critical engine speed or critical engine failure speed) by which any decision to reject a take-off must be made. Above V_1, the take-off must be continued unless there is reason to believe that the aircraft will not fly. An engine failure identified not later than V_1 should always result in a rejected take-off.

If the decision is made to reject, the aircraft can be brought to a stop within the Accelerate Stop Distance Available (ASDA). If the decision is made to continue the take-off, either in a non-engine failure case which occurs prior to V_1 or in an engine failure case which occurs at or after V_1, the aircraft can get airborne and achieve or exceed the appropriate screen height within the Take-off Distance Available (TODA). If a reject is initiated at a speed above V_1, a runway excursion is probable.

Stopping the aircraft within the confines of the runway or safely continuing the take-off is predicated on an appropriate and timely stop/go decision and the corresponding appropriate and timely actions. The V_1 call should be made such that the call is complete just as the speed is achieved. If a reject decision is taken, it is critical that stopping action is initiated within two seconds and that full stopping device capability is utilized. If the take-off is continued, the yaw due to engine failure must be corrected, the aircraft rotation must occur at V_r and the appropriate climb speed must be maintained to guarantee that the screen height will be achieved.

5. Rotation Safety Speed (V_r)

V_r is defined as the speed at which the rotation of the aircraft should be initiated to take-off attitude. Rotation speed (V_r) cannot be less than V_1. If it is greater than V_1 and it is found that, at V_r, rotation cannot be achieved, a subsequent rejected take off may not be possible within the remaining runway length and is likely to result in a Runway Excursion.

V_r is a function of aircraft weight and flap setting but may also vary with pressure altitude and temperature.

In the engine failure case, V_r must allow for acceleration to V_2 at screen height - 35 feet above the level of the runway surface for aircraft certificated as meeting Performance 'A'.

6. Take-off Safety Speed (V_2)

The take-off safety speed which must be attained at the 35ft height at the end of the required runway distance. This is essentially the best one-engine inoperative angle of climb speed for the airplane and is a minimum speed for flight in that condition until at least 400ft above the ground.

1.19 Useful or Effective Investigation Technique

Nil.

2.0 ANALYSIS

2.1 General

The 4 member flight crew and 2 maintenance engineers were trained, certified and qualified to conduct the flight in accordance with UCAA's regulations. The flight crew had sufficient rest before the intended flight. There was no evidence of any significant medical condition or use of any substance that might have impaired their performance during the flight. Neither were there any critical life events that could have adversely affected the performance of their duties. The crew have sufficient experience to conduct the flight.

The aircraft was maintained in accordance with UCAA's approved programme.

Although the left engine suffered an engine surge during the take-off roll due to the bird strike according to the crew, timely response to this could have averted the accident. However, the Captain delayed the action by about 5 seconds before he finally decided to reject the take-off.

2.2 The Flight

The flight was intended to operate with call sign CVK 7087 as a return flight with first technical stop at Kotoka International Airport, Accra, Ghana. There were six persons on board (all crew) with fuel uplift of 5,700 kg.

At 0905hrs, the aircraft began take-off roll. The First Officer was the Pilot Flying (PF) while the Captain was the Pilot Monitoring (PM).The engines and systems parameters were reported to be normal at that time.

According to the Captain, he saw five to six eagles get off the ground of the runway which flew dangerously close to the aircraft at the beginning of the take-off roll. At a speed of 180km/h, the crew asserted that they saw ahead of them a flock of eagles which were not seen initially getting off the ground from the runway.

Post-crash inspection conducted by the BAGAIA investigation team could neither establish any physical evidence (traces of bird) nor its parts found on the engine or its surrounding to suggest any physical damage to the engine or its surrounding like the engine intake, engine nacelle, turbine, and turbine guide vanes.

Another comparative report of post inspection conducted on the two D-36 series 2A engines by the representative of the engine manufacturer (SE "Ivchenko-Progress") revealed that some fragments of birds feathers were found at various locations of the left engine (fan blade, slot between the guide vanes, cavity of the lower engine mount strut main duct cowling of the engine core) respectively. These suggest that there was a bird encounter with the aircraft during the execution of the rejected take-off.

Further inspection of the fragments of feathers found at various locations inside the left engine was conducted by the Zoological Museum of the National Museum of Natural History of NAS, Ukraine. The report suggested that the fragments of feathers belonged to the dead bird found on the runway. It might have penetrated into the left engine as a result of being "overtaken" by the aircraft from behind on take-off during which part of its left feather was pulled out.

However, according to the INAC CARs (STP CAR-Part 14) Aerodrome Certification and operation section 14.20.D.10 (3), states that *"wildlife remains found within 60 meters of a runway or an airside pavement area are presumed to be a wildlife strike unless another cause of death is identified."*

Figure 18: Picture showing the dead bird found on the runway

The Captain took control of the aircraft and requested the Flight Engineer to check if the landing lights were ON and to monitor the engine parameters. The Captain further stated that he assessed the situation within 4 - 5 seconds and decided that the best option for the crew was to abort the take-off. The Captain immediately initiated a rejected take-off, instructing the Flight Engineer to apply the thrust reversers. The rejected take-off was initiated at a speed of 220 km/h, about 5 seconds after sighting the birds.

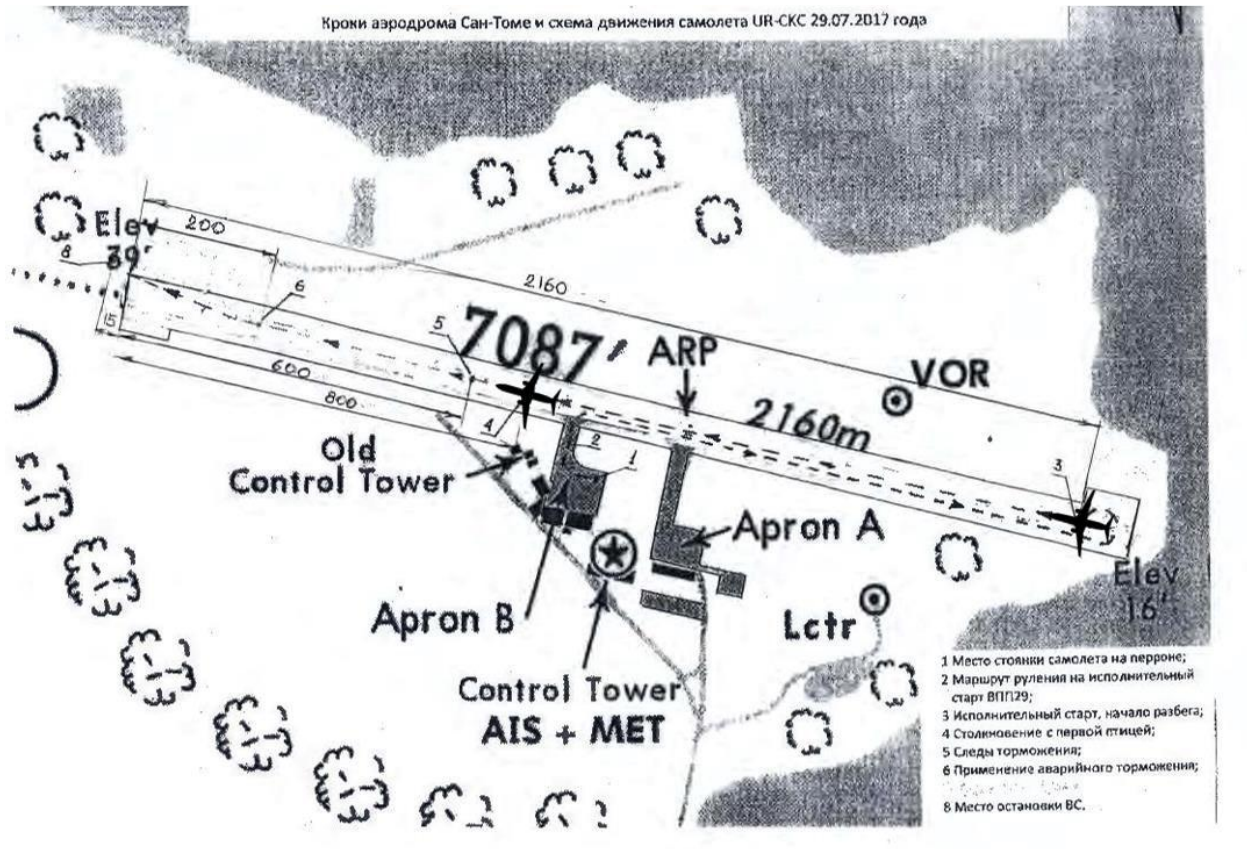

Figure 19: Runway configuration showing positions of aircraft during the attempted take-off roll

The decision not to continue the take-off could have been made when the flight crew observed that the runway surface appeared to be rising as the aircraft was accelerating towards the take-off speed, before they sighted the flock of birds. The investigator believes that the pilot intended to continue the take-off despite the birds seen and the runway factor.

According to the post investigation report received from Antonov State Enterprise Company, the pilot in command of the aircraft deliberately decided to abort the take-off at the speed exceeding the take-off decision speed V_1, which was followed by the runway overrun, since an aircraft overrun during the take-off is obviously less dangerous than an aircraft impact at failure of two engines at the initial stage of the climb. Thus, the pilot's actions were motivated by a state of emergency and aimed at minimizing the consequences of the occurrence.

However, the Captain was hesitant on the decision to discontinue the take-off. This resulted in a delayed and inappropriate response to the situation. At that time, the aircraft rotation speed was attained, the captain called for rotation initially then he reversed his rotation call out and instructed the first officer not to rotate. At about 5 seconds after V_r (200 km/h), with the fear of losing multiple engines, the Captain was certain that a reject was imminent; he took control, initiated a rejected take-off and called for reversers at a speed in excess of V_1 (20 km/h > V_1) which is inconsistent with CAVOK’s SOP and AN-74TK-100 Airplane Flight Manual (AFM).

