ISS 0803-3633

THE AIRCRAFT ACCIDENT INVESTIGATION BOARD/NORWAY
(AAIB/N)

REP.: 07/99

REPORT ON THE ACCIDENT TO VNUKOVO AIRLINE'S TUPOLEV TU-154M RA 85621 NEAR SVALBARD AIRPORT LONGYEAR, NORWAY ON 29 AUGUST 1996

SUBMITTED NOVEMBER 1999

The Aircraft Accident Investigation Board has compiled this report for the sole purpose of improving flight safety. The object of any investigation is to identify faults or discrepancies which may endanger flight safety, whether or not these are causal factors in the accident, and to make safety recommendations. It is not the Board's task to apportion blame or liability. Use of this report for any other purpose than for flight safety should be avoided.

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REPORT ON THE ACCIDENT TO VNUKOVO AIRLINE'S TUPOLEV TU-154M RA 85621 NEAR SVALBARD AIRPORT LONGYEAR, NORWAY ON 29 AUGUST 1996

Aircraft type:	Tupolev TU-154M
Registration:	RA 85621
Call sign:	VKO 2801
Owner:	Vnukovo Airlines 1st Ulitsa Relsovaya 12 Vnukovo Airport Moscow, 103027, Russia
User:	Same
Crew:	11 crew members, 4 in cockpit, 5 cabin attendants and 2 technicians
Passengers:	130
Accident site:	14.2 km (7.7 NM) east of Svalbard Airport Longyear. On top of the mountain Operafjellet at 907 m, in the Adventdal valley, Svalbard, Norway N 78° 12.846' E 016° 05.719'
Time of accident:	29 August 1996 at 08:22:23 hours

All times given in this report are UTC, if not otherwise stated. (The local time was UTC + 2 hours). All times given refer to the time of the impact recorded by a seismographic station (satellite-based clock) at Janssonhaugen in the Adventdal valley about 7 km from the accident site. The recorded time has been corrected for the time the seismic waves needed to reach the instruments. The flight recorder, voice recorder and tower communication recorder times were all adjusted to the recorded time of the impact.

NOTIFICATION

The Aircraft Accident Investigation Board/Norway (AAIB/N) was notified on 29 August 1996, at 08:50 hours (hrs), that an aircraft, callsign VKO 2801, was missing during an approach to Svalbard Airport Longyear. That an accident had happened was confirmed approximately one hour later, as the wreckage had been spotted by a helicopter at 10:06 hrs. This information had also been given to the Civil Aviation

Administration/ Norway (NCAA) and to the police. The organization of an investigation team was immediately initiated. The same day two inspectors departed the AAIB/N base in Oslo, and started the investigation. The next day the investigation team was reinforced by four inspectors.

The Russian authorities had been informed, and a Russian investigation team departed from Moscow arriving at Svalbard Airport Longyear on 30 August 1996. Mr. Nikolaj Khizhnjak from the Russian Federation Civil Aviation Administration (RFCAA), was appointed as the accredited representative to participate in the investigation. To assist him and the AAIB/N at Svalbard, Boris Gorjunov, Interstate Aviation Committee (IAC), Alexey Morozov (IAC), Gennady Petrov (State Scientific Research Institute), Boris Vorobjev (Vnukovo Airlines) and Abram Topaz (Tupolev factory) participated. The following investigation has been a joint effort by the IAC and AAIB/N. The IAC has been responsible for handling the investigations in Russia, especially the readout of the Cockpit Voice Recorder (CVR) and Flight Data Recorder (FDR) and the relations to Vnukovo Airlines including a test flight, all with the AAIB/N representatives as supervisors/ observers. The AAIB/N has been responsible for handling the accident site, all investigations in Norway and elsewhere, cooperating with the Norwegian police authorities, the NCAA and writing and distributing the report. The IAC and AAIB/N have agreed that the report be written in one of the official International Civil Aviation Organization (ICAO) languages, i.e. English.

In addition to the accredited representative, Boris A. Gorjunov held the important role of liason and was responsible for the smooth cooperation between the Russian Authorities, the Royal Norwegian Embassy in Moscow and the AAIB/N. The results of the investigations carried out in Russia have been reported to the AAIB/N. The participating investigators and experts under the leadership of V. D. Kofman (Vice-Chairman, the IAC), R. A. Teymourazov (Vice-Chairman-Chairman, the IAC), F. S. Tsivilyov (Head of Administration, the IAC), V. A. Trusov (Assistant Head of Administration, the IAC),V. E. Ovcharov (Assistant Head of Administration, the IAC), A. N. Morozov (Head of Department, the IAC), Yu. V. Chigirev (Head of Department, the IAC) and A. S. Belan (Head of Department, the IAC) include:

- A. N. Morozov — Participation in field work, restoration of information from the Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR), calculation and modelling of track, formulation of conclusions and recommendations.

  Registration of information during the test flight, compilation of processing program, processing of SSPI material, analysis of the processed results, compilation of the testflight report.

- V. E. Ovcharov — Compilation of the conclusions, analysis of the crew's actions and condition, experiments in analysing 'professiograms,' formulation of conclusions and recommendations.

  Preparations for the test flight, registration of information during flight, compilation of processing algorithms, analysis of processed results, and compilation of the test flight report.

- A. S. Belan — Deciphering, restoration, timekeeping and synchronisation of CVR information.

- A. N. Kuznetsov — Processing of FDR information.

- V. I. Poperechny — Deciphering and record-keeping of CVR information.

- V. A. Trusov — Restoration of FDR information, modelling of track, formulation of conclusions and recommendations.

- A. V. Klyuyev — Analysis of the crew's condition and actions.

- A. N. Katchalkin — Analysis of the crew's condition and actions.

Other participating experts include:

- G. L. Lifshits, S. V. Abel, A. A. Domorod and I. B. Rozenfeld of the Russian Federation CAA Scientific Center for Flight Safety Investigations.

- P. I. Kruglov, G. G. Petrov and A. S. Androsov of the State Scientific Research Institute 'Aeronavigatsiya.'
  G. G. Petrov was also involved in the test flight registrating information during the flight, analysis and processing of information from the laboratory aircraft and analysis of the processed results.

- A. D. Filippov and V. P. Belov of the M. M. Gromov Scientific Flying Research Institute.

- V. G. Nekrasov of the IAC's Aviation Register.

- B. S. Vorobiev, N. S. Vinogradov, B. G. Skadin, V. V. Popov and others from Operations and technical workshops, Vnukovo Airlines.

- A. S. Rasputikov (analysis of meteorological conditions and forecasting) of the Russian Federation's BPFAS State Institute.

The test flight crew comprised:

Leading pilot	Assistant head of Civil Aviation Research Institute for OLR, 1st class test pilot, R. T. Esayan.
Second pilot	Pilot instructor at Vnukovo Airlines, 2nd flight department, 1st class pilot, N. S. Vinogradov.
Navigator	Senior navigator inspector at Vnukovo Airlines, 1st class Civil Aviation navigator, G. S. Chernichenko.
Flight Engineer	Flight engineer instructor at Vnukovo Airlines, 2nd flight department, 1st class flight engineer, O. S. Chaykovsky.
Supervisors	Commander at Vnukovo Airlines 2nd flight department, 1st class Civil Aviation pilot B. S. Vorobyov. Two Inspectors of accidents from the AAIB/N and an interpreter.

As the AAIB/N is a small organisation, with relatively limited resources, this investigation has benefitted from the IAC, as well as other Russian institutions dedicated to flight safety, putting their knowledge, expertise and resources at the disposal of the AAIB/N.

SUMMARY

On 29 August 1996, at 08:22:23 hours, a Russian Tupolev TU-154M, RA 85621 hit the mountain Operafjellet on Svalbard, Norway and crashed while on a localizer (LLZ) approach (offset) to runway 28 at Svalbard Airport Longyear. The aircraft was operating as Vnukovo Airlines flight VKO 2801 from Moscow to Longyear, with a crew of 11 and 130 passengers. All on board perished instantly. The subsequent investigation has led to the conclusion that the aircraft was airworthy and that the crew was in control of the aircraft when it hit the ground. The accident took place in daylight under Instrument Meteorological Conditions (IMC). The crew was well prepared for an Instrument Landing System (ILS) approach to runway 10. However, the traffic that morning was using runway 28 for take-off and landing, due to the wind direction. Owing to limited knowledge of the English language, the crew had difficulty communicating their intention of making an approach to runway 10, which was within the aircraft performance criteria, to the AFIS officer (Aerodrome Flight Information Service) on duty. In addition, the crew was not fully aware of the status of an AFIS officer compared to the authority of a Russian air traffic controller, with the result that the crew conceived the safety information given as an instruction. Accordingly, the crew decided to use runway

28 for landing while the aircraft was descending to the initial approach altitude. The navigator, in particular, became very busy preparing the new approach in addition to taking care of the pilot duties controlling the aircraft laterally and communicating with the AFIS. The frequency 109.5 MHz for the localizer approach to runway 28 was set correctly. The rule requiring the setting of the landing course on the Horizontal Situation Indicator (HSI) was adhered to, and 283° was set instead of the approach course 300°. Most probably the same course 283° was set on the GPS (Global Positioning System), which was being used as backup navigational aid. In the base turn overshooting the approach centerline and rolling out on final, the crew showed a lack of situational awareness, being confused by differences in the instrument indications. Instead of intercepting the approach centerline to correct for the aircraft being about 3 km to the right, the crew continued with a slowly increasing right displacement until impact. The interpretation of the CVR shows disagreement within the crew as whether to correct to the left or right. Descent was started without positive control of the lateral navigation. In spite of uncertainty as to whether they were approaching correctly or not, the crew did not discontinue the approach and climb to a safe altitude to solve the problem. The checks and the flight inspections of the ground navigational aids have not resulted in any indications of radiation anomalies within the ± 10° sector of the localizer authorized for use. Eighteen significant factors have been identified as leading the flight to the disaster. For example, inadequate planning, unsatisfactory crew resource management and monitoring, a lack of a suitable procedure for offset localizer approaches in connection with an inappropriate rule requiring the landing course to be set instead of the localizer course, not solving navigational problems at a safe altitude, not discontinuing the approach when procedural uncertainties exist, a limited knowledge of the operating language and the actual airspace with respect to service given. The two Boards, the Interstate Aviation Committee and the Aircraft Accident Investigation Board have submitted 19 safety recommendations to be reviewed by the companies involved and the authorities.