The braking action was initiated by the Captain at a time lead of 2 seconds as against the activation of the reversers by the Flight Engineer (FE) after the captain’s instruction. This delay in activation of the reversers resulted in the reduction of the braking effectiveness, hence increasing the unlikelihood of the aircraft stopping before the end of the runway.

During the cockpit examination following the accident, the investigators found the SPEED BRAKE/SPOILERS lever in the down detent position. This position would normally not deploy the system manually or automatically should the thrust lever be retarded to idle. Also, FDR data recordings did not physically indicate the deployment activation of speed brake/spoilers. The failure of the flight crew to activate the speed brake/spoilers during the reject procedures also increased the severity of the accident as a result of decreased effectiveness in slowing the speed of the aircraft within the shortest practicable distance. Had the flight crew used the speed brake/spoilers, it would have assisted considerably in slowing down the aircraft, therefore stopping capability would be enhanced and braking effectiveness would increase; enabling the crew to stop the aircraft before the end of the runway and also to achieve a successful rejected take-off (See Figure 15).

2.3 Flight Crew Performance Before and During Take-off Roll

The flight crew deviated from the Standard Operating Procedures (SOP) in a number of significant ways that later affected the sequence of events leading up to the occurrence. The investigation identified the following deviations by the crew:

1. The omission of take-off briefing. [ref. AN-74TK-100 Normal Operation Checklist (See Appendix 3)]
2. The delay in rejecting the take-off. [ref. AN-74TK-100 Operations Manual Part B, Sections 3.2.2.2 and 3.2.2.3 (See Appendix 4]
3. The initiation of a rejected take-off after $V_{1.}$ [ref. AN-74TK-100 Flight Manual Sections 5.1.2 and 5.1.3 (See Appendix 5).
4. The failure to deploy speed brakes during the rejected take-off. [ref. AN-74TK-100 Quick Reference Handbook (QRH), Section 1.5.]

Prior to entering the runway, the crew conducted a visual check on and around the runway. After that, the beginning of the take-off roll was initially conducted in a proper manner, with the First Officer controlling the aircraft and the captain performing the duties of the non-flying pilot while the Flight Engineer and the Navigator were performing their duties such as setting power, monitoring the engine instruments and flight navigational instruments respectively. The investigator believes that, had the captain initiated the reject at an appropriate time, the aircraft could have stopped on the runway.

The normal time to achieve 111 km/h would have been 14 seconds with about 820 feet of roll. The rejected take-off was not initiated until about 36 seconds from the start of the take-off roll after the aircraft had travelled nearly 4,363 feet.

The investigation was unable to determine positively the reason for the captain's apparent delayed response to the abnormal situations of the birds' encounter and the engine surge. The Captain's command responsibilities require him to monitor all aspects of the take-off roll, with attention to the instrument panel, the view outside the windshield and the First Officer. Considering that it was the first time the flight crew had operated into that airport, including the runway conditions as observed by the flight crew, it is apparent that the Captain experienced pre-eminent workload during the take-off roll. Still, the investigator believes that these situations should not have precluded the Captain from attending to the abnormal situation.

2.4 Runway Surface Condition

Runway 29 is 2160m long. Runway 29 has neither RESA, nor Stopway, and the airfield does not meet ICAO standards for a runway strip (FPST runway strip extends beyond the end of the runway for the distance of 10m). There is a ravine at 15m from the end of the runway 29 in addition to a major road adjacent to the airport's perimeter fence. Clearway on RWY 29 is 60m long. Information of the ravine at the end of RWY 29 is absent in AIP. At both ends of RWY 11/29, the areas are provided with the runway turn-around pads 60m long each, one of which (at the end of the runway) is included in RWY 29 length of 2160 m.

Figure 20: Length of Runway 29

The Aerodrome Reference Point elevation is 10m, RWY 29 threshold has the elevation of 5m, RWY 11 threshold has the elevation of 12m, thereby indicating that there is an inflection of the runway ("humpback" runway), approximately in the centre.

According to the ICAO SARPs, an airport for aeroplanes with the reference field length 800m and over should have a runway strip, which extends before the threshold and beyond the end of the runway or stopway for a distance of at least 60m. In addition, a runway end safety area (RESA) shall be provided at each end of a runway strip for such aeroplanes, RESA should extend from the end of a runway strip to a distance of at least 90 m.

Unless its function requires it to be there for air navigation or for aircraft safety purposes, no equipment or installation shall be:

a) on a runway strip, a runway end safety area, a taxiway strip or within the distances specified in Table 3-1, column 11, of ICAO Annex 14 volume 1, if it would endanger an aircraft; or

b) on a clearway if it would endanger an aircraft in the air. Any equipment or installation required for air navigation or for aircraft safety purposes must be located:

- on that portion of a runway strip within 75m of the runway centreline for aeroplanes with reference field length 1200m and over; or
- on a runway end safety area, a taxiway strip or within the distances specified in Table3-1 of ICAO Annex 14 volume 1; or
- on a clearway and which would endanger an aircraft in the air; shall be frangible and mounted as low as possible.

Where provision of a runway end safety area is impossible, consideration may have to be given to reducing some of the declared distances.

The take-off limitations of a transport category aircraft are described in terms of the maximum weight of the aircraft that will ensure performance compatibility with the runway length. In a rejected take-off, the aircraft accelerate-stop distance shall not exceed the length of the runway plus the length of any stopway. The aircraft's accelerate-stop distance is in turn established as a part of the aircraft's certification. Basically, the rules require that the aircraft be capable of accelerating normally to a speed at which an engine failure or other emergency recognises that, should there be a prompt decision to reject a take-off, the flight crew's initial actions to decelerate would be taken as the aircraft reaches V_1 speed and is brought to a full stop within the accelerate-stop distance.

The accident aircraft was within the weight limitation of 27,857 kg at the beginning of the intended flight, being 6,943 kg lighter than the maximum weight permitted, (34,800 kg) for take-off on the 7087 ft runway. According to the weight computation by the Captain based on CAVOK's operating procedures, the V_1 speed of the accident aircraft, with a gross weight of 27,857 kg, using a standard flap setting for the typical aircraft and with the existing meteorological condition was 200 km/h. Under such condition, the aircraft should have been able to accelerate normally and stop within a total distance of 4,921 ft, 2,166 ft before the end of the runway if maximum full braking was applied and the RTO was initiated appropriately at or before 200 km/h.

Detailed analysis of FDR data conducted by the Antonov State Enterprise Company outlined "In case of need to perform an aborted take-off at the take-off decision speed, the crew should have performed all the required braking actions specified in the Flight Crew Operation Manual." The crew carried out the take-off in the rated operational mode of engines (the "rated" operational mode of engines is specified in the report of SE "Ivchenko-Progress"), the take-off decision speed exceeded the speed specified in the Flight Crew Operation Manual, and the crew did not use the interceptors for braking.

The report further explained that the simulation of An-74TK-100, reg. UR-CKC, take-off at the Sao Tome Airport with a mathematical model, which is based on the certification flight test results, has made it possible to determine that, at the pilot's actions according to the provided records of BUR-3-1 of An-74TK-100 aircraft, UR-CKC, the aircraft would roll out of the runway. See Appendix 7.

Even with the delayed and moderate braking, and use of spoilers and speed brakes, the aircraft should have been brought to a full stop within the confines of the runway, if the RTO was initiated by V_1. The combination of the reduced braking effectiveness and RTO initiation speed resulted in the runway excursion.

The location of the ravine (N 000 22' 51", E 0060 42' 07") is about 106 ft from the end of runway 29, this provided little room for runway overrun, and this distance is far less than the recommended. If the captain had rejected the take-off below V_1, or if he had based on other input, overruled the assumption of multiple engine failure due to multiple birds' strike and allowed the first officer to rotate and take-off the length of the 7,087 ft runway with its 200 ft safety area, it would have been adequate to complete the manoeuvre successfully. In a rejected take-off with the existing runway conditions, at an airspeed just below V_1, the aircraft may have stopped just on the runway. But the Captain denounced the rotation call out.

2.5 CAVOK Checklist Procedures

CAVOK provided AN-74TK-100 pilots with checklist guidance in the Operations Manual Part B section 2 (Normal Operation). Checklist items that were to be accomplished prior to take-off were "Before pushback/Before Start", "After Start", "Taxi" and "Before Take-off." CAVOK normal checklists up to but not including the "After Take-off" checklist were to include the "Take-off Briefing" item. However, the CAVOK normal operating checklist that was used by the accident flight crew was reviewed on 21st February, 2017 and subsequently approved by UCAA.

In summary, the CAVOK's normal checklist policy does not incorporate the "take-off briefing" item. It does not define specific flight crew member responsibility in the event of any unprecedented emergency or abnormal condition. Therefore CRM capability was degraded (See Appendix 3).

Take-off briefing item is a very important part of the normal operating checklist. It re-emphasises the appropriate individual flight crew actions in the event of emergencies or abnormal situation especially at the take-off phase of a flight. It also reminds and reaffirms any crew of their responsibilities during emergency and abnormal conditions.

2.6 Reasons for Airspeed Indication Anomaly

As aircraft passes through the air, the pressure at the nose of the aircraft is increased by an amount that is directly proportional to the square of the aircraft's speed. The indicated air speed system is simply a comparison of the pressure at the nose of the aircraft as measured at the inlet of the pitot tube (total pressure) and the local ambient pressure as measured at the aircraft's static ports (static pressure). If the inlet to the pitot system is blocked or tampered with so that the increase in pressure is no longer measured, the air speed indication system will no longer function properly. If the static port is similarly clogged, the pressure differential measurement will not be accurate.

The FDR acceleration and the air speed traces showed that the aircraft accelerated normally and the air speed indication was valid when the aircraft reached about 227km/h, but it became sporadic thereafter even though the aircraft continued to accelerate up to the point of the attempted reject. However, another picture showed the cross section of the nose wheel gear assembly being impacted by a large bird.

Figure 21: Picture showing the bird remains entangled in the nose wheel.

The post-accident tests on the FDR conducted by the Antonov State Enterprise Company revealed that "the conclusion of reliability of the instrument speed indications of the aircraft and other parametric information indications registered in ZBN-1-3 ser.3 of An-74TK-100, reg. UR-CKC, the mathematical calculation of speed of An-74TK-100, reg. UR-CKC, on the runway indicates that the actual aircraft speed on the runway was approximately by 10 km/h lower than that recorded by the aircraft on-board recorder. Probably, this is caused by the incorrectly calibrated characteristic of the instrument speed sensor. At the same time, some of the parameters of systems were not registered at all in the flight data recorder." It could be deduced from the above conclusion that the reason for the erratic reading of the airspeed indicator was not established by Antonov Company, therefore its evidence was a probability.

The nature of the impact suggests that the aircraft impacted the bird during the take-off roll just before the left engine surge occurred. The impact on the nose gear assembly resulted in damage to some parts and wires linking the squat switch mounted on the nose gear. This has a tendency to cause the sporadic increase of the air speed.

3.0 CONCLUSION

3.1 Findings

The investigation revealed the following:

3.1.1 The aircraft had a valid Certificate of Airworthiness.

3.1.2 The State of Registry and the State of the Operator is Ukraine.

3.1.3 There were six persons on board the aircraft (all crew).

3.1.4 The crew were certified and qualified to conduct the flight. The accident flight was the first to be conducted for that day by the crew.

3.1.5 There was effective communication between the Air Traffic Controller (ATC) and the crew before and during the take-off roll.

3.1.6 The flight was conducted in accordance with the operating procedures as contained in the company's Operations Manual. However, the emergency briefing item in the before take-off checklist was missing in the normal checklist.

3.1.7 The flight was initially cleared by ATC to depart from runway 11 but changed to runway 29 at the request of the crew.

3.1.8 The First Officer was the Pilot Flying while the Captain was the Pilot Monitoring.

3.1.9 At 0905hrs when the aircraft began its take-off roll, the engines and systems parameters were reported to be normal.

3.1.10 At a speed of 180 km/h, the crew asserted that they saw a flock of birds on the runway which prompted the Captain to take control of the aircraft. Subsequently, the aircraft sustained multiple bird strikes.

3.1.11 The left engine suffered failure possibly due to bird ingestion.

3.1.12 The remains of birds were found at various locations of the left engine (fan blade, slot between the guide vanes, cavity of the lower engine mount strut, main duct cowling of the engine core), at nose landing gear and on the runway.

3.1.13 The Captain initiated a rejected take-off at a speed of about 220 km/h which is 20 km/hr in excess of decision speed, V_1.

3.1.14 The Captain's actions were stated to be motivated by a state of emergency and aimed at minimizing the consequences of the occurrence, since an aircraft overrun during the take-off is obviously less dangerous than an aircraft impact at failure of two engines at the initial stage of the climb.

3.1.15 There is a ravine at 15m from the end of RWY 29 in addition to a major road that is adjacent to the airport's perimeter fence.

3.1.16 The Captain, in a bid to increase the stopping distance and avoid the ravine veered to the right of the runway centreline.

3.1.17 Runway 29 is 2160m long. At both ends of RWY 11/29, the areas are provided with the runway turn around pads 60m long each, one of them (at the end of RWY 29) is included in RWY length of 2160m.

3.1.18 Runway 29 has neither runway end safety area, nor stopway. Runway strip extends beyond the end of the runway for a distance of 10m only. Clearway on RWY 29 is 60m long.

3.1.19 Airport services did not carry out the runway inspection prior to the departure clearance on the presence of the birds before take-off of CVK7087, as required by the Airport Wildlife Control Programme.

3.1.20 The Ornithological report on the bird remains found on the runway after the occurrence identified it as the juvenile specimen of diurnal carnivorous bird of Falconiformes of the Hawk Family (Accipitridae) – Common Honey Buzzard, Pernis apivorus.

3.1.21 Statistics of bird strike collisions in the aerodrome area is not properly kept

3.1.22 The Airport Rescue and Fire Fighting (ARFF) service responded promptly.

3.1.23 One of the six occupants suffered minor injuries.

3.2 Causal Factor

The investigation determines that the cause of this accident as:

Due to the presence of birds on the runway, the take-off was rejected at a speed above decision speed V_1, which is inconsistent with CAVOK's Standard Operating Procedures (SOP).

3.3 Contributory factors

The contributory factors to this accident include but are not limited to the following:

i. Failure of the crew to deploy interceptors (speed brakes/spoilers).
ii. Inadequate flight crew training on details of rejected take-off procedure scenarios.
iii. The omission of the take-off briefing in CAVOK's Normal Operations checklist.
iv. Poor Crew Resource Management (CRM), especially in a multi-crew flight operation.

4.0 SAFETY RECOMMENDATIONS

4.1 Instituto Nacional de Aviacao Civil (National Civil Aviation Authority of STP)

4.1.1 Should improve the habitat management programme (including reduction or elimination of trees, shrubs and other plants which provide food, shelter or roosting sites for birds)

4.1.2 Should enhance its aerodrome grass management appropriate to the prevalent species and the degree of risk that they pose.

4.1.3 Should liaise with local inhabitants to limit the attraction of birds to fields (in the vicinity of the airport).

4.1.4 Should install specialized ground-based radar equipment used for tactical detection of large flocking birds.

4.1.5 Should adopt and extend Runway End Safety Area to conform to ICAO standards.

4.1.6 Should include the information about the ravine at the end of RWY 29 into the AIP and Send it as Notice To Airmen (NOTAM).

4.2 Ukraine Civil Aviation Authority

Should enhance its oversight functions by reviewing all safety related items pertinent to operators' checklists and manuals.

4.3 CAVOK Airlines

4.3.1 Should review its Rejected Take Off (RTO) training syllabus to incorporate robust RTO training plan for both initial and recurrent aircraft type simulator training and assessment to include unexpected scenarios and stop-and-go decision making.

4.3.2 Should review its Normal Operations checklist in order to include take-off briefing as an item for each flight.

APPENDICES

Appendix 1: Expert Report

Expert Report

of Bird Species and Status Established with Biological and Photographic Evidence from Site of Accident, Which Took Place with Ukrainian Aircraft AN-74TK-100, UR-CKC,on July 29, 2017, in Democratic Republic of Sao Tome and Principe

The research of the five photocopies of photographs taken from different distances of the bird deceased, apparently, on the runway in the area of its collision with the abovementioned aircraft at the take-off, makes it possible to identify it as a diurnal carnivorous birdof Falconiformes of the Hawk Family (Accipitridae) — **Common Honey Buzzard,*Perm's apivorus* L.**

Judging by the photo materials, the bird is a juvenile (the first annual dress) and represented by a *bright* morph, that is, one of the three typical color typescharacteristic for this species – typical, dark and light ones.

As regards the provided biological evidence, it was found that itis composed of fragments of several secondary contour feathers, which are probably related to the body or flight feathers. The light bordering of the wing feathers is also more common for young birds of the Honey Buzzard, which is present on one of the fragments.

A comparison was made of the received fragments with ornithological materials at the Zoological Museum of the National Academy of Sciences of Ukraine, and it was determined that they, in general, may correspond to the mentioned species bythe color and form, though, in the same way, to the several representatives of the Hawk Family. Unfortunately, a limited number of the feathers and their condition can not undoubtedly guarantee their belonging to the Common Honey Buzzard.But, in the photographs, it is clearly visible the damage of the feathering of the bird deceased on the runway from the left wing side and the lack of primary flight feathers and most of the ruddersof the tail. If this particular bird penetrated into the left engine, then one can suggest that atthe take-off, the aircraft "overtook" the bird from behind, at that, a part of the left side feathers was pulled out.

It should be noted that the photographs do not contain a view of the bird from the lower (abdominal) part, which makes it impossible to determine, whether there is a damage there, and, if there is, whether the damage could cause death of this individual.

Regarding the status of the Honey Buzzard in the area, where the Ukrainian plane crashed, we report the following:

The Common (or European) Honey Buzzard nests in the most partof the territory of Europe and West Asia (Russia). The number of the European population alone is on average about 150 thousand nesting pairs. It is a distant migrant and flies for winteringmainly to the West and Central Africa (from Guinea to Zaire). One of the largest mass migratory routes passes through the Gibraltar, where only for2016 season (spring and autumn), 97,000 individuals of migrating Common Honey Buzzards of were counted. Further, the birds cross the Sahara and then dispersealong the equator.

In such a way, the islands of the Gulf of Guinea, in this case, the Democratic Republic of Sao Tome and Principe, are part of the winter areal for the Honey Buzzard. In wintering places, it stays until mid-April-early May, and then returns to the breeding grounds.

As it turns out from the information provided, the accident that involves,presumably, the mentioned species took place on July 29. The Honey Buzzard departure from the breeding grounds usually begins only since mid-August. The young bird migration usually begins several weeks earlier than the adult migration (end of August – beginningof September). Even taking this into account, it is difficult to explain the presence of the young bird of this species in the Gulf of Guinea in late July. Assuming the earliest beginning of the autumn migration, the bird would need a certain period to reach wintering places. So, according to the satellite tracking results (from radio beacons attached to the birds), it was found that on average, this period is more than 50 days for the Common Honey Buzzard residing in the southern Sweden.

Therefore, the most probable is the other version based on the study of foreign scientists. It has been found that some young birds remain in Africa throughout the summer and do not return to the nesting sites for a yearminimum. This is also noted for some other species of diurnal carnivorous birds.

It can be assumed that the Honey Buzzard individual, which may have caused the accident with the Ukrainian aircraft in the Democratic Republic of Sao Tome and Principe, belongs to the category of young birds that have remained fora summer period in the region of the species wintering. Its (maybe, of other Honey Buzzards) presence within the aerodrome area is explained by peculiarities of the species nutrition, where the mainfoodis formed by the insects,which are particularly well visible in the places that should be periodically moweddown. The possibility of the bird penetration under the plane is associated with frequent walking on the ground in the search for prey, which is behavioral for this species.