1 FACTUAL INFORMATION

1.1 History of the flight

1.1.1 On 29 August 1996, Vnukovo Airlines flight VKO 2801, with the registration RA 85621, departed Vnukovo Airport (UUWW) Moscow at 04:44 hrs bound for Svalbard Airport Longyear (ENSB), Norway. It was a chartered flight with workers and their families to the coal mining towns of Barentsburg and Pyramiden at Svalbard. The estimated flight time was 3 hours and 30 minutes. The alternates for Svalbard Airport Longyear were Murmansk (ULMM) and Severomorsk (XLMV) airports.

1.1.2 The flight departed with 141 people on board. These included 127 adults, 3 children and a crew of 11. Included in the crew were two technicians for servicing the

aircraft during the ground stop at Svalbard Airport Longyear. The flight crew consisted of two pilots (both aircraft commanders), one navigator and one flight engineer. One of the pilots, the Pilot-in-Command (PiC), had had previous experience in landing at Svalbard Airport Longyear. The other commander, formally the co-pilot on this flight, was the piloting pilot having his route introduction because he had not flown to this airport before.

1.1.3 The flight proceeded from Moscow directly on routing W 29 to Padun (just west of Murmansk), thereafter crossing the border into Bodø Oceanic FIR at BARMO over the Barents Sea, cruising at FL 350 with an average indicated airspeed of 500 km/h. From this point, the flight proceeded overhead Bear island (BJO) NDB (Non Directional Beacon), abeam Isfjord (ISD) NDB to Advent (ADV) NDB. The flight was normal until the start of the descent.

1.1.4 Before radio contact with Longyear Information, the crew went through the detailed landing procedure for runway 10 at Svalbard Airport Longyear. At 07:55:40 hrs, at a distance of about 265 km from the airport, the crew requested a clearance to start descent. Due to lack of communication with Bodø ATCC, a descent clearance could not be obtained. But after contact had been established with Longyear Information, the AFIS officer on duty at 07:56:08 hrs transmitted to VKO 2801 that there was no conflicting traffic for descent to 6 000 ft, the transition level was FL 65 and the QNH below 1005 hPa, after which the descent was commenced. A little later, the crew received additional information consisting of runway in use 28, wind 230° 16 knots, visibility more than 10 km, rain showers, clouds: few at 1 500 ft, scattered at 2 000 ft and broken at 4 000 ft, temp. 5 °C, dewpoint -0 °C and QNH 1005 hPa. (Later changed to 1006 hPa).

1.1.5 The crew tried to request runway 10 for landing, but the request was not understood as such by the AFIS officer on duty at Longyear Information due to language difficulties. Longyear Information transmitted the actual weather, and the crew was informed that the runway in use at Svalbard Airport Longyear was 28. The crew started the descent and confirmed, on request from the AFIS, that their routing would be via ISD. During the descent, the crew repeated their request for the use of runway 10 for landing. Again, the request was not understood due to misuse of the phrase 'runway in use'. The AFIS officer repeated that the runway in use at Longyear was 28. The crew accepted this, and made preparations for the approach to runway 28.

1.1.6 The navigational aids for the approach to runway 28 were tuned according to the information on the Jeppesen approach chart Svalbard, Norway 11-2 dated 21 JAN 94 (see Appendix 1). The magnetic runway heading of 283° was according to rules and procedures set in both HSI course windows. The magnetic localizer course of 300° for the 17° off-set approach was not used. A GPS receiver, installed on the central flight instrument panel, was used as an approach back-up navigational aid. The crew made no requests to the AFIS at any time for VDF bearings (QDM - the magnetic heading 'to steer to reach the station') during the approach.

1.1.7 The descent continued without deviations and the aircraft reached 5 000 ft (1 524 m), which is the minimum altitude to ADV and the initial approach altitude) on the latest QNH of 1006 hPa at 08:10:36 hrs. From about 10 000 ft until impact, the flight was carried out in Instrument Meteorological Conditions (IMC). The flight was controlled in automatic stabilization mode (AFCS ABSU-154) in pitch and roll channels. The navigator controlled the lateral navigation of the aircraft by operating the turn knob on the autopilot. After passing abeam ISD, the crew set course for ADV.

1.1.8 When the flight was overhead ADV, at 08:15:32 hrs, the crew reported the position to Longyear Information and entered the base turn with a bank angle of 22°. At 08:16:28 hrs, the aircraft came out of this turn on magnetic heading 160°, which means that the crew made a correction for the wind drift in the correct direction. However, no attempt was made to intercept the magnetic course 155° outbound from ADV.

1.1.9 During the right turn to the base turn, the FDR registered a malfunction in the electric trimming mechanism (MET-4U). While the bank angle was increasing, the AFCS - to stabilize the flight altitude - shifted the pitch servogear (actuating rod RA-56) to pitch-up. After the bank angle had been established at 08:15:36 hrs, the aircraft was balanced in the pitch channel and the pitch actuating rod stopped moving. At the same time, the electric trimming mechanism continued moving the controls (back) to pitch-up. The AFCS moved the pitch actuating rod to pitch-down to stabilize the flight altitude. This process continued until 08:15:58 hrs, when the piloting pilot (the co-pilot) turned off the AFCS servogear in the pitch channel by 'overriding it'. At 08:16:42 hrs, the crew, after having trimmed the aircraft into horizontal flight, again turned on the automatic flight stabilization mode. After this, there were no registered malfunctions in the electric trimming mechanism.

1.1.10 At 08:17:08 hrs, the crew started the turn to bring the aircraft out on the magnetic inbound course 300°, as prescribed by the approach chart. The distance from the airport at this moment was 14 NM (25.9 km), as prescribed by the approach chart, but the lateral deviation from the outbound magnetic course 155° from ADV was 2 NM (3.7 km) to the left.

1.1.11 During the turn, the crew confirmed they would next report established inbound at 8 NM - 08:17:57 hrs Navigator: 'Ah, abeam eight miles 2801 inbound' - to which the AFIS officer, at 08:17:59 hrs, replied: 'Correct'. This was the last radio communication between the crew and Longyear Information. At that time (08:17:57 hrs), the AFIS officer checked the VDF display (VHF Direction-Finding) and observed a QDM close to 300° M which indicated that VKO 2801 was where he expected the aircraft to be at that time during approach.

1.1.12 At 08:18:24 hrs, after the radio altimeter aural warning had been activated twice, the co-pilot took the controls and, after 6 seconds, turned the autopilot pitch

channel off by 'overriding' it. From then on until the impact, the flight continued in autopilot mode in the roll channel, and in manual mode in the pitch channel. At 08:18:37 hrs, the flaps were extended to 15° and the horizontal stabilizer changed to -3°.

1.1.13 The aircraft passed through the localizer centerline and when the turn had been completed, the aircraft rolled out on a magnetic heading of 290°. At this time, there was a discussion within the crew as to whether or not the final turn had been made at the correct time (08:19:06 hrs Co-pilot: 'Maybe we took the fourth (final turn) too early?'; 08:19:11 hrs PiC: 'Let's level out!'; 08:19:14 hrs PiC: 'No, (? it should be) to the right'. The discussion led to the roll out of the turn to final approach and a corrective turn to the right to magnetic heading 306°. At this point, the aircraft was 14.7 NM (27.4 km) from the airport, 2.8 km to the right of the approach centerline, maintaining an altitude of 5 000 ft (1 520 m) and the crew increased the flapsetting to 28°. The airspeed was reduced to approx. 330 km/hr (180 kt).

1.1.14 Instead of intercepting the centerline, the crew continued the flight on the right side, more or less paralleling the localizer course with minor heading changes. At 08:19:51 hrs, the Navigator stated the distance to the airport: 'But it's fourteen here' after a discussion between the two pilots of starting the descent. At 08:20:17 hrs, the PiC ordered: 'No! Turn to the left!' following a statement from the Navigator two seconds earlier: 'It should be a corrective turn'. This resulted in a turn to the left to magnetic heading 291° which, taking the drift into consideration, resulted in a track close to 300°. At this point, the lateral deviation from the approach centerline was 3.7 km to the right. During this corrective turn, at 08:20:24 hrs, 12.5 NM (23.2 km) from the airport, the aircraft started descending. Three seconds earlier, the Navigator stated: 'It's thirteen. Let's descend!' which is the prescribed distance on the approach chart for start of the final descent.

1.1.15 At 08:21:13 hrs, in a position 10.3 NM from the airport, the crew made yet another corrective turn to the right. In the communication at 08:21:19 hrs, a command from an Unidentified crew member - the Navigator? - was registered: 'To the right.' The corrective turn was completed at 08:21:24 hrs to a magnetic heading of 300°. Meanwhile the aircraft continued descent with a rate of 900 to 1 260 ft/min (5-7 m/s).

1.1.16 At 08:22:05 hrs, the aircraft started turning towards the left. The distance to the airport was 8 NM (14.8 km). On this part of the final approach, the aircraft apparently entered an area of strong turbulence created by the proximity to the mountains. This is evident from the substantial deflections of the actuating rods in the pitch and roll channels (from the dampers), as well as considerable deflections of the controls by the co-pilot.

1.1.17 During initial approach and at a safe altitude, the radio altimeter warning had been activated several times, which meant that it was less than 750 m between the aircraft and underlying terrain. On final approach, the Ground Proximity Warning

System (GPWS) activated 9 seconds before impact and the warning lasted until impact. According to the FDR readout, the crew reacted to the warning by applying power and initiating a pitch-up. Six seconds before impact, the radio altimeter warning was activated and lasted until impact.

1.1.18 At 08:22:23 hrs, 7.7 NM (14.2 km) from the airport at an altitude of 2 975 ft (907 m), the aircraft collided with the top of the mountain Operafjellet 3.7 km to the right of the approach centerline. The aircraft was destroyed and all occupants perished instantly.

1.2 Injuries to persons

INJURIES	CREW	PASSENGERS	OTHERS
FATAL	11	130	
SERIOUS			
MINOR/NONE			

1.3 Damage to aircraft

The aircraft was completely destroyed on impact with the mountain.

1.4 Other damage

None.

1.5 Personnel information

1.5.1 The Pilot-in-Command

1.5.1.1 The Pilot-in-Command, male, aged 44, held a pilot licence I P No. 021942. The licence was issued 1 February 1995 and was valid until 19 February 1997. He underwent his last medical examination 19 February 1996. The PiC had an approved and unrestricted medical certificate. The PiC was qualified as an aircraft commander and flight instructor on TU-154 aircraft. The PiC was employed by the Crew group No. 2 of Vnukovo Airlines. Besides his flying duties, he performed no other work professionally for the airline.

1.5.1.2 The PiC started his basic training at Tambov military flight training academy in 1973.

1.5.1.3 The PiC's last periodical training was carried out on 11 August 1996 in a simulator and his last supervision flight was performed on 19 November 1995 on the route Vnukovo - Athens - Vnukovo. He was qualified for CAT II approaches.