In general, it should be noted that the bird strike problem is on the front burnerworldwide. Its resolution is handled by special scientific units that conduct accident investigations and develop techniques for their maximal prevention. In Ukraine, for many years,such a group of ornithologists existed at the Institute of Zoology and successfully collaborated with civilian and military aerodromes throughout the country. And in this case, it is obvious that the presence of an ornithologist at the scene of the accident, or at least,a timely consultation on sample collection and storage, would enable not only to avoid the majority of the above issues, but also to issue some recommendations for the further prevention of the similar occurrences in this region.

Main Sources Used:

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3. Hake, M., Kjellen, N. and Alerstam, T. 2003. Age-dependent migration strategy in honey buzzards Pernisapivorus tracked by satellite. - Oikos 103: 385-396.

4. Bruderer, B., Blitzbalu, S., Peter, D. 1993. Migration and flight behavior of Honey Bazzards*Pernisapivorus* in Southern Israel observed by radar. - Ardea 82: 111 -122.

Expert:
Cand. Sc. (Biology) /***signed***/
Head of Fauna and Chine SpeciesDivision
I.I. Shmalgauzen Institute of Zoology
National Academy of Sciences of Ukraine

Stamp: [I certify authenticity of the signature of .
Clerical Office Head] /***signed***/
Seal: [Identification Code: 05416975
I.I. Shmalgauzen Institute of Zoology
National Academy of Sciences of Ukraine]/***signed***/ 20.10.2017

Appendix 2: Fuel Sample Analysis

Inspectorate Marine Services (Nigeria) Ltd.
51A, Marine road Apapa, Lagos Nigeria.
Tel : +234 (0)7098727040

BUREAU VERITAS 1828
INSPECTORATE

Client	AIB
Vessel	NOT ADVISED
Cargo	JET A-1
Port	NOT ADVISED
Date sampled	BROUGHT BY CLIENT

ANALYTICAL REPORT

Sample Source	BROUGHT BY CLIENT
Product	JET A-1
Laboratory ID	INSP/09/2121/LA17
Seal Number	N/A
Container Volume	1X500mL

TEST PERFORMED

Test	Method	Result	Units
Colour	ASTMD 156-02	+16	
Total Sulpur	ASTMD 4294-04	0.118	%wt
Mercaptans sulphur	ASTMD 3227	0.0018	%wt
Doctor test	ASTMD 4952-02	POSITIVE	
Distillation	ASTMD 86-04		°C
Initial Boiling Point		166.0	
10% Recovery		178.0	
50% Recovery		198.0	
90% Recovery		238.0	
End Point		262.0	
Residue		1.0	%vol
Loss		0.5	%vol
Flash point	IP 170	50.0	°C
Density @15°C	ASTMD 1298-99	0.8021	g/cm3
Freezing Point	ASTMD 2386-01	-57.0	°C
Copper Strip(class)2hrs@100°C	ASTMD 130-04	1A	
Existent Gum	ASTMD 381-03	1.0	mg/100ml
Microseparometer with SDA	ASTMD 3948-99	87	rating
Electrical conductivity@27.5°C	ASTMD 2624-02	121	Ps/m

INSPECTORATE
51 Marina Road, Apapa
Lagos, Nigeria.
www.inspectorate.com

Name
Signed
Date 27/09/2017 Time 1740HRS

Documents not signed and stamped by the appropriate Laboratory authority remain invalid.

Precision Parameters apply in the determination of the above results. Also please refer to ASTM D 3244-90A, IP367/93 and IP Standards Appendix E for utilazation of test data to determine conformance with specifications.

This report is issued by the Company under its General Terms and Conditions for inspection and testing services. Except by special arrangements, samples if drawn will not be retained by the Company for more than 3 months.

Appendix 3: AN-74 Operations Manual

PAGE 2-6	*AN-74 OPERATIONS MANUAL*	CAVOK
21.02.2017	PART B. FLIGHT OPERATION OF THE AIRCRAFT AN-74	
REVISION 0 OPS 1	2. NORMAL OPERATION *2. НОРМАЛЬНАЯ ЭКСПЛУАТАЦИЯ*	

WARNINGS:		***ПРЕДУПРЕЖДЕНИЯ:***
1. It is forbidden to make direct coordination of the scales on the plane pressure altimeter BM.		1. Запрещается производить непосредственно на самолете согласование шкал давления высотомеров ВМ.
2. If the difference between the pressure at the airport of departure and the bar pressure altimeter, and also between the readings and the height of the airfield futomerov exceed specified tolerances, ***FORBIDDEN takeoff.***		2. Если разность между давлением на аэродроме вылета и показаниями шкал давления на высотомерах, а также между показаниями футомеров и высотой аэродрома превышает указанные допуски, ***ВЗЛЕТ ЗАПРЕЩАЕТСЯ***;
➢ check tables altimeter readings with the total corrections.		➢ проверьте наличие таблиц показаний высотомеров с учетом суммарных поправок.
Altimeter setting procedures to watch: OM Part A Ch. 8, p / n 8.3.3.		Процедуры установки высотомеров смотреть: OM Part A Гл. 8, п/п 8.3.3.
2.4. TAXIING, TAKEOFF, CLIMB.		**2.4.РУЛЕНИЕ, ВЗЛЕТ, НАБОР ВЫСОТЫ**
2.4.1. Preparing for taxiing and taxiing		***2.4.1. Подготовка к рулению и руление***
Before taxiing:		***Перед выруливанием:***
➢ switch on lighted signs FASTEN BELTS, NO SMOKING	**КВС**	➢ включите световые табло ЗАСТЕГНУТЬ РЕМНИ, НЕ КУРИТЬ
➢ make sure that there are no signals on warning annunciators	**Э**	➢ убедитесь в отсутствии сигналов на предупреждающих табло
WARNING! AT AMBIENT TEMPERATURE BELOW MINUS 30 °C BEFORE TAXIING-OUT PERFORM SEVERAL DEFLECTIONS OF AN ELEVATOR AND A RUDDER FROM ONE EXTREME POSITION TO ANOTHER AS WELL AS DEFLECTION AND RETRACTION OF SPOILERS USED AT A DRAG MODE		***ВНИМАНИЕ!*** ПРИ ТЕМПЕРАТУРЕ НАРУЖНОГО ВОЗДУХА НИЖЕ МИНУС 30 °С ПЕРЕД ВЫРУЛИВАНИЕМ ПРОИЗВЕДИТЕ НЕСКОЛЬКО РАЗ ОТКЛОНЕНИЕ РУЛЯ ВЫСОТЫ И РУЛЯ НАПРАВЛЕНИЯ ИЗ ОДНОГО КРАЙНЕГО ПОЛОЖЕНИЯ В ДРУГОЕ, А ТАКЖЕ ОТКЛОНЕНИЕ И УБОРКУ ИНТЕРЦЕПТОРОВ, ИСПОЛЬЗУЕМЫХ В ТОРМОЗНОМ РЕЖИМЕ
➢ test for the serviceability of the elevator trimming tab	**КВС, 2П**	➢ проверьте работоспособность триммера РВ
➢ set trim tabs of the elevator, rudder and ailerons into the neutral position	**КВС, БМ**	➢ установите триммеры РВ, РН и элеронов в нейтральное положение
➢ make sure that navigation, flight, radio communication and radio equipment of the plane and recording instruments are on, the annunciator НК-ГОТОВ (INTEGRATED NAVIGATION SYSTEM - READY) is illuminated	**КВС, 2П, ШТ**	➢ убедитесь, что навигационное, пилотажное, радиосвязное и радиотехническое оборудование самолета и регистрирующие приборы включены, горит табло НК - ГОТОВ
➢ tune ADF N1 on the frequency of the LOM, while ADF N2 - on the frequency of airway recovery	**ШТ, (КВС, 2П)**	➢ настройте АРК № I ни частоту ДПРМ, а АРК № 2 - на частоту привода коридора выхода (соотв. КУРС-МП-1, КУРС-МП-2)
➢ specify the runway heading and the maneuver of leaving the airfield zone	**ШТ**	➢ уточните курс взлета и маневр выхода из зоны аэродрома (STAR)
➢ switch on airplane transponder CO-72M and TCAS	**КВС**	➢ включите самолетный ответчик СО-72М,TCAS.
➢ make sure that controls of CPCS - (automatic cabin pressure control system) are properly installed	**БМ**	➢ убедитесь в правильности установки регулирующих органов САРД включите СКВ самолета
➢ switch on the switches LEFT ICE SNSR and RGT ICE SNSR and set the switches of the antiicing system the airframe and of the engines into the position AUTO	**КВС, 2П**	➢ установите переключатели обогрева стекол в положение ОСЛАБЛ, включите выключатели СО ЛЕВ и СО ПРАВ и установите переключатели ПОС планера и двигателей в положение АВТ
➢ switch display EXIT (emergency lighting PREPARED)	**КВС**	➢ включите табло ВЫХОД (АВАР. ОСВЕЩ. ПОДГОТОВЛЕНО)
➢ make sure that emergency and warning display are off, make sure that the ADR on and do not burn display ADR - FAILURE ADR- and no reserves.	**КВС**	➢ убедитесь, что аварийные и предупреждающие табло не горят убедитесь, что АДР включен и не горят табло АДР - ОТКАЗ и АДР- НЕТ РЕЗЕРВА.
➢ If the display off, press the ADR PREPARATION while placards shall extinguished	**БМ**	➢ Если табло горят, нажмите кнопку АДР ПОДГОТОВКА при этом табло должны погаснуть
➢ read out the "BEFORE TAXIING-OUT", checklist	**ШТ**	➢ зачитайте карту контрольной проверки ПЕРЕД ВЫРУЛИВАНИЕМ
➢ request taxiing-out clearance	**КВС, 2П**	➢ запросите разрешение на выруливание
➢ make sure that there are no obstacles on the taxiway	**КВС, 2П**	➢ убедитесь в отсутствии препятствий в полосе руления

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	PART B. FLIGHT OPERATION OF THE AIRCRAFT AN-74	21.02.2017
	2. NORMAL OPERATION *2. НОРМАЛЬНАЯ ЭКСПЛУАТАЦИЯ*	REVISION 0 OPS 1

➢ give the order to disconnect the cable of the airfield ICS and remove the braking blocks	КВС	➢ дайте команду отсоединить кабель аэродромного СПУ и убрать колодки
➢ warn the crew about taxiing-out	КВС	➢ предупредите экипаж о выруливании
➢ switch on the nose landing gear control	КВС	➢ включите управление передней опорой
➢ release the airplane from the parking brake and add power to the made necessary for a smooth moving off from rest	КВС	➢ снимите самолет со стояночного тормоза и увеличьте режим работы двигателей до необходимого для плавного страгивания -
➢ double switching display "fasten your seat belts," let the team cabin crew to prepare for takeoff.	КВС	➢ двойным включением табло «ПРИСТЕГНУТЬ РЕМНИ» дайте команду ИТС приготовиться к взлёту.
NOTE. In case of necessity of using the reversal at the parking area or while taxiing the engines must be warmed up in accordance with the instructions of sub-section 8.1.		***ПРИМЕЧАНИЕ.*** В случае необходимости использования реверса на стоянке или при рулении двигатели должны быть прогреты
While taxiing:		***На рулении:***
➢ test the operation of the main and than that of the emergency system of braking	КВС, 2П	➢ опробуйте работу основной, а затем аварийной систем торможения
➢ set the necessary speed of taxiing depending on the condition of the taxiway, availability of obstacles and visibility conditions at ambient temperature below 0°, heavy snow or ice heating of the static pilot tube and (the pilot tube). At time delay when taxiing for more that 5 minutes, switch off the heating of the static pilot tube and the pilot tube periodically for cooling with 5-min intervals	КВС, 2П, БМ	➢ установите потребную скорость руления в зависимости от состояния рулежной полосы, наличия препятствий и условий видимости -при отрицательных температурах наружного воздуха, сильном снегопаде или обледенении включите обогрев ПВД и ППД. При задержке на рулении на время более 5 мин периодически отключайте обогрев ПВД и ППД на 5 мин для охлаждения
➢ turns and direction, while taxing, are to be kept by turning the knob, and, if necessary, - by a separate braking of wheels or by creating the asymmetry of thrust. The scheme of motion of characteristic points of the airplane and its landing gear while turning with a minimum radius is shown in Fig. 1.	КВС	➢ развороты и направление на рулении выдерживайте поворотом рукоятки, а при необходимости - раздельным торможением колес или созданием асимметрии тяги. Схема движения характерных точек самолета и его шасси при развороте с минимальным радиусом показана на Рис. I
➢ at turns make sure of the serviceability of the flight and navigational instruments,АДР	КВС, ШТ, 2П	➢ на разворотах убедитесь в работоспособности пилотажных и навигационных приборов, АДР
➢ switch on the mode of heading alignment according to TWY (if the TWY heading is known and the heading alignment is marked)	ШТ	➢ включите режим выставки курса по РД (если известен курс РД и она маркирована)
➢ read the checklist "DURING TAXIING"	ШТ	➢ зачитайте карту контрольной проверки НА РУЛЕНИИ
WARNING!		***ВНИМАНИЕ!***
1. DO NOT ALLOW THE TURNS TO BE CARRIED OUT WHEN THE WHEELS OF ANY OF THE MAIN LANDING GEAR ARE FULLY BRAKED ON.		1. НЕ ДОПУСКАЙТЕ РАЗВОРОТОВ ПРИ ПОЛНОСТЬЮ ЗАТОРМОЖЕННЫХ КОЛЕСАХ ОДНОЙ ИЗ ОСНОВНЫХ ОПОР ШАССИ.
2. WHEN THE CROSSWIND EXCEEDS 10 m/sec DO NOT USE THE ENGINE POWER (FROM THE LEEWARD SIDE) ABOVE 0.7 OF A RATED VALUE.		2. ПРИ БОКОВОМ ВЕТРЕ БОЛЕЕ 10 м/с НЕ ИСПОЛЬЗУЙТЕ РЕЖИМ ДВИГАТЕЛЯ (С ПОДВЕТРЕННОЙ СТОРОНЫ) ВЫШЕ 0,7 НОМИНАЛЬНОГО.
3. WHILE TURNING, KEEP THE SPEED UNDER 10 km/h. REMEMBER ABOUT LOADS ON CHASSIS AND WHEELS WHICH PROPORTIONAL CUBE SPEED.		3. ПРИ РАЗВОРОТАХ ВЫДЕРЖВАИТЕ СКОРОСТЬ НЕ БОЛЬШЕ 10 км/ч. ПОМНИТЬ О НАГРУЗКАХ НА УЗЛЫ ШАССИ И КОЛЕС, КОТОРЫЕ ПРОПОРЦИОНАЛЬНЫ КУБУ СКОРОСТИ.

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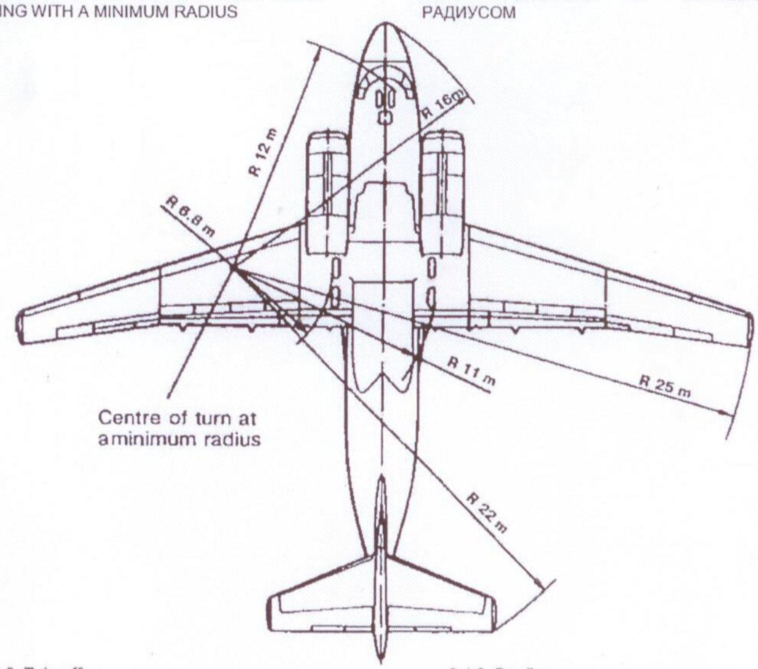
FIG. 1. DIAGRAM OF MOTION OF CHARACTERISTIC EXTREME POINTS OF THE AIRPLANE AND ITS LANDING GEAR WHEN TURNING WITH A MINIMUM RADIUS

РИС.1. СХЕМА ДВИЖЕНИЯ ХАРАКТЕРНЫХ ГАБАРИТНЫХ ТОЧЕК САМОЛЕТА И ЕГО ШАССИ ПРИ РАЗВОРОТЕ С МИНИМАЛЬНЫМ РАДИУСОМ



2.4.2. Takeoff		2.4.2. Взлёт
Preparetion for takeoff		*Подготовка к взлету.*
<u>At taxi holding point:</u>		*<u>На предварительном старте:</u>*
➢ extend flaps and leading edge slats into the take-off position 10/19	КВС	➢ выпустите закрылки и предкрылки во взлетное положение 10/19°
➢ make sure that the annunciator FULL on the central control panel is illuminated and the annunciator RESTRICT is gone out	КВС, БМ	➢ убедитесь, что загорелось табло ПОЛН на центральном пульте и погасло табло ОГРАНИЧ,
➢ check for locking the seat, closing the side direct vision windows, positioning of the canopy defogging knobs	Э	➢ проверьте стопорение кресла, закрытие форточек, положение рукояток обдува фонаря
➢ make sure that the pointers of altimeters ВМ-15115 and indicators УВ-75-15ПБ are set to zero, while the pointer of indicator УВ-75-15(ф)-ВБЭ is set to the airfield level.	Э	➢ убедитесь, что стрелки высотомеров ВМ-15ПБ и указателей УВ-75-15ПБ установлены на нуль, а стрелка указателя УВ-75-15ф-ПБГ и ВБЭ на высоту аэродрома.
Compare the pressure on the altimeters with the barometric pressure at the airport of departure, and the pressure on the foot-graduated indicator with the pressure reduced to the mean sea level in accordance with the data of the air traffic control service.		Сравните давление на высотомерах с барометрическим давлением на аэродроме вылета(QFE), а указателя футов - с давлением, приведенным к среднему уровню моря(QNH), в соответствии с данными службы УВД.
Readings of the pressure indicators of the altimeters (foot-graduated, altimeter) must correspond to the data of the weather service with a tolerance of:		Показания указателей давления высотомеров (футомера) должны соответствовать данным метеослужбы с допуском:
± 1.5 mm Hg (2.0 hPa) for the УВ indicators ± 2.0 mm Hg (3.0 hPa) for the ВМ meters		± 1,5 мм рт.ст. (2,0 гПа) - для УВ ± 2,0 мм рт.ст. (3,0 гПа) - для ВМ