1.5.1.4 The PiC had not previously been involved in any aircraft accidents. A pre-flight briefing for the flight to Svalbard Airport Longyear had been carried out the day before the accident.

1.5.1.5 The PiC had acquired a total flight time of 6 232 hrs, 1 940 of which were on Tu-154 aircraft.

FLYING EXPERIENCE	TOTAL	ON TYPE
LAST 24 HOURS	3:38	3:38
LAST 3 DAYS	9:48	9:48
LAST 30 DAYS	-	-
LAST 90 DAYS	116:13	116:13

1.5.1.6 The PiC had made 3 flights to Svalbard Airport Longyear before the accident flight, none of these with approaches to runway 28.

1.5.1.7 The PiC had had a rest period of 43 hrs before the flight. He underwent a standard medical check before departure.

1.5.2 The co-pilot

1.5.2.1 The co-pilot, male, aged 58, held a pilot licence P-P No. 002472, First class. The licence was issued on 13 August 1975 and was valid until 19 Desember 1996. He underwent his last medical examination on 19 December 1995. The co-pilot was an aircraft commander on aircraft type TU-154 in squadron No. 2 of Aircraft Group No. 2 at Flight Operations of Vnukovo Airlines. He was a flight instructor on TU-154 aircraft. The co-pilot had an approved and unrestricted medical certificate. Besides his flying duties, he performed no other work professionally for the airline.

1.5.2.2 The co-pilot started his basic training at Sasovo flight training center in 1960.

1.5.2.3 The co-pilot's last periodical training was carried out on 12 June 1996 and his last supervision flight was performed on 10 June 1996. His last simulator flight was made on 13 July 1996. The co-pilot was qualified for CAT II approaches.

1.5.2.4 The co-pilot had not previously been involved in any aircraft accidents. He attended a pre-flight briefing for the flight to Svalbard Airport Longyear with the flight crew the day before the accident.

1.5.2.5 The co-pilot had acquired a total flight time of 19 538 hrs, 10 177 of which were on TU-154 aircraft.

FLYING EXPERIENCE	TOTAL	ON TYPE
LAST 24 HOURS	3:38	3:38
LAST 3 DAYS	9:38	9:38
LAST 30 DAYS	13:13	13:13
LAST 90 DAYS	114:53	114:53

1.5.2.6 The co-pilot had not made any previous flights to Svalbard Airport Longyear. The accident flight was his introduction flight to this airport.

1.5.2.7 The co-pilot did not perform any flight duty the last days before the flight to Svalbard Airport Longyear. He underwent a standard medical check before departure.

1.5.3 The navigator

1.5.3.1 The navigator, male, aged 50, held a navigator licence I Sj. No. 001565. The licence was issued on 3 April 1995 and was valid until 25 April 1997. He underwent his last medical examination on 25 April 1996. The navigator was employed by Vnukovo Airlines in squadron No.1 in the Crew group No. 2 . The navigator had an approved and unrestricted medical certificate.

1.5.3.2 The navigator started his basic training at the Leningrad Forest Technical Academy, OLA GA in 1974.

1.5.3.3 The navigator's last periodical training was carried out on 12 July 1996 in a simulator. Last supervision flight was performed on 9 March 1996. A pre-flight briefing of the crew for the flight to Svalbard Airport Longyear was made the day before the accident.

1.5.3.4 The navigator has not previously been involved in any aircraft accidents.

1.5.3.5 The navigator had acquired a total flight time of 13 814 hrs, 4 646 of which were on TU-154 aircraft.

FLYING EXPERIENCE	TOTAL	ON TYPE
LAST 24 HOURS	3:38	3:38
LAST 3 DAYS	3:38	3:38
LAST 30 DAYS	38:13	32:28
LAST 90 DAYS	116:13	-

1.5.3.6 The navigator had previously made two flights to Svalbard Airport Longyear, with approaches to runway 10 only.

1.5.3.7 He was off duty the last 3 days before the accident. He underwent a standard medical check before departure.

1.5.4 The flight engineer

1.5.4.1 The flight engineer, male, aged 38, held a flight engineer licence I BI No. 002163 . The licence was issued on 7 February 1994 and was valid until 26 January 1997. He was qualified on the aircraft type TU-154. He underwent his last medical examination on 20 August 1996.

1.5.4.2 He started his basic training at the Kiev Institute for Civil Aviation Engineers (KII GA).

1.5.4.3 The flight engineer's periodical flight training was made in simulator on 12 July 1996. Last supervision flight was performed on 18 October 1995. The flight engineer attended a pre-flight briefing of the crew for the flight to Svalbard Airport Longyear the day before the accident.

1.5.4.4 The flight engineer had not previously been involved in any aircraft accidents.

1.5.4.5 The flight engineer had acquired a total flight time of 5 254 hrs on the aircraft type TU-154.

FLYING EXPERIENCE	TOTAL	ON TYPE
LAST 24 HOURS	3:38	3:38
LAST 3 DAYS	7:03	7:03
LAST 30 DAYS	7:03	7:03
LAST 90 DAYS	120:18	120:18

1.5.4.6 The flight engineer had previously made three flights to the Svalbard Airport Longyear.

1.5.4.7 He was off flight duty the two days preceding the accident flight. He underwent a standard medical check before departure.

1.5.5 The AFIS officer

1.5.5.1 The AFIS officer, male, aged 57, was authorized for AFIS duty in 1975. He had been an AFIS officer at Svalbard Airport Longyear for eight years altogether. His last refresher training was completed in 1995. At the time of the accident, he had been on duty for 3 hours and 22 minutes.

1.6 Aircraft information

1.6.1 The TU-154M is a medium-range transport aircraft with three turbofan engines, manufactured by the Tupolev Factory, which delivered the first two aircraft of this model on 27 December 1984. The aircraft is operated by a crew comprising two pilots, a flight engineer (minimum crew) with provisions for a navigator, and 5 cabin staff. This flight was dispatched with the navigator on the flight deck and two technicians to take care of the aircraft on the ground at Svalbard Airport Longyear.

Serial number:	86A 742
Date of manufacture:	14.01.87
Basic operating mass empty:	55.3 tons
Maximum take-off mass:	100 tons
Maximum payload:	18 tons
Maximum fuel:	39.75 tons
Maximum landing mass:	80 tons
Maximum number of seats:	164
Maximum cruising speed:	950 km/h
Range with maximum payload:	3 740 km
Range with maximum fuel and 5.45 tons payload:	6 600 km
Wingspan:	37.55 m

Length overall:	47.90 m
Height overall:	11.40 m
Diameter of fuselage:	3.80 m

Powerplant: Three Solviev D-30KU-154-II turbofans rated at 103 kN

The avionic equipment met ICAO standards for Cat. II weather minima.

1.6.2 Mass and balance

The aircraft was loaded within the specified mass and balance limits and remained within the limits for the whole flight.

1.6.3 Compass swing

The last compass swing on RA 85621 was accomplished after a major repair on 28 June 1991. Residual deviation after the completion of the compass swing was mostly zero or, on some headings, + 1° or - 1° except Compensator no. 1, which had - 2° on three headings.

1.6.4 Lateral navigation equipment

For the crew members to carry out the lateral navigation relevant for the approaches to runways 10 and 28 at Svalbard Airport Longyear, they had the following at their disposal:

- Two compass systems TKS-P2 with an additional magnetic channel operating in the gyro-magnetic mode.

- Two sets of APK-15M Automatic Direction Finder (ADF), which may be tuned to any two frequencies on each set and provision for selecting either frequency in flight by means of the CHANNEL 1-2 selector switch. The Flight Manual (FM) - 4.8.3.7 states that "The Co-pilot should make sure that the ADF 1 is tuned to the outer marker frequency and the ADF 2 to the inner marker frequency and the call signs are heard."

- Two sets of KYPC-MII VOR/ ILS navigation systems connected to two sets of CA-75 Distance Measuring Equipment (DME) when the DME ground installation is paired with the ILS installation as at Svalbard Airport Longyear. The FM - 4.8.3.7 states that: "The Co-pilot should make sure that the VOR /ILS system is set up correctly, switched on, on the correct frequency, with the SP50 - KATET - ILS selector switch positioned corresponding to the system installed at the aerodrome of landing, if no VOR is present, both systems will be tuned to the localizer and the landing course ... degrees set on both Captain's and

Co-pilot's HSI." This item is stressed by "The Co-pilot and the Captain make sure a landing course of ...degrees is set to their respective horizontal situation indicators."

- One independant GPS Allied Signal Aerospace Bendix/King KLN 90A TSO.

1.6.5 Other equipment

Other equipment installed relevant to this investigation includes:

- Two radio altimeters PB-5M mounted on each pilot's instrument panel, designed to indicate absolute altitude of flight within the range of 0 to 750 m and to give warning during descent when the aircraft reaches the set decision height. Descent to the preselected height is indicated by the illumination of the amber light annunciator on the instrument itself and also by the illumination of the H-amber annunciator on the pilot's and copilot's instrument panels, as well as by an aural signal supplied to the two pilots headsets and to the flight compartment loudspeakers of the passenger address system. Radio altimeter no. 1 is also an altitude transmitter for the Ground Proximity Warning System (GPWS).

The inflight procedure at flight level before descent is to set indicator no. 1 to decision height or at 60 m, whichever is higher, and indicator no. 2 to traffic pattern altitude or to 750 m (2 500 ft) if traffic pattern altitude is above 750 m.

After reaching pattern altitude, compare readings of the barometric altimeter with those of radio altimeter no. 2 (terrain features taken into account) and then set the selected height bug to decision height or at 60 m, whichever is higher.

If there is no reliable contact with the light annunciators (lead in lights, approach lights) of the aerodrome and the time the radio altimeter warning operates, it is necessary to make a go around.

1.6.6 GPWS

The Ground Proximity Warning System that was installed warns of dangerous ground proximity by illuminating red light annunciators on the pilot's and co-pilot's instrument panels and intermittent sounding of a horn providing that:

- the aircraft descends with gears not down and locked below an absolute altitude of 250 m

- the aircraft descends within the absolute altitude range of 600 m to 50 m with rates of descent between 15 m/s to 7.5 m/s respectively

- the aircraft flies over mountainous terrain within the absolute altitude range of 400 m to 50 m and the closure rate to the terrain exceeds dangerous values from 25 m/s to 5 m/s respectively

- the aircraft is closer to the ground than 600 m and the rate of descent is at a dangerous value. The warning is cut out as the rate of descent is reduced.