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CAUTION. IF READINGS OF THE PRESSURE INDICATORS OF THE ALTIMETERS (FOOT-GRADUATED ALTIMETER) EXCEED ALLOWABLE VALUES THE DEPARTURE IS ***PROHIBITED.***		***ПРЕДУПРЕЖДЕНИЕ.*** ЕСЛИ ПОКАЗАНИЯ УКАЗАТЕЛЕЙ ДАВЛЕНИЯ ВЫСОТОМЕРОВ (ФУТОМЕРОВ) ПРЕВЫШАЮТ ДОПУСТИМЫЕ ЗНАЧЕНИЯ - ВЫЛЕТ ***ЗАПРЕЩАЕТСЯ.***
➢ switch on the heating of the static pilot tube three minutes before departure	БМ	➢ включите обогрев ПВД, ППД за 3 мин до взлета
➢ read the checklist taxi holding point AT HOLDING POINT	ШТ	➢ зачитайте карту контрольной проверки НА ПРЕДВАРИТЕЛЬНОМ СТАРТЕ
➢ obtain the take-off conditions and clearance for taxiing-out to the runway.	2П	➢ получите условия взлета и разрешение на выруливание на ВПП
At the lineup:		***На исполнительном старте:***
➢ align the airplane with the runway centreline in the direction of the take-off, taxi to the final approach line 5 - 10 m and brake the wheels	КВС	➢ установите самолет по оси ВПП в направлении взлета, прорулите по прямой 5-10 м и затормозите колеса
➢ set corresponding mode of operation of the transponder CO-72M, TCAS.	КВС	➢ установите соответствующий режим работы ответчика СО-72М и TCAS
➢ make sure that the annunciators LEFT (RGT) T/REV MLFCNT and LEFT (RGT) ENG REVERSE are not illuminated	КВС, БМ	➢ убедитесь, что табло ЛЕВ (ПРАВ) РЕВЕРС НЕИСПР и ЛЕВ (ПРАВ) РЕВЕРС не горят
➢ make sure that the annunciators of the open position of the nozzle shutters of the engine are illuminated	БМ	➢ убедитесь, что табло сигнализации открытого положения створок сопел двигателя горят
➢ make sure that the switch AUTO - MAN of the nozzle shutter control is in the AUTO position	БМ	➢ убедитесь, что переключатель АВТ - РУЧН управления створками в положение АВТ - проверьте установку курса
➢ let out headlights and turn them into "takeoff and landing.	ШТ, КВС, 2П, БМ,	➢ выпустите фары и включите их в режим "Взлет-посадка
NOTE. Switching on the lights in the regime "Take-off - landing" is realized by the captain decision depending on the conditions of take-off.		***ПРИМЕЧАНИЕ.*** Включение фар в режим "Взлет-посадка" выполняется по решению КВС в зависимости от условий взлета.
➢ check the heading selection.	ШТ	➢ проверить курс взлета.
➢ cut off the air bleed from engines and air supply to the flight compartment and to the cargo compartment*)	2П	➢ отключите отборы воздуха от двигателей и подачу воздуха в кабину экипажа и пассажирскую кабину (при необходимости)
➢ read the checklist THE LINE UP	ШТ	➢ зачитайте карту контрольной проверки НА ИСПОЛНИТЕЛЬНОМ СТАРТЕ
➢ obtain the take-off clearance	КВС, 2П	➢ получите разрешение на взлет
➢ remind the crew about the speed value of V_1, V_R, V_2	КВС	➢ напомните экипажу величину скорости V_1, Vп.оп.,V_2
➢ report: "The first turn at a height... to the left (to the right) for the heading ... degrees"	ШТ	➢ доложите: "Первый разворот на высоте .... влево (вправо) на курс ... градусов"
➢ make sure that there are no obstacles on the runway and that the parking brake is disengaged	КВС, 2П	➢ убедитесь в отсутствии препятствий на ВПП и в выключении стояночного тормоза, дайте команду: «РЕЖИМ ВЗЛЁТНЫЙ»
➢ * holding the airplane with brakes set smoothly the mode of operation 74 - 76° for both engines according to HII-33 (air compressor - low pressure valves are opened)	БМ	➢ плавно установите обоим двигателям режим 74-76° по ИП-33 (КПВ КНД открыты)
➢ make sure that the engine operates normally	БМ	➢ убедитесь в нормальной работе двигателя
➢ release the brakes synchronously and in 2-3 seconds boost smoothly the engines mode of operation to the take-off power	КВС, 2П	➢ синхронно отпустите тормоза и через 2-3 с плавно увеличьте режим работы двигателей до взлетного
WARNING! WHEN TAKING OFF FROM THE SLIPPERY RUNWAYS, WHICH ARE COVERED WITH PRECIPITATIONS, BOOST THE MODE OF ENGINES OPERATION TILL MOVING OFF THE AIRPLANE FROM REST BUT DO NOT EXCEED 74-76° ACCORDING TO ИП-33, RELEASE THE BRAKES SYNCHRONOUSLY AND, AT THE BEGINNING OF THE TAKE-OFF RUN, SMOOTHLY AND SYNCHRONOUSLY		***ВНИМАНИЕ!*** ПРИ ВЗЛЕТЕ СО СКОЛЬЗКИХ ВПП, ПОКРЫТЫХ ОСАДКАМИ, УВЕЛИЧЬТЕ РЕЖИМ РАБОТЫ ДВИГАТЕЛЕЙ ДО СТРАГИВАНИЯ САМОЛЕТА, НО НЕ ВЫШЕ 74-76° по ИП-33, СИНХРОННО ОТПУСТИТЕ ТОРМОЗА И В НАЧАЛЕ РАЗБЕГА ПЛАВНО И СИНХРОННО УВЕЛИЧЬТЕ РЕЖИМ РАБОТЫ ДВИГАТЕЛЕЙ ДО ВЗЛЕТНОГО

Appendix 4: AN-74TK Flight Manual

5.1. ENGINE FAILURE

5.1.1. General

Engine failure features
1. Turning and rolling of aircraft to the failed engine side.
2. The annunciator RGT ENG FAIL (LEFT ENG FAIL).
3. The intermittent signal at crew telephone receives is sounding.
4. The decreasing of engine rotational speed.

WARNING! IT IS NECESSARY TO STOP ENGINE, TO INFORM THE ATC DISPATCHER AND LAND THE AIRCRAFT AT THE NEAREST AERODROME AFTER ILLUMINATION OF "LEFT ENG-HI VIBR" ("RGT ENG-HI VIBR") PANEL.

After engine failure :	
- set the FUEL OFF LFT (FUEL OFF RGT) lever of the failed engine to the SHUT OFF position	C, C-FE, C-CO
- switch off the failed engine generator	C
- close the failed engine fuel emergency shut-off cock crane	C, C-FE, C-CO
- disconnect the air bleeding of failed engine	CO
- disconnect the air conditioning system (AIR COND) of the cargo compartment	CO
- inspect the opening of cross-feed valve by illumination CROSS-FEED VALVE OPEN at the hydraulic system panel. in the case of the annunciator non-illumination, open the cross-feed valve setting the switch CROSS-FEED VALVE to the OPEN position	C
The procedure of air bleeding use for AIR COND after engine failure:	
At the take-off or climb:	
- start APU at height circuit, but at least 400 m	C
- start the air bleeding at AIR COND of both cabins from APU, disconnect the air bleeding from engine	CO
In the cruising flight:	
- start APU at height lower than 6000 m	C
- start the air bleeding at AIR COND of both cabins from APU, disconnect the air bleeding from engine.	CO
5.1.2. Engine failure at take-off run ($V \leq V_1$)	
Interrupt the take-off, for this:	
- set the engine control levers to the IDLE position, keeping the aircraft from turning and rolling using rudder pedals declining and using asymmetrical wheels braking (if it is necessary)	C

- decline the control wheel beyond the neutral position	C
- set REV lever of operating engine to the maximum reverse thrust position	C-CO
- extend the spoilers	C
- apply the main braking	C
- turn off the thrust reversal (if it is necessary) for decreasing side-ways deflection of the airplane at the run end under the speed close to taxing one	C-CO
- carry out the operations in accordance with para. 5.1.1	C
<u>5.1.3. Engine failure at take-off run (V > V_1)</u>	
Operating engine is automatically switched to the extreme regime EM LEFT (EM RGT)	
Continue takeoff, for this:	
- report that "emergency power condition on"	FE
- keep the aircraft from turning and rolling using rudder pedals, ailerons deflecting	C
- carry out the lifting of nose landing gear at the 175...230 km/h speed	C
- provide the incidence angle 7...8° using automatic pilot control (APC) (2...3° in pitch)	C
- after aircraft lift-off provide roll to 3° to the operating engine side, no performing slip (slip indicating ball shall be declined at 1/4 diameter to rolling side)	C
- pull up the aircraft to climbing with the simultaneous increase of the speed up to 205...250 km/h	C
- at 10 m height retract the landing gear and continue climbing keeping 205...250 km/h speed	C-CO
- inspect and report the height and speed change	CO
- inform the air traffic control (ATC) dispatcher	C, C-CO
- at 400 m height increase the speed to 250...290 km/h, retract flaps, increasing simultaneously the speed to 285...315 km/h on completion of the flaps retraction and converting the operating engine to the extreme intermediate regime	C-CO
- in the process of retracting do not permit the height loss	C
Remove the control wheel forces using elevator trimming tab	

<u>NOTE</u>. The flaps retracting generates the over-balancing of the rudder pedals connected with changing of rudder first link gear ratio. This fact demands to increase the pedal declining for the aircraft balancing to 4/5 travel

- carry out the operations in accordance with para. 5.1.1	C
- fulfil the circuit flight at 300...320 km/h speed	C
- fulfil the turning with rolling no more than 15°	C
- come to decision about landing at aerodrome of departure or at the nearest alternative aerodrome	C
- perform landing in accordance with recommendation of subsection 4.23	C

Appendix 5: Crew Actions in Specific Situations

AN-74TK-100
CREW ACTIONS IN SPECIFIC SITUATIONS

ABNORMAL PROCEDURES

1 Engine failure.
1.1 General quidlines.

Engine failure features:
1. Turning and rolling of aircraft to the failed engine side. 2. The annunciator RGT ENG FAIL (LEFT ENG FAIL) is on. 3. The intermittent signal at crew telephone receivers is sounding. 4. The engine rotational frequency is decreasing.

WARNING! WHEN "LEFT ENG – HI VIBR" ("RGT ENG – HI VIBR") ANNUNCIATOR IS ON, TURN THE ENGINE OFF, REPORT TO ATC DISPATCHER AND LAND AT THE NEAREST AERODROME.