Flight Manual Normal Procedures - Landing Approach 4.6.2.1 (7) & (8):

"In case of operation of the ground proximity warning system during landing approach manoeuver at the aerodrome located in the hilly or mountain terrain, vigorously move the airplane to climb, keeping the tolerable values of the load factor and the angle of attack. This done, set the throttle levers to the take off power maintaining it until the warning system switches off. Report to the ATC controller about the maneuvering execution.

In case of operation of the ground proximity warning system during glide path descent, immediately decrease the rate of descent, monitor the correct holding of the descent profile as well as the landing gear position: if the landing gear is retracted, execute go-around."

AAIB/N comment: The examination of the landing gear indicates that the gear was in transit, not yet down and locked, when the aircraft hit the mountain.

1.7 Meteorological information

1.7.1 Synoptic situation

The weather situation was dominated by a low-pressure trough between Svalbard and the coast of East-Greenland. This trough directed a southwesterly airmass towards the islands. A frontal area situated just south of the Spitsbergen islands separated cold moist air from warmer air in the south. On the west coast of Spitsbergen, the wind on ground was 10 to 20 kt from the southwest. The wind at FL 50 was estimated 240 - 270°, 15 to 30 kt. There were a few rain showers in the area, but the visibility was generally more than 10 km. A weak trough passed over Longyear between 08:00 and 09:00 hrs. Before that time the visibility was good and the cloudbase was 3 000 - 4 000 ft. During the passage of the trough, the visibility went down to 6 km and the cloudbase came down to 1 300 - 1 500 ft. After the passage, the visibility and cloudbase were approximately as before 08:00 hrs.

Top of clouds was estimated to 10 000 ft. There was a chance for light to moderate icing between 3 000 to 10 000 ft.

1.7.2 Forecast:

TAF ENSB
0612 VRB08KT 9999 FEW010 BKN025 TEMPO 0612 22015KT 5000 RADZ SCT005 BKN 010=
0915 23015KT 9999 -RA FEW010 BKN025 PROB30 TEMPO 0915 27020KT 4000 RADZ BKN010=

1.7.3 Actual weather:

METAR ENSB
0733 22014KT 9999 FEW015 SCT021 BKN040 05/M00 Q1005 NOSIG RESH WIND EAST 20007KT 120V290=
0750 23014KT 9999 -SHRA FEW015 SCT020 BKN040 05/M00 Q1005 NOSIG WIND THR28 23010KT 140V250=
Observation taken at 0820-25: VIS 9999 FEW008 BKN020
0850 20016KT 7000 SHRA FEW008 BKN015 04/M02 Q 1006 TEMPO 5000 SCT008 BKN012=
0950 23015KT 180V270 9999 FEW025 BKN040 04/M02 Q1006 RESH TEMPO 5000 SHRA SCT008 BKN012=

1.7.4 It was daylight at the time of the accident.

1.8 Aids to navigation

1.8.1 There are three inbound routings to Svalbard Airport Longyear:

- Approach via NDB Isfjord (ISD)
- Direct NDB Longyear (LON)
- Approach via NDB Svea (SV).

1.8.2 The approach system for runway 10 is a standard ILS with a 3° glide slope. A DME is frequency-paired with the localizer. The final approach is over the sea (the Isfjord). The use of the ILS localizer is limited to 15° either side of the localizer centerline. This is differing from the International Civil Aviation Organization Provisions ref. Annex 10 Vol. 1, paragraph 3.1.3.3.1. Localizer coverage sectors. There is an inner marker beacon co-located with the NDB LON.

1.8.3 The approach system for runway 28 is a localizer DME approach with the localizer course offset 17° from the runway centerline. The use of the localizer is limited to 10° either side of the centerline for topographical reasons, which limits the signal

coverage to 18 NM (normally 25 NM). In addition, reference is made to ICAO Provisions ref. Annex 10 Vol. 1, paragraph 3.1.3.3.1. *Coverage*:

"The localizer shall provide signals sufficient to allow satisfactory operation of typical aircraft installation within the localizer and glide path coverage sectors. The localizer coverage sector shall extend from the center of the localizer antenna system to distances of:

46.3 km (25 NM) within plus or minus 10 degrees from the front course line;

31.5 km (17 NM) between 10 degrees and 35 degrees from the front course line;

18.5 km (10 NM) outside of plus or minus 35 degrees if coverage is provided;

except that, where topographical features dictate or operational requirements permit, the limits may be reduced to 33.3 km (18 NM) within the plus or minus 10-degreee sector and 18.5 km (10 NM) within the intermediate approach area."

A DME is frequency-paired with the localizer. There is no glide path. When performing a non-precision approach, a descent of 3.6° (descent gradient 6.3%) is necessary. The final approach to this runway is over the Adventdal valley, with high terrain on both sides (3 000 + ft) close to the approach path, especially outside 11 NM from the airport. Terrain obstruction lights are not available.

To follow the LLZ 28 procedure, the following is required:

- when passing overhead the NDB Advent, intercept and track the course 155°

- at the DME distance of 14 NM (25.9 km), start a turn to the left to intercept and track the inbound course 300° determined by the equisignal zone of the localizer with the frequency 109.5 MHz

- at the DME distance of 13 NM (24 km), start a descent with a glide slope of 3.6° until reaching the Minimum Decision Altitude/ Height (MDA/ H) of 530 ft/ 452 ft (162 m/ 138 m)

- at the DME distance of 1 NM, either perform the missed approach procedure or with visual contact with the runway, turn left to the landing course of 283°.

1.8.3.1 Considering the possibility of limiting radiation from the localizer antennas due to the ± 15° limitation for ILS 10 and the ± 10° limitation for LLZ 28, reference is made to ICAO Annex 10 Vol. 1, Attachment C:

"Section 2.1.11 *Guidance on operational aspects of improving the performance of the ILS localizer in respect to bends.*

2.1.11.1 *Introduction.* Owing to site effects at certain locations, it is not always possible to produce with simple standard ILS installations localizer courses that are sufficiently free from troublesome bends or irregularities. At such installations, it will often be possible to reduce bends and irregularities in the localizer course to a satisfactory extent by various methods, most of which require acceptance of some deviation from the specification for ILS set forth in this Annex, together with possible penalties from an operational aspect.

2.1.11.2 *Methods of effecting improvement.* In general, improvements in localizer courses from the aspect of bends or irregularities may be effected by restriction of radiation in particular directions so as to avoid or minimize reflection from objects that give rise to the bends. In the majority of instances where special treatment is required, this may be achieved by screens placed and designed to reduce the radiation in the direction of the object. Where reflecting objects are numerous or of large dimensions, however, it may be necessary to restrict almost all radiation from the localizer to a narrow sector centred on the course line. Each method introduces certain disadvantages which should be weighed for the individual installation in the light of the specific operational application to be made of the installation and the following considerations.

2.1.11.3 *Disadvantages of methods of effecting improvements mentioned above*

2.1.11.3.1 The use of screens limiting radiation in selected directions will, in general, give rise to a reduction of the clearance between the two modulation signals of the ILS in some other direction, with the consequence that the ILS indicator needle may move towards the center when the aircraft is passing through areas in that direction. It is considered however that, in general, such deviations are not operationally significant or may be overcome by suitable procedures. In certain applications including the use of screens or reflectors to reinforce signals in the course sector, the use of screens or reflectors will modify the range and characteristics of the back course. In this latter case, it may be necessary to provide an additional facility to supplement or replace the back course.

2.1.11.3.2 Where it is necessary to limit radiation from the localizer over a wide sector and confine most of it to a sector centred on the front course of the localizer in order to reduce bends sufficiently, disadvantages will, in general, be as follows:

1) Orientation information from the localizer in the sector in which radiation is limited will no longer be available or will be unreliable.

2) It will not be practicable to carry out a preliminary check of the

performance of the aircraft receiver through the flag system until the aircraft is within the sector centred on the course line.

3) In the area outside the sector centred on the course line, sufficient radiation may occur in particular directions to operate the ILS indicator in the aircraft in an erratic manner, giving rise to false indications."

1.8.3.2 The NCAA utilizes localizer antennas which give reduced radiation outside 15° off localizer centerline to obtain significantly improved signal quality/ flyability on the centerline.

1.8.3.3 The reason for the ± 10° user-limitation on the LLZ 28 is less than the required signal strength at 25 NM. The radiation from the 6-element antenna is not limited. It is radiating normally.

1.8.4 It is the NCAA's policy to have all the navigational approach aids operational at all times to avoid delays if a situation arises that calls for the use of the opposite runway and corresponding approach aids. Then Flight Inspection Section (FIS), which carries out flight inspections of navigational approach aids, has found interference just above the site of the LLZ 28-antenna, where the signals are not usable.

1.8.5 The airport is equipped with two NDBs; Longyear, LON, frequency 350 kHz, positioned at the end of runway 28, and the Advent, ADV, frequency 326 kHz, positioned in the Adventdal valley, some 8 NM southeast of the airport.

1.8.6 There is approach lighting and Precision Approach Path Indicator 3° (PAPI) for both runways.

1.8.7 The tower is operated by AFIS officers and is equipped with a VDF. Information about the VDF was not printed on the approach charts produced by Jeppesen or in the adapted Jeppesen guide for Russian-speaking users or on the diskette providing operative information for the GPS KLN-90, supplied by the Allied Signal Corporation all in use by Vnukovo Airlines. During the interviews with the AFIS officers, the AAIB/N discovered that nobody could remember that Russian crews, not stationed at Svalbard, ever having asked for QDMs when flying the approaches to Svalbard Airport Longyear.

1.8.8 The airport is not equipped with VOR or radar.

1.9 Communications

1.9.1 Approx. 04:45 hours, Bodø ATCC was informed by a Longyear AFIS telephone that a departure message on flight VKO 2801 enroute to Svalbard had been received. In spite of several attempts through Murmansk ACC, it was not possible for Bodø ATCC to receive an ATC flightplan for this flight before it entered Bodø OCA.

1.9.2 In addition to the missing flightplan, there were some communication difficulties between the aircraft and the various control and information units. It is noted by the AAIB/N that the AFIS officer at Svalbard Airport Longyear had problems in understanding some of the English expressions and names/callsigns of navigational aids used by the navigator/communicator on VKO 2801. During the initial approach, there was some confusion at Longyear AFIS as to the whereabouts of the flight, as the navigator used the name LA (LIMA ALFA) instead of ADV when communicating during that stage of the flight. LA is the identification of the LOC DME for runway 28.

As a result of the review Bodø ATCC has carried out in relation to this accident, the Chief Air Traffic Controller will lay emphasis on the procedure

- on issuing oceanic clearances for flights entering Bodø OCA
- for the necessity of issuing a descent clearance to start descent towards, in this case, Svalbard
- for giving the frequency for contact with the next unit before the flight is allowed to check out of its own frequency.

1.9.3 Definitions from ICAO Annex 10 Volume II, Aeronautical Telecommunications:

- APPROVED: "Permission for proposed action granted"
- ROGER: "I have received all of your last transmission'"
  Note.- Under no circumstances to be used in reply to a question requiring "READ BACK" or a direct answer in the affirmative (AFFIRM) or the negative (NEGATIVE).

1.10 Aerodrome information

1.10.1 All necessary information concerning Norwegian airspace, including the airports, is contained in the Aeronautical Information Publication (AIP), Norway. This information is considered vital to conduct safe flights in Norwegian airspace and to

the different airports.

1.10.2 The Svalbard Svalbard Airport Longyear is located on the south shore of Isfjord at Hotellneset, halfway up the fjord, with high terrain to the south, southeast and east of the airport. The highest minimum sector altitude is 5 100 ft. The site of the aerodrome is 78°14'43" N and 15°28'10" E. The runway 10/28 has an asphalt surface and is 2 140 m long by 45 m wide. The area from threshold 28 and 60 m eastward has the same width and strength as the runway. The further 60 m is paved 60 metres in width and has the same strength as the runway. The total length of the 'underrun' is 120 m. The elevation is 94 ft. Magnetic variation was 2° E (1995). Transition altitude is 5 000 ft.

1.10.3 Svalbard Airport Longyear airspace is established as follows: A Traffic Information Zone (TIZ) - Ground to 1 500 ft and a Traffic Information Area (TIA) - 1 500 ft AMSL to FL 100, both airspace class G. The surrounding airspace is also class G from ground to FL 195 and class A above FL 195. The AFIS unit will provide flight information service and alerting service to known traffic operating in the TIZ, TIA and in the airspace delegated by Bodø ATCC, as well as to arriving/ departing aircraft in those portions of airspace normally used for approach and departure and communication-wise transferred to the AFIS unit, or which has not yet been transferred to another unit. The airport is not to be considered a controlled airport under the terms set out in ICAO Annex 2, nor is approach control service provided, meaning that the responsibility for avoiding collision rests with the PiC. The services provided by the AFIS unit and set out in the AIP comprise:

- The relay of air traffic clearances
- Information about other known traffic
- Meteorological conditions
- Servicability of the airport and its facilities
- QDM when the AFIS unit is equipped with direction-finding equipment. (Available at Svalbard Airport Longyear on frequency 118.1 MHz)
- Other relevant information of importance to aircraft manoeuvring
- Alerting service.

1.10.4 Point 3 on page RAC 1-37 of the AIP Norway gives examples of the use of radiotelephony in the communication between an AFIS unit and aircraft.

The AFIS unit will give RUNWAY IN USE; WEATHER, QNH transition level, etc. and TRAFFIC information to arriving aircraft.

"Note: Information regarding 'runway in use' as given by the AFIS unit, indicates which runway the unit considers most suitable taking into account type of aircraft, wind direction and speed, traffic conditions etc. It is expected that the pilot-in-command will inform the AFIS unit in case 'runway in use' will not be used."

The arriving aircraft will confirm with RUNWAY.... (or WILL USE RUNWAY...).

1.10.5 On 29 August 1996, runway 28 became the runway in use early in the morning when the PiC of a Boeing 737 from Braathens decided to take off on that runway because of the wind direction, the short distance to taxi from the terminal to the runway and the more favourable climb-out procedure. All the other PiCs taking off or landing before VKO 2801 approached, used runway 28.

1.11 Flight recorders

1.11.1 Cockpit Voice Recorder (CVR)

1.11.1.1 The CVR MARS-BM is intended for recording the information received and transmitted by the crew on interphone and external communication systems, the conversations between the crew members on open microphones and background sounds. Additionally a pulsecoded time for the synchronization of the recorded oral information and the flight parameters registered by the FDR is recorded. The four MDM microphones are mounted on the left and right side of the center instrument panel glareshield, on the left side of the flight engineer's control panel and on the supernumery crewmember's instrument panel.

1.11.1.2 The CVR was recovered from the wreckage area on top of the mountain. On request by the AAIB/N the CVR was brought to the IAC Technical-Scientific Center in Moscow for closer examination. A representative of the AAIB/N supervised the examination. The container, OL4 106.002-1 no. 4285 had mechanical deformations on the outside. When the lid was removed, it became evident that the mechanism inside had survived the impact. There was no damage, neither to the tape steering-gear type 70A-11no. 237013 nor to the tape itself. The tape had been fitted correctly in accordance with the standard procedure. The tape cassettes were removed and fitted in a laboratory tape recorder MARS-N for evaluation. The replay of the tape proved that the recording was of medium quality for channels 1 and 2 (external communication and intercom) and the legibility was satisfactory. The recording on channel 3 (open microphone) was of extremely low quality.

1.11.1.3 The recording of the open microphones had a very unfavourable signal-to-noise ratio (the speech level is 5-10 times less than the level of the background noise)

making the deciphering of the intra cockpit conversation extremely difficult. This fact called for more work by the IAC assisted by a laboratory in St. Petersburg, as well as representatives from the FAS of the Russian Federation and Vnukovo Airlines all on behalf of the AAIB/N. The additional work was very successful and 85 - 90 % of the conversation could be interpreted. The communication between VKO 2801 and the AFIS officer was of good quality and identical to the recording of this communication in the tower. A readout of the interpreted parts of the intra cockpit conversation, of the communication between VKO 2801 and the AFIS unit, and parts of the communication between the unit and other traffic in the area is to be found in Appendix 2. Essential parts of the communication is systemized in the Sequentially Timed Events Plotting (STEP) in Appendix 3.

1.11.1.4 The aural warning signal of the GPWS was not recorded on the CVR.

1.11.2 Flight Data Recorder (FDR)

1.11.2.1 The MSRP-64M-2 flight data recorder system is designed for magnetic tape recording of the principal flight data of the latest 26 + 3 flying hrs to permit the use of the stored information in the assessment of aircraft handling and airborne systems operation in the investigation of the causes of flight accidents, and in training. The MSRP system installed in RA 85621 was designed to record 48 analog parameters and 56 events or on/off signals.

1.11.2.2 The FDR was found buried in the snow in the valley below the point of impact. At the request of the AAIB/N, the FDR was brought to the IAC Technical-Scientific Center in Moscow for closer examination. A representative of the AAIB/N supervised the examination. The processing of the flight data recording was carried out on the 'Luch-84' system developed by the flight data department specialists. The container 6L4.106.008-1 no. 11819 had suffered almost no mechanical damage on impact. The recorder mechanism no. 90966 was intact, as was the tape itself. The tape had been fitted in compliance with the standard procedure. The recording of the parameters was of satisfactory quality except for channel no. 18, which recorded the position of the right elevator, and channel no. 12, which recorded gyro-magnetic heading.

However, channel 18 is duplicated by channel 10 recording the position of the left elevator which works synchronous with the right elevator. The unreliable recording of the gyro-magnetic heading is of episodic character and was a consquence of a functional error in the recording channel only (in the BR-40 element of the MSRP-64M-2 system). Even though the BR-40 did not work, the function of the compass system TKS-P2 was not affected and all users of the system received reliable gyro-magnetic heading signals. Similar malfunctions in the BR-40 element have been seen before according to IAC. However, there are no recordings by crew, engineers or technicians about the functionality of the TKS-P2 system on board this aircraft RA 85621.

1.11.2.3 The FDR of RA 85621 recorded the last flight on 29 august 1996 from engine start 03:51 hrs until 08:23:35 hrs (FDR time). A readout of the FDR from 08:10 hrs FDR time until impact is presented in Appendix 4. The magnetic heading was reconstructed on the basis of the recorded bank angle and vertical acceleration. Comparing the calculated magnetic heading with the registered one, the correlation is very good the last 3 minutes and 45 seconds of flight.

1.11.2.4 During initial approach the aural warning of the radio altimeter system was activated and recorded by the CVR five times when the aircraft was flying at a safe altitude. During final approach, the aural warning was activated once, i.e. the six last seconds of the flight. The warning, as recorded by the FDR, started about 530 m before impact when the height difference to the mountain side was approximately 270 m (quickly rising). As recorded by the FDR, the GPWS was acitivated about 9 seconds before impact due to one of the activating conditions (ref. subsection 1.6.6) being met.

1.11.2.5 The reconstruction of the aircraft trajectory over the ground was adjusted in the horizontal plane with input from the FDR geographic altitude parameter in relation to recorded radio altimeter warnings on the CVR when the aircraft passed over terrain details high enough to trigger this warning. The IAC secured the reliability of the calculated flight path by adjustments derived from comparison of this information to the relief of the overflown terrain as it is presented on the large scale maps of the area. The Norwegian Defence Research Institute on behalf of the AAIB/N also confirmed the flight path, having been able to do the comparison flight path/ overflown terrain due to its having access to the map data in digital form. A presentation of the flight path is shown in Appendix 5.

1.12 Wreckage and impact information

1.12.1 Just before impact, the left navigation light touched a small cliff at the mountain edge, evidenced by fragments of the red plastic cover. The area was covered with snow. The aircraft hit the edge of the mountain at an angle of about 45° which caused a wreckage trail direction of about 330°. The AAIB/N believes the aircraft hit the edge with the fuselage at the entrance door just ahead of the wing, resulting in the forward part of the fuselage with the cockpit, part of the left wing with flaps extension jacks and the left undercarriage with the attachments to the centersection coming to rest in an area 60 m by 30 m on top of the mountain. The rest of the aircraft, including the engines and the tail, slid about 500 m down into the Koslådal valley. The impact triggered an avalanche, which came to rest on the steep slope within an area 400 m by 40 m with a snowdepth of 2 - 3 m. Some of the victims were found together with wreckage parts in the snow.

1.12.2 The initial effort of the AAIB/N was to make a survey of the accident site together with representatives of the National Bureau of Crime Investigation, taking photographs and create a basis for a map of the area with the limitation that taking

care of the perished passengers and crew members had first priority. Secondly, all instruments and control boxes that were not damaged beyond identification were taken care of. Experts brought in by the IAC facilitated this work.