When engine failure occurs:

(1) – STOP RGT (STOP LEFT) lever of the failed engine to the STOP position	Set	F E
(2) – Generator of the failed engine	Switch off	F E
(3) – Fuel emergency shut-off cock of the failed engine	Close	F E
(4) – Failed engine air bleed	Switch off	F E
(5) – Air conditioning system of the cargo compartment	Switch off	F E
(6) – Opening of cross-feed valve when CROSS-FEED VALVE OPEN annunciator is on at the hydraulic system panel.	Inspect	C
(7) If the annunciator is not on, cross-feed valve	Open	C
The procedure of air bleed use at air conditioning system when engine failure occurs:		
<u>At the take-off or ascending:</u>		
(a) – at height of 500 m, but at least 400 m, APU	Launch	F E
(b) – air bleed at air conditioning system of both cabins from APU	Switch on	F E
(c) - air bleeding from engine	Switch off	F E
<u>In the cruising flight:</u>		
(a) – at height lower than 6,000 m APU	Launch	F E
(b) – air bleed at air conditioning system of both cabins from APU	Switch on	F E

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CREW ACTIONS IN SPECIFIC SITUATIONS

1.2. Engine failure at take-off run ($V<V_1$)		
Interrupt the take-off, for this:		
(1) – engine control levers to the IDLE position	Set	FE
(2) – control wheel beyond the neutral position	Decline	C
(3) – REV lever of operating engine to the maximum reverse thrust position	Set	FE
(4) – spoilers	Extend	FE
(5) – main braking	Apply	C
(6) – thrust reversal for decreasing side-ways deflection of the airplane at the run end under the speed close to taxiing one, but at most 60 km/h, if necessary	Switch off	FE
→(7) – operations in accordance with para. 1.1 (1) - (7).	Perform	A

FE

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CREW ACTIONS IN SPECIFIC SITUATIONS

1.3. Engine failure at take-off run (V>V1)		
Continue take-off, for this:		
(1) - aircraft from turning and rolling using rudder pedals, ailerons deflecting	Keep	C
(2) – lifting of nose landing gear at the 175...230 km/h speed	Carry out	C
(3) – incidence angle 7...8° using automatic pilot control (2..3° in pitch)	Provide	C
(4) – after aircraft lift-off roll to 3° to the operating engine side, no allowing slip	Provide	C
(5) – aircraft to ascending with the simultaneous increase of the speed up to 205…245 km/h	Pull up	C
(6) ~ at 10 m height the landing gear	Retract	C-CO
(7) – to the ATC dispatcher	Report	C, C-CO
(8) – flaps, increasing simultaneously the speed to 285...315 km/h on completion of the flaps retraction and converting the operating engine to the maximum continuous power	Retract	C-CO
NOTE. The flaps retracting results in over-balancing of the rudder pedals connected with changing of rudder first link gear ratio, which demands to increase the pedal declining for the aircraft balancing to 4/5 travel.		

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Цей переклад з російської мови на англійську мову вчинено мною, перекладачем Соловйовим Андрієм Анатолійовичем____________________________________

Appendix 6: Extracts from AN-74 Operations Manual

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English		Русский
3.2 ACTION IN COMPLEX SITUATIONS		**3.2 ДЕЙСТВИЯ В СЛ СИТУАЦИЯХ**
3.2.1 Engine failure		*3.2.1 Отказ двигателя*
3.2.1.1 General notes.		3.2.1.1 Общие указания.
Symptoms engine failure:		*Признаки отказа двигателя:*
1. Torn and bank of the airplane to the side of faulty engine.		*1. Разворот и кренение самолета в сторону отказавшего двигателя.*
2. Warning annunciator LEFT ENG-FAIL (RGT ENG-FAIL) illuminates.		*2. Горит табло ПРАВ ДВИГ - ОТКАЗ (ЛЕВ ДВИГ - ОТКАЗ).*
3. Intermittent buzzer warning sounds in the headphones of the crew members.		*3. Звучит прерывистый сигнал в телефонах членов экипажа.*
4. Engine rotational speed loss.		*4. Падение частоты вращения роторов двигателя*
ATTENTION!		***ВНИМАНИЕ!***
AT FIRE OF A SCOREBOARD "THE LEFT ENGINE - DANGEROUS VIBRATIONS" ("RIGHT-HAND DRIVE - DANGEROUS VIBRATIONS") ENGINE STOP, REPORTED AIR TRAFFIC CONTROLLERS AND TO LAND AT THE NEAREST AIRFIELD.		*ПРИ ЗАГОРАНИИ ТАБЛО "ЛЕВ ДВИГ - ОПАСН ВИБР" ("ПРАВ ДВИГ - ОПАСН ВИБР") ДВИГАТЕЛЬ ОСТАНОВИТЕ, ДОЛОЖИТЕ ДИСПЕТЧЕРУ УВД И ВЫПОЛНИТЕ ПОСАДКУ НА БЛИЖАЙШЕМ АЭРОДРОМЕ.*
When engine failure:		*При отказе двигателя:*
❖ set the lever RIGHTS STOP (STOP LEV) engine failed to STOP	КВС-БМ	❖ установите рычаг СТОП ПРАВ (СТОП ЛЕВ) отказавшего двигателя в положение ОСТАНОВ
❖ switch off the failed engine generator	КВС-2П	❖ отключите генератор отказавшего двигателя
❖ close the failed engine fuel emergency shut-off cock crane	КВС-БМ	❖ закройте пожарный кран отказавшего двигателя
❖ disconnect the air bleeding of failed engine	КВС-БМ	❖ отключите отбор воздуха от отказавшего двигателя
❖ disconnect the air conditioning system (AIR COND) of the cargo compartment	КВС-БМ	❖ отключите СКВ транспортной кабины
❖ inspect the opening of cross-feed valve by illumination CROSS-FEED VALVE OPEN at the hydraulic system panel, in the case of the annunciator non-illumination, open the cross-feed valve setting the switch CROSS-FEED VALVE to the OPEN position	КВС	❖ проконтролируйте открытие крана кольцевания по загоранию табло КРАН КОЛЬЦЕВ ОТКРЫТ на щитке гидросистемы. В случае незагорання табло, откройте кран кольцевания, установив переключатель КРАН КОЛЬЦЕВ в положение ОТКР
The procedure of air bleeding use for AIR COND after engine failure:		Технология использования отбора воздуха на СКВ при отказе двигателя:
<u>At the take-off or climb:</u>		<u>На этапах взлета или набора высоты:</u>
❖ start APU at height circuit, but at less 400 m	КВС-БМ	❖ на высоте круга, но не менее 400 м, запустите ВСУ
❖ start the air bleeding at AIR COND of both cabins from APU, disconnect the air bleeding from engine	КВС,2П	❖ включите отбор воздуха на СКВ обеих кабин от ВСУ, отбор от двигателя выключите
<u>In the cruising flight:</u>		<u>На этапе крейсерского полета:</u>
❖ start APU at height lower than 6000 m		❖ на высотах ниже 6000 м запустите ВСУ
❖ start the air bleeding at AIR COND of both cabins from APU, disconnect the air bleeding from engine.		❖ включите отбор воздуха на СКВ обеих кабин от ВСУ отбор от двигателя выключите
3.2.1.2. Engine failure at take-off run ($V < V_1$)		*3.2.1.2. Отказ двигателя на разбеге ($V<V_1$)*
<u>Interrupt the take-off, for this:</u>		<u>Взлет прекратите, для чего:</u>
❖ set the engine control levers to the IDLE position, keeping the aircraft from turning and rolling using rudder pedals declining and using asymmetrical wheels braking (if it is necessary)	КВС	❖ удерживая самолет от разворота и кренения отклонением педалей РН, элеронов, а при необходимости и несимметричным торможением колес, установите РУД в положение ЗМГ
❖ decline the control wheel beyond the neutral position	КВС	❖ отклоните штурвал от себя за нейтральное положение
❖ set REV lever of operating engine to the maximum reverse thrust position	КВС-БМ	❖ установите рычаг РЕВ работающего двигателя в положение максимального реверса
❖ extend the spoilers	КВС-БМ	❖ выпустите интерцепторы