After the operation at the mountain had been terminated, and the AAIB/N could start the examination of the salvaged parts, reviewing the photographs and studying the wreckage map, it was discovered that the GPS that had been mounted on the center instrument panel, was missing. The GPS had been spotted lying by itself in the wreckage area both by the IAC and AAIB/N during the survey/ planning phase before registration started. As there was a very good chance that this unit had been lost in the snow or become entangled in other wreckage parts during the work in retrieving the bodies, the AAIB/N went back to Operafjellet in the beginning of October 1996. However, winter had already come too far to make a search for the GPS feasible. Conditions on top of the mountain did not become good enough to carry out the search until July the next year. The snow had then melted and it was then possible to conduct a thorough search of the accident site and of all the different parts of the wreckage. The AAIB/N managed to identify two of the three missing control units, but the GPS was definitely not in the area or among the wreckage. The AAIB/N concludes that somebody removed the GPS early in the salvage operation on the mountain, most probably taken as a souvenir by a person not realizing that all parts of the wreckage could be of importance. A request for the GPS to be returned openly or anonymously made through the police at Svalbard and the IAC has not given any result. The AAIB/N has therefore been unable to examine the GPS. However, Allied Signal has informed the AAIB/N that, in their experience, the data stored in the memory is usually lost in an impact like this because the connection to the internal battery becomes broken.

1.12.3 The readout of the FDR performed by the IAC in Moscow enabled the conclusion that examination of anything other than the recovered parts relating to the navigation of the aircraft was unnecessary.

1.12.4 Five altimeters were recovered, all of which were torn away from their mountings. The following pressure settings were indicated on the scales:

- Altimeter setting 1006.0 hPa equal to 754.6 mm Hg
- Altimeter setting 751.5 mm Hg equal to 1001.9 hPa
- Altimeter setting 755.5 mm Hg equal to 1007.2 hPa
- Altimeter setting 752.0 mm Hg equal to 1002.5 hPa
- Altimeter setting 746.0 mm Hg equal to 994.5 hPa.

1.12.4.1 Before the descent, the altimeter setting was stated as 751 mm Hg (QFE) by the PiC, probably based on information received earlier. At 08:09:19 hrs, the Navigator stated correctly that: 'The pressure is 751 mm' (QFE). At that time, the QNH was 1,005 hPa (equal to 753.8 mm Hg) as it had been transmitted to VKO 2801 and lastly confirmed by the navigator at 07:57:26 hrs.

1.12.5 The radio altimeter no. 1 (pilot's instrument panel) in front of the co-pilot (piloting pilot) was recovered from the accident site with the height selection bug set at 70 m. The radio altimeter no. 2 (co-pilot's instrument panel) in front of the PiC had been ripped out of the instrument panel, but was recovered lying by itself with the height selection bug found at 260 m.

When the Radio Altimeter warning sounded six seconds before impact, the aircraft was about 270 m above the terrain, which means that radio altimeter no. 2 triggered the warning.

(For ILS approach to runway 10 the CAT. D DA is 223 m and DH 202 m. For LOC approach to runway 28 the DA (all categories) is 162 m and DH 138 m.)

1.12.6 The following control panels and instruments were brought to Moscow for examination with the object to determine if they were capable of functioning, what the indicators displayed on impact and which frequencies were set. The work was carried out by technicians from Vnukovo Airlines under the leadership of the IAC and AAIB/N supervising the examinations:

- Mode Control Panel (MCP) PUR SD-75 no. 1, serial no. 6107 produced 1991-02-25, functional check 1991-05-23 before installation on TU-154M RA 85621, no overhaul performed, operation hours 7 365.

- MCP SD-75 no. 2, serial no. 6538, produced 1993-06-27, overhauled 1995-09-24 at operation hours 3 654, installed on TU-154M RA 85621 1995-10-11, total operation hours 5 234.

- Mode Selector Kurs MP-70 (SR), serial no. 303, produced 1986-05-07, overhauled 1991-05-24 and installed on TU-154M RA 85621, total operation hours 18 587 since overhaul 7 371 hours.

- ADF Control Panel ARK-15M, serial no. I-1455, produced 1979, overhauled in 1986 and 1991-05-17, installed 1988-07-28 on TU-154M RA 85621, operation hours since overhaul 7 371.

- ADF Control Panel ARK-15M, serial no. E-3303, produced 1990-05-31, overhauled 1990-03-23, installed 1992-05-07 on TU154-M RA 85621, total operation hours 14 555 since overhaul 7 208 hours.

- Radiomagnetic Indicator RMI-2B, serial no. 410362, produced 1992-03-31, 1994-11-24 at operation hours 49 overhauled and installed on TU-154M RA 85621 1995-08-30, total operation hours 1 886.

- Radiomagnetic Indicator RMI-2B, serial no. 380113, production date unknown, overhauled 1991-05-20 and installed on TU-154M no. 85621 1991-08-31, total operation hours 13 420 since overhaul 7 731 hours.

- Horizontal Situation Indicator (HSI) PNP-1, serial no. 9460261325, produced 1986-03-05, installed on TU-154M RA 85621 left instrument panel 1989-08-30, overhauled 1991-04-26 at operation hours 3 985, total operation hours 11 356 since overhaul 7 731 hours.

- Horizontal Situation Indicator (HSI) PNP-1, serial no. 9460933240, produced 1983-10-18 installed on TU-154M RA 85621 1994-10-28, overhauled 1993-03-26, total operation hours 12 416 since overhaul 2 666 hours.

- UShDB the navigators bearing indicator and VOR/ADF intercom system (ICS).

1.12.7 Examination of PUR SD-75 nos. 1 and 2 serial no. 6107 installed in the left hand position and no. 6538 installed in the right hand position. Both DME sets are governed by the corresponding Mode Control Panel, left pilot's no. 1 and right pilot's no. 2 respectively. The same mode control panels also govern two semi-installations (VOR navigation unit and ILS approach unit) and the mode selector Kurs MP70 for selecting either ILS, Katet or SP-50. The DME distances are displayed to the left and right pilots from SD-75 no. 1 and 2 respectively. Output from Kurs MP-70 in approach mode is displayed on left and right pilots HSI. If an error develops, the MP-70 switches automatically to the other semi-installation.

1.12.7.1 The aluminum case of unit no. 6107 was cut open to gain access to the interior of the frequency control switches. The left-hand (L/H) switch setting MegaHertz (MHz), has a total of ten positions, with a potential to select from 108 MHz to 117 MHz, both included. The switch was found in a position corresponding to 109 MHz. The frequency was determined by setting a serviceable unit to the identical mechanical position as the one found in the unit being examined. The same procedure was used for the right-hand (R/H) switch, setting kiloHertz (kHz). This switch has a total of 20 positions for setting from 000 to 950 kHz in 50 kHz increments. The position of this switch was found to correspond to the area between 450 and 500 kHz.

The construction of the switches requiring rotation of the switch body for changing frequencies makes it likely that no, or very little, displacement takes place during impact and break-up.

There are also three switches for the functions DME-VOR Hold, AUTO-MAN and NAV. MILES - KM. These are two-position toggle switches which inherently have a great potential for being displaced on impact. The positions of these switches may consequently not be considered as reliable information. The display and the annunciators were completely destroyed.

1.12.7.2 Unit no. 6538 was examined using the same procedure. The contact points of the frequency control switches were found in positions corresponding to a frequency between 109.45 MHz and 109.50 MHz.

1.12.7.3 Based on the findings, it was concluded that the most probable setting at the time of impact had been 109.5 MHz for both installations, equal to the frequency of the localizer LA for approach to runway 28 at Svalbard Airport Longyear.

1.12.7.4 Due to the damage the two units had suffered on impact, it was not possible to carry out a functional test. There were, however, no signs of any electrical defects, such as burnt elements, outlets or connectors.

1.12.8 The mode selector Kurs MP-70 serial no. 303, installed for the crew to select the mode of operation for the approach installation, choosing either ILS, Katet or SP-50, was examined as far as possible. The unit was almost completely destroyed due to the intense force on impact (on the overhead switch panel) in the direction front towards aft. The unit was registered and photographed on top of the mountain with the selection switch pointing to the right, i.e. 45° beyond position SP-50. On examination of the fragments left of the switch mechanism, it was possible to determine that the switch was in position '1' corresponding to the ILS operation mode. (ILS systems are installed at Vnukovo Airport and the airport visited before Vnukovo. If the selector switch is in the SP50 position and an ILS is tuned and used, the warning flags will be visible with the CDI and the Glide Path indicators centered on the HSI.)

The three toggle switches ROUTE-LANDING, DAY - NIGHT and SHORAN - DME cannot give reliable information. The four warning lights K1, K2, G1 and G2 are missing. There are no signs of electrical defects. Due to the condition of the unit, a functional test was impossible.

1.12.9 ADF Control Panels PU ARK-15M, serial no. I-1455 and E-3303 govern two ARK-15 radio compasses. The outputs are displayed on left and right pilots RMIs as well as on the navigator's indicator UShDB-2. On all three instruments, the narrow needles display information from ADF no. 1 and the broad needles display information from ADF no. 2.

1.12.9.1 The damage inflicted on the two control panels I-1455 and E-3303 was so severe that it was impossible to carry out any functional testing. There was, however, no indication pointing to any preimpact damage.

1.12.9.2 The selectors for setting the frequencies on I-1455 are jammed. The left one is set indicating 316 kHz corresponding to Bear Island NDB (BJO). The right one is not quite as easy to determine, although the way the damage has been inflicted on the selector makes it likely that the frequency set was 304 kHz, corresponding to Isfjord NDB (ISD).

1.12.9.3 The toggle switch was found in position 1, indicating that the left frequency had been selected. This is, however, considered an unreliable finding substantiated by the fact that VKO 2801 passed ISD after BJO, making switch position 2 most likely.

1.12.9.4 On E-3303 the left frequency selector indicates 425 kHz, which does not correspond to any likely frequency used from Vnukovo, Moscow to Svalbard. However, the damage inflicted on the unit indicates that the figures may have been changed during impact. The deformation of the right selector makes it possible to conclude that the frequency set was 326 kHz, corresponding to Advent NDB (ADV). The toggle switch governing the selection between left and right frequency selector was found in position 1 indicating 425 kHz was utilized, but again this is an unreliable indication unless it is confirmed by other factual information.

1.12.10 The two radiomagnetic indicators RMI-2B, serial no. 380113 and 410362 display relative bearings from the ADF's ARK-15M or from Kurs MP-70 when this unit is in navigation mode. This is dependent upon the position of the two ADF/VOR selectors on the front of the RMI instruments, i.e. 'ADF/VOR 1' or 'ADF/VOR 2'. The RMIs also display gyro-magnetic course information from the compass system TKS-2P. The left (pilot) RMI displays course information from the auxiliary gyro-unit and the right (co-pilot) RMI displays course information from the main gyro-unit. The narrow needle on both RMIs display information from ADF no. 1 or Kurs MP-70 no. 1 and the broad needles display information from either ADF no. 2 or Kurs MP-70 no. 2.

1.12.10.1 RMI serial no. 380113 is damaged to the extent that course information on impact cannot be determined because the dial displaying gyro-magnetic course is missing and the axle on the SC transformer (Sine/ Cosine transformer) turning the dial is disengaged and turning freely. The needles displaying the relative bearings are missing as well. The axles of the SC transformer which turn the needles are jammed. The ADF/VOR selector is in position ADF (ARK 1 and ARK 2 respectively).

1.12.10.2 RMI serial no. 410362 is also substantially damaged. The dial and the needles are missing. It is not possible to determine the gyro-magnetic course on impact. The axles of the SC-transformer turning the dial and the no. 1 needle are disengaged and turn freely. The axle turning no. 2 needle is jammed. The ADF/VOR selector is in position ADF.

1.12.10.3 Functional testing of the RMIs is not possible due to the inflicted damage. No indication of other types of failure was found.

1.12.10.4 To determine the relative bearings from the position of the stator windings of the SC tranformer, the rotor winding was supplied a voltage of 36 V 400 Hz and the voltage was measured across the stator windings, sine/ cosine respectively. The measured voltages were as follows:

RMI ser. no.	SC-transf. no.	Winding	Voltage	Octant
410362	transf. no. 2	sine	- 5.6 V	8. octant
		cosine	+ 32.4 V	
380113	transf. no. 1	sine	- 28.73 V	7. octant
		cosine	+ 15.57 V	
380113	transf. no. 2	sine	- 4.98 V	8. octant
		cosine	+ 32.4 V	

With two oscilloscopes, the phase of the windings relative to the phase of the input voltage was checked and then the octant of the measured voltages was determined. The tangent was calculated and the rotor angle of rotation was determined. As a check, an equivalent setup with an SC transformer with a graduated rotor winding was made. By adjusting the rotor until the phases and voltages of the sine and cosine windings became identical to the examined SC transformer, it was determined that the relative bearing indicated by the no. 2 needle on both RMIs was close to 350° with an inaccuracy of 1°. The inaccuracy was the result of the sources of error in the SC transformer. The inaccuracy for TU-154M is +/-1.5°. The relative bearing indicated by the no. 1 needle on RMI 380113 was determined to be close to 300°.

1.12.10.5 Using the Magnetic Heading 291° recorded by the FDR on impact the calculated True Bearing is: 291° Magnetic Heading + 2° E Variation + 350° Relative Bearing - 360° = 283° True Bearing which corresponds very well with the position of Longyear (LON) NDB measured from the point of impact. At 08:21:02 hrs, the PiC asked the navigator 'Igor, set Advent for me'. At 08:21:08 hrs, the Navigator answered 'Not now. Later on!' These statements imply that the no. 2 needle on both RMIs indicated Advent NDB when the aircraft passed overhead this radio beacon starting the base turn and that the crew changed to Longyear NDB afterwards. Needle no. 1 on both RMIs was most probably indicating Isfjord NDB, but did not display any useful information on impact due to the distance to the beacon and the terrain in between. This setup was maintained until impact.

1.12.10.6 The Boards conclude that the two RMIs were functioning on impact.

1.12.11 The two HSIs serial no. 9460261325 and 9460933240 were installed on the pilot's and co-pilot's instrument panels respectively. The HSI displays the gyro-magnetic heading from the compass system TKS-P2, the drift in relation to the set course and deviations from the ILS/Localizer centerline and the glide path. The set course is indicated by a counter in the upper right corner and by a split arrow (Course deviation Indicator - CDI) in the center of the instrument, both adjusted by a knob at the right, lower corner. A course indicator the 'Crown' is operated by a knob at the left, lower corner. There are two warning flags K and G which are pulled out of sight if the ILS system is working properly and the aircraft is within the particular ILS system coverage. An additional warning flag, KS, is deactivated if the compass system is working correctly. The CDI will indicate if the aircraft deviates from the localizer centerline by displaying where the centerline is in relation to the position of the aircraft. If the K-flag appears, the CDI will move to the neutral position.

1.12.11.1 HSI serial no. 9460261325 has significant damage. The front of the instrument is deformed and depressed inwards. The compass dial heading indicator was found to indicate about 300°. The drift angle indicator was in a near straight-up position, which indicates 0° drift in relation to the set course. The 'Crown' is opposite 283° on the dial. The numbers on the counter are 281°, but the damage suggests that the numbers were 283° before impact. Fragments of the CDI are present, the split arrow pointing to near 270°, but with the head bent to the left and the tail pointing to near 100°. Down left the K warning flag is visible. This is considered an unreliable finding and cannot be used to determine the signal strength on impact. The G flag is also visible in the upper left area of the instrument as it should be since there is no glide path with the runway 28 approach.

1.12.11.2 HSI serial no. 9460933240 is more damaged than the left pilot's HSI. The compass dial was torn loose from the face of the instrument, but the deformation and the scratches make it possible to determine a course close to 300°. The drift angle indicator was in a near straight-up position. The 'Crown' is opposite 283° on the dial, as are the numbers on the course selection counter. The CDI is missing. The warning K and G flags were found in the de-activated position behind the instrument front.

1.12.11.3 None of the HSIs have any indications of any faults being present before impact. Functional testing is impossible due to the damages inflicted on impact. It is possible to conclude that the HSIs were functioning on impact.

1.12.12 The navigator's UShDB bearing indicator mounted on the center instrument panel was found lying by itself, damaged and with both needles missing. The 'Kurs' knob is broken.

A piece of the Intercom System panel has the toggle switches selecting VOR/ADF in the ADF position. Being toggle switches, the information is considered

unreliable by itself. However, this position agrees with the absence of VORs at Svalbard and the examination of the ADF/ RMIs.

1.12.13 Of the two control panels (IIH) PN-5 and (IIH) PN-6 on the center pedestal connected to the KYPC-MII VOR/ ILS and the Automatic Flight Control System, only PN-5 was identified and recovered in July 1997. However, the damage inflicted on the panel on impact was so extensive that the examination carried out in Moscow did not give any results.

1.12.14 The control panel (IIy) PO-46 of the Automatic Flight Control System with the Turn knob operated by the navigator during the approach, was identified and recovered in July 1997. The damage inflicted on the panel on impact was so extensive that the examination performed in Moscow did not give any results.

1.12.15 The panel with the two KM-5 compensators of the TKS-P2 compass system on the right-hand side of the instrument panel was recovered. The needle on KM-5 no. 1 indicates 310° and the needle on KM-5 no. 2 indicates 316°. (The compensators display the current gyro-magnetic heading relative to the magnetic meridian at the actual aircraft position. The compensators are not used for inflight navigation.)

1.12.16 The aircraft was fitted with GPS form Allied Signal, Bendix/King KLN 90A TSO serial no. 13473 produced in 1995 and mounted on the center instrument panel. The unit was fitted in RA 85621 16 March 1996. The GPS was working independently of the other navigation systems installed. Total operation hours was 873 and the unit had not been removed from the aircraft since new. Because the GPS had been removed by somebody from the accident site on top of the mountain, the AAIB/N has not been able to check if any useful information could be recovered from the damaged unit.

1.12.16.1 The information in the data base cartridge serial no. 27179 was valid to 22 May 1996. Allied Signal General Aviation Avionics (ASGAA) receives new NavData information from Jeppesen Sanderson every 28 days. ASGAA encourages customers to update their data bases on a regular basis, if not every 28 days. Allied Signal supplied the AAIB/N with a copy of the data base installed in RA 85621 on the day of the accident. The Board has checked that the information pertinent to ENSB Longyear was correct. It is important to note that the database concerning ENSB IAP (Instrument Approach Procedures) stated 'No approach for this airport in database'. The AAIB/N has also made a note of the following facts: 'Mag invalid. All data referred to true North.' Altitudes/elevations are based on Mean Sea Level. The datum is unspecified.

Since some units, according to the Norwegian Bendix/King Service Center, may display runway heading as default value in OBS-mode (selected course mode), AAIB/N checked this matter with IAC/Vnukovo Airlines. The answer was that the operator would have to type the four letter code i.e. ENSB and set the landing

course in degrees. Then the course line will be displayed in OBS-mode.

1.12.16.2 The AAIB/N checked which satellites were available when the crew flew the approach to runway 28. At 08:20 hours, in position N 78° 16' E 016° 06' height 905 m, the following satellites with azimuths and elevation were available: Satellite no. 2 - Az. 345° elev. 13°, no. 3 - Az. 192° elev. 53°, no. 17 - Az. 094° elev. 29°, no. 19 - Az. 290° elev. 14°, no. 21 - Az 166° elev. 32°, no. 23 - Az. 120° elev. 49°, no. 26 - Az. 043° elev. 36°, no. 27 - Az. 323° elev. 29°, no. 28 - Az. 148° elev. 20° and no. 31 Az. 263° elev. 47°.

The Norwegian Mapping Authority, Geodetic Institute has a GPS reference station at New Aalesund, Svalbard. GPS data show nothing unusal for the period VKO 2801 flew the approach to Svalbard Airport Longyear. The satellite geometry was also normal.

The GPS antenna on the TU-154M is on top of the fuselage between station 16 and 17. The tail did not obstruct any of the available satellites during approach. There were enough satellites available to provide good cuts.

1.12.16.3 Representatives from Vnukovo Airlines explained to the AAIB/N that their experience with the installed GPS was very good. The crews were allowed to use the GPS installation en route as a primary navigational aid, but only as a backup system during approaches. The normal procedure which had developed over time was that the course set on the HSI (the landing direction) was also the course to be set on the GPS, thereby creating a standard ('habit'). When utilizing the GPS as a backup on approaches, past experience had shown that the GPS had never been more than 100 m - 120 m off. The crews had therefore built up a strong belief in this system.

1.13 Medical and pathological information

An autopsy was performed on each cockpit crew member. The examination did not reveal any anomalies. A chemical analysis of the body fluids was also carried out. None of the crew members were under the influence of any chemical substances.

All of the 141 persons on board the aircraft were positively identified. DNA was used as the main method of identification and proved to be very effective and successful. It was decided that the results of the DNA test should be supported by at least another finding.

1.14 Fire

There was no indication of fire, neither in flight nor after the crash.

1.15 Survival aspects

This was a non-survivable accident.