❖ apply the main braking	КВС	❖ примените основное торможение
❖ turn off the thrust reversal (if it is necessary) for decreasing side-ways deflection of the airplane at the run end under the speed close to taxing one	КВС-БМ	❖ при необходимости, для уменьшения бокового увода в конце пробега на скорости близкой к скорости руления, но не более 80 км/ч, выключите реверс тяги
❖ carry out the operations in accordance with para. 3.2.1.1.	БМ	❖ выполните действия в соответствии с п. 3.2.1.1.
3.2.1.3. Enoine failure at take-off run (V > V_1)		*3.2.1.3. Отказ двигателя на разбеге (V>V_1)*
Continue takeoff, for this:		Взлет продолжайте, для чего:
❖ keep the aircraft from turning and rolling using rudder pedals, ailerons deflecting	КВС	❖ удерживайте самолет от разворота и кренения отклонением педалей РН, элеронов
❖ carry out the lifting of nose landing gear at the 175...225 km/h speed.	КВС	❖ выполните подъем передней опоры шасси на скорости 175...225 км/ч. > 180
❖ provide the incidence angle 7...8° using automatic pilot control (APC) (2...3° in pitch)	КВС	❖ создайте угол атаки 7...8° по УАП (угол тангажа 2...3^0)
❖ after aircraft lift-off provide roll to 3° to the operating engine side, no performing slip C (slip indicating ball shall be declined at 1/4 diameter to rolling side)	КВС	❖ после отрыва самолета создайте крен до 3° в сторону работающего двигателя, не допуская скольжения (шарик указателя скольжения должен быть отклонен в сторону крена на 1/4 диаметра)
❖ pull up the aircraft to climbing with the simultaneous increase of the speed up to 205...245 km/h	КВС	❖ переведите самолет в набор высоты с одновременным разгоном до скорости 205...245 км/ч
❖ at 10 m height retract the landing gear and continue climbing keeping 205...245 km/h speed α= 7-8°	КВС-БМ	❖ на высоте 10 м уберите шасси и продолжайте набор высоты, сохраняя скорость 205...245 км/ч α= 7-8°
❖ inspect and report the height and speed change	2П	❖ контролируйте и докладывайте изменение скорости к высоты
❖ inform the air traffic control (ATC) dispatcher	КВС	❖ доложите диспетчеру УВД
❖ at 400 m height increase the speed to 250...235 km/h, retract flaps, increasing simultaneously the speed to 285...310 km/h on completion of the flaps retraction and converting the operating engine to the extreme intermediate regime	КВС	❖ на высоте 400 м увеличьте скорость до 250...235 км/ч, уберите закрылки с одновременным увеличением скорости к концу уборки закрылков до 285...310 км/ч и переводом работающего двигателя на номинальный режим:
❖ in the process of retracting do not permit the height loss	КВС	❖ в процессе уборки не допускайте потери высоты.
❖ Remove the control wheel forces using elevator trimming tab	КВС	❖ Усилия ка штурвале снимайте триммером РВ
NOTE.		***ПРИМЕЧАНИЕ:***
The flaps retracting generates the over-balancing of the rudder pedals connected with changing of rudder first link gear ratio. This fact demands to increase the pedal declining for the aircraft balancing to 4/5 travel		Уборка закрылков вызывает перебалансировку по педалям РН, связанную с изменением передаточного отношения первого звена РН, что требует увеличения отклонения педали для балансировки самолета до 4/5 хода
❖ carry out the operations in accordance with paraf 3.2.1.1	КВС-БМ	❖ выполните действия в соответствии с п. 3.2.1.1
❖ fulfil the circuit flight at 300...320 km/h speed	КВС	❖ полет по кругу производите на скорости 300...320 км/ч
❖ fulfil the turning with rolling no more than 15°	КВС	❖ развороты выполняйте с креном не больше 15°
❖ come to decision about landing at aerodrome of departure or at the nearest alternative aerodrome	КВС	❖ примите решение о посадке на аэродроме вылета или ближайшем запасном аэродроме
❖ perform landing in accordance with recommendation of subsection 4.23 of OM.	КВС	❖ произведите посадку в соответствии с рекомендациями подразд. 4.23 РЛЭ
3.2.1.4. Engine failure on the glide slope		*3.2.1.4. Отказ двигателя на глиссаде*
After failure:		При отказе:
❖ switch off the AFCS using button AP DISENG at control wheel	КВС	❖ отключите САУ кнопкой ОТКЛ АП на штурвале
❖ keep the aircraft from rolling and turning	КВС	❖ удерживайте самолет от кренения и разворота
❖ inform the ATC dispatcher	КВС	❖ доложите диспетчеру УВД
❖ keep the speed of pre-landing descent	КВС	❖ сохраняйте скорость предпосадочного

Appendix 7:

[Official Letterhead]: "Antonov Company"

1 AkademikaTupoleva Str., Kyiv,03062 Ukraine
Fax: 38(044) 400-81-44. Phone: 38(044) 454-31-49 Phone: 38(044) 454-32-33 E-mail: info@antonov.com

05.12.2017 724/11858-17
State Enterprise "Antonov"

To: Director of the National Bureau
of Air Accidents and Incidents Investigation
with Civil Aircraft

Phone/fax: (044) 351-43-23
e-mail: info@nbaai.gov.ua

Dear

I take this opportunity to express my respect to you and the staff of the National Bureau of Investigation of Air Accidents and Incidents with Civil Aircraft and inform you of the following.

In reply to your letter №1-1.9/605 dated 17.11.2017, and in addition to the letter of the ANTONOV State Enterprise #724/10470-17 dated 01.11.2017, I inform you that the specialists of the ANTONOV State Enterprise familiarized themselves with the materials provided regarding the accident of An-74TK-100 aircraft, reg. UR-CKC, at the Sao Tome Airport.

Concerning delivery of the conclusion of reliability ofthe instrument speed indications of the aircraft and other parametric information indications registered in ZBN-1-3 ser.3 of An-74TK-100, reg. UR-CKC, I inform you that the mathematical calculation of speed of An-74TK-100, reg. UR-CKC, on the runway indicates that the actual aircraft speed on the runway was approximately by 10 km/h lower than that recorded by the aircrafton-board recorder. Probably,this is caused by the incorrectlycalibrated characteristic of the instrument speed sensor. At the same time, some of parameters of systems were not registered at allat the flight data recorder. All this testifies to improper performance by the airline of the requirements of "Regulations on Flight Management System inAir Transport" No.895 of November 25, 2005 (paragraphs 7.3.9, 7.3.10.) ANTONOV State Enterprise has not developed the design and operational documentation regarding the replacement of ZBN-1-2 equipment with ZBN-1-3 ser.3equipment for An-74TK-100 aircraft, besides, ANTONOV State Enterprise has not participated in modification of the above-mentioned aircraft with this equipment,nor carried out the required tests in this case, which would exclude the above inconsistencies.

018505 LV

As assistance to the National Bureau on Air Accident and Incident Investigation with Civil Aircraft in investigation of the crash of An-74TK-100 aircraft, reg. UR-CRC, at Sao Tome Airport, I inform you that, according to the paragraph 2.3.1. ("Responsibility of AircraftPilot in Command")of Appendix 2 ("Flights Rules") to the Convention onInternational Civil Aviation, an aircraft PIC, regardless of whether he is flying the aircraft or not, shall bear the responsibility for flying the aircraft in accordance with the flight rules, except for those occurrences, where he can deviate from these rules, under the circumstances requiring thisas absolutely necessary for safety. In this case, at the time of take-off run on the runway, the airplane was stricken by a flock of birds, which unexpectedly appeared on the take-off course. Multiple hits of birds at the airplane led to failure of one of the engines and created danger of failure of the other engine at the initial stage of climb. This situation is not stipulated by the airworthiness standards, and actions of the pilot in this case are not regulated by the Flight Crew Operation Manual.

The pilot in command of the aircraft deliberately decided to abort the take-off at the speed exceeding the takeoff decision speed V, which was followed by the runway overrun, since an aircraft overrunduring the take-off is obviously less dangerous than an aircraft impact at failure of two engines at the initial stage of the climb. Thus, the pilot's actions were motivated by a state of emergency and aimed at minimizing the consequences of theoccurrence.

The simulation of An-74TK-100, reg. UR-CKC, take-off at the Sao Tome Airport with a mathematical model,which is based on the certification flight testresults, has made it possible to determine that, at the pilot's actions according to the provided recordsof BUR-3-1 ofAn-74TK-100 aircraft, UR-CKC, the aircraft would roll out of the runway (see the figure enclosed to the letter.)

In case of need to perform an aborted takeoff at the takeoff decision speed, the crew should have performed all the required braking actions specified in the Flight Crew Operation Manual. The crew carried out the take-off in the rated operational mode of engines (the "rated" operational mode of engines is specified in the report of SE "Ivchenko-Progress"), the takeoff decision speed exceeded the speed specified in the Flight Crew Operation Manual, the crew did not use the interceptors for braking.

Enclosure: The abovementioned graphic charton 1 sheet.

Regards,

First Vice-President /***signed***/

From the desk of Polubenskyi V.L. ph: 454-33-00

Appendix 8:

[Official Letterhead]:

IVCHENKO PROGRESS

UKRAINE, 69068, Zaporozhye, Ivanova, 2. Ph.: +380 (612) 650327, 654625 Fax: +380 (612) 654697.128922, 7690137 E-mail: progress@ivchenko-progress.com

Our Ref.#: 7819/KNIK of 14.11.2017

*To whom:*______________________

Enterprise: Cavok Air LLC, Kiev

Fax: ____________ e-mail: ____________

*From the desk of :*__________ *Ph.:* +____________

Total quantity of pages: _2 ____________

Dear Sergey V.,

According to the analysis of parametric recorders of engines No.708036312A006 and No. 708036412005 regarding the accident of An-74TK-100 UR-CKC aircraft at Sao Tome Airport on 29.07.2017, we send you the data on thrust and operation modes of the specified engines for the points requested by you. The engine parameters and operational modes are set out in the table:

Atmospheric conditions: Atmospheric Pressure at the aerodrome (QNH) = 1016 hPa.Surface Temperature = 25 degrees C. Ms = 0.2 (Points 2; 3; 4)

Point No.	***Flight Time Moment***	***Engine***	***Operation Mode***	Nfan, %	Nlow.pr, %	Nhigh.pr, %	***R, kgs***
1	***Breakaway at take-off run***	***right***	***0.7 nominal***	***63.3***	***72.5***	***85.1***	***- 2440 ****
		left	***0.7 nominal***	***65.6***	***73.1***	***85.8***	***- 2440 ****

2	***9:04:43 UTC***	***right*** ***left***	***Nominal*** ***Nominal***	***72.6*** ***75.0***	***72.5*** ***78.6***	***88.5*** ***89.4***	***- 3700 **** ***- 3700 ****
3	***Before bird penetration into the left engine***	***right*** ***left***	***> Nominal*** ***> Nominal***	***75.0*** ***76.9***	***78.7*** ***79.4***	***89.7*** ***90.4***	***- 3900 **** ***- 3900 ****
4	***After return of reverse RPM***	***right*** ***left***	***> Nominal*** ***~ Mcr***	***74.9*** ***69.4***	***79.1*** ***76.1***	***90.2*** ***88.3***	***- 3900 **** ***- 3360***

* ideal thrust.

The ideal thrust was calculated according to the altitude-speed performances of D-36 engine of series 1A, 3A and does not take into account:

- losses at air bleed for aircraft needs, anti-icing system and loading of aircraft accessories;

- losses connected with the external flow of the engine nacelle, engine air intake and jet deviation from the axial direction;

- losses connected with the thrust reverse setting.

SE "Antonov" can provide corrections on the indicated losses.

Yours faithfully,

Designer General **(*signed*)**