1.16 Tests and research

1.16.1 Radio climatic conditions

1.16.1.1 On behalf of the AAIB/N a scientist from the Norwegian Meteorological Institute studied the weather situation on 29 august 1996 with respect to radiowave propagation conditions. The AAIB/N has made a summary of his report presented in points 1.16.1.1 to 1.16.1.4. No relevant observations exist for the Longyear area. The closest meteorological station was New Aalesund, 110 km to the northwest. Radio soundings also exist for Jan Mayen and Bear Island. The conclusion is that an anomalous propagation situation (superrefractive) existed over New Aalesund at noon that day. This superrefractive layer was surface-based, extending from 8 to 45 meters. How much refraction this situation could cause has been studied by an expert panel.

1.16.1.2 An overview of the general weather situation in the area limited by Jan Mayen, Bear Island and Svalbard indicates the movement of a weather system from west to east. A review of the radio soundings taken show that Jan Mayen at midnight on 28 August had a refractivity profile indicating an anomalous propagation situation. The same situation was observed at Bear Island 12 hours later. Examination of the refractivity situation at Jan Mayen and Bear Island show strong ground-based ducts. (Refractivity gradients -924 N/km at Jan Mayen and -463 N/km at Bear Island).

1.16.1.3 To check if ducting could be observed in the Adventdal valley, 13 radio sondes were released between 31 August and 4 September 1998. The radio soundings showed that ducting situations could occur in this valley. The conditions for ducting were observed between 1 000 m and 1 500 m. The highest refractivity gradient measured was -467 N/km and the deepest duct measured was 148 m. None of the ducts found had the necessary height or enough intensity to catch the localizer frequency 109.5 MHz linked to the runway 28 approach.

1.16.1.4 Data from radio sondes released at Jan Mayen and Bear Island during the same period show a similar propagation situation (ducts) at the same altitudes as were observed in the Adventdal Valley. A major difference between the radio climatic

conditions in August/ September of 1996 and that of the same period in 1998 was the lack of strong ground-based ducts or evaporation ducts. A Kolmogorov-Smirnov technique applied to the data obtained at the Longyear stations and other meteorological stations in the area and long-term mean values for the area, show a clear connection of low probability values being a normal profile and condition for anomalous propagation conditions. In spite of rather few ascents, there is some evidence to show that there is a necessary similarity between the stations, at least in showing up simultaneous high probability. However, when adverse weather with low pressure and fronts occurs, the propagation conditions are determined on a more local scale. Using the same technique on data from the period of the accident, very low values of the probability are obtained, indicating anomalous propagation conditions. Examination of the surface refractivity gives for the period of 1996 the curious result that the southernmost station, Jan Mayen, had the lowest refractivity values in reality contrary to theory. This can also give rise to the conclusion that anomalous propagation conditions existed at this time.

1.16.1.5 A detailed study of the propagation was performed by running a fine-scale atmospheric model, and computing the index of refraction, based on pressure, temperature and humidity from the model. The atmospheric model used was the Canadian MC2 model, run at 1 km horizontal resolution. The initial conditions were prepared using the operational HIRLAM model at 10 km horizontal resolution.

The full 3-dimensional fields of the index of refraction were then used as input to a detailed wave propagation model.

1.16.1.6 AAIB/N comment: The Dornier crew experienced no deviations when tracking localizer 28 during the search phase the day of the accident, and the AFIS officer registered a sensible QDM from the last communication by VDF (frequency 118.1 MHz, which is close to the localizer 28 frequency 109.5 MHz and would therefore be influenced about the same amount).

1.16.1.7 During the period summer/ autumn 1998, remote field monitors placed on top of the mast of the Advent NDB and in the area close to the Eiscat radar have been registering the field strength of LLZ 28. The data collected has been turned over to the expert panel studying electromagnetic wave propagation in the atmosphere.

The study shows small deviations due to known traffic from ships at the harbour and known problems with the data link. The data does not indicate abnormal deviations on the localizer course line during this period.

1.16.2 Impairments to a localizer signal due to propagation

1.16.2.1 In considering possible impairment due to radiowave propagation, there are two topics of interest: deviation of the propagation direction through the atmosphere and the effects of ground reflections. In the first case, assuming there is no visible

impact of a ground reflection, the radio wave could mislead the flight crews by giving a normal localizer signal in a position to the side of the published localizer centerline. In the event of a strong reflection, a similar erroneous conclusion could be drawn, but the localizer signal would vary and indicate crossings of the localizer centerline with an increasing frequency towards the antenna.

1.16.2.2 A change in the refractive index of the air (or refractivity) in the atmosphere will change the propagation direction of the wave front. The bending of the ray or wave front direction, depend on the incidence angle and change of refractivity. By using a geometrical optical approach and physical reasonable horizontal changes of refractivity, the localizer would indicate a location of a few metres from the correct position at 30 km distance, perhaps a few tens of metres. Ray bending cannot therefore be the sole cause of any significant horizontal misplacement of an aircraft.

1.16.2.3 A combination of reflection from terrain features and the direct radio wave between the transmitter at the airport and the aircraft, can deflect the localizer signal and create significant deviation. In studying this possibility, it is assumed that there are no such effects under normal flying conditions at Svalbard Airport Longyear. It is therefore a question whether enhanced signals occasionally can create such a situation. An enhanced reflected signal may be created if the transmitter illumination becomes stronger. If the atmosphere acts as an amplifier, e.g., under ducting conditions, this might theoretically be possible. This situation was investigated using the MC2-estimated atmospheric refractivity data provided by the Norwegian Meteorological Institute and full wave calculations (the simplification called parabolic equation modelling). It was not possible to show a significant enhancement of the illumination of such terrain features. It is therefore unlikely that the localizer signal has been deflected by the effects of enhanced terrain reflections.

Note: Despite the fact that the none-hydrostatic MC2 model, with its very fine grid, is one of the most advanced tools available to the meteorological community, one does not have a full guarantie that all small scale phenomena in the atmosphere are captured or described adequately by the model.

1.16.2.4 By looking at the MC2 data, a noticeable change of refractivity is observed. The sizes of the eddies seem to be of a few kilometres over the bay from the Isfjord and up the Adventdal valley. Under ducting conditions, the atmosphere is stratified over a larger area and it is not surprising that the signal strength estimated is similar to what it would be under normal conditions. Eddies present may create scintillation of the radio signal, but these effects decrease with decreasing frequency and this will presumably not result in significantly enhanced signals. If it did though, the ground reflected signal would also vary, but very fast (several periods in a second) and in the averaging carried out by the aircraft localizer receiver, no deviation would be noticed.

1.16.3 Test flying with TU-154M at Svalbard Airport Longyear

1.16.3.1 To verify the investigation into this accident, the IAC and AAIB/N agreed that a test flight using the same type of aircraft was necessary at Svalbard Airport Longyear. For flight safety reasons, it was agreed that the test should take place under the leadership of the IAC with the AAIB/N supervising. The Norwegian Government funded the flight.

1.16.3.2 In cooperation with a scientist from the Norwegian Meteorological Institute, the AAIB/N decided that the flight should take place on 01 September 1998 and the following days, weather permitting. This was because the ocean is at its warmest at this time of the year and there were better chances of southwesterly weather on Svalbard. The possibilities for favourable climatic conditions for studying electromagnetic wave propagation through the atmosphere, thereby creating a basis for looking into this phenomena in relation to VHF frequencies, was a deciding factor when this date was selected.

1.16.3.3 One of the main objectives of the flight was to see how this aircraft type and the mounted navigational equipment performed in relation to the ground-based navigation installations at Svalbard Airport Longyear by strict adherence to the LLZ 28 approach procedure. Specific crossover flying was planned on headings 030° and 210°of the localizer at DME distances 15.8 and 5 NM in order to check and evaluate the equisignal zone symmetry and beam with angles for approach course 300°, in accordance with a test flight programme prepared by the IAC. To obtain the necessary information, the following events/ aircraft positions were to be observed and/ or recorded:

- The point at which the K-flag disappeared and reappeared on the HSI (PNP-1)

- The positions at which the CDI on the HSI started shifting right to left or left to right and the geographical positions when the CDI crossed the scale of the instrument. The times these CDI movements lasted.

- Whether the movement of the CDI across the scale was smooth within the area of linear change in the signal of deviation in the equisignal zone.

- Whether the onboard navigation system received and displayed any reversed signals on the HSI which could have led to a mistake in determining the aircraft position.

The VDF and GPS were to be used for backup navigation. Video recording was to be used for verification of instrument readings as well as information retrieved from the aircraft FDR, CVR (the last 30 minutes) and communication recorded in the tower.

1.16.3.4 For the benefit of the AAIB/N, it would be possible to observe how the Russian crew concept worked in the air, how the GPS and the compass system worked at high latitudes and observe if the two offset NDBs, LON and ADV, could be used as backup navigation when the aircraft was following the localizer.

1.16.3.5 Additional benefits included demonstrating the accuracy of the VDF service to the test flight crew, flying the track of VKO 2801 at a safe altitude, observing the information given by the navigational instruments and demonstrating that a TU-154M could follow the localizer 28 approach and land safely on runway 28.

1.16.3.6 To keep track of the local weather conditions during the test flying, a team from the Meteorological Institute, under the leadership of the aforementioned scientist, released 13 radio sondes in the Adventdal valley.

1.16.3.7 The flight inspection aircraft LN-ILS of NCAA FIS participated to serve as a backup for the data collected by the TU-154M test aircraft and assist the meteorological team with field strength measurements (μA).

1.16.3.8 The distortion of the LLZ equisignal zone relative to the geometric approach axis with magnetic course 300° was determined by strict adherence to the centerline as indicated by the CDI on the HSI. Testruns were made at 7 000 ft, 6 000 ft and 5 100 ft. In addition, full approaches were performed. Recordings were made at fixed points determined by DME: 15 NM, 13 NM, 10 NM, 8 NM and 5 NM. During the processing, these distances were corrected according to the coordinates received from the GPS. To obtain a common basis for comparison, the geographical coordinates of the recordings were converted to a rectangular great circle system with an X-axis true direction 301° passing through the position of the LLZ 28 antenna. The QDMs obtained by VDF were also converted.

The resulting approach track parameters using the various methods were close, thus confirming that the results were correct. (Because of the established accuracy of the GPS, the recordings from this independent system were preferred.) The distortion of the equisignal zone diminished with reduced flight altitude. Thus, at 7 000 ft and 25 km, the maximum deviation from the approach axis was 1.08 km, at 6 000 ft 0.67 km and at 5 000 ft 0.26 km. The distortion diminished coming closer to the antenna and at distances (at the different altitudes) of about 7.5 km, it constituted no more than 0.3 - 0.36 km.

A reconstruction of the tracks made on the basis of data recorded by the FDR showed good correlation.

It is therefore possible to conclude that lateral deviations from the geographical approach axis due to distortion of the course equisignal zone are within the established safety limitations, given that the estimated/ required glide path and LLZ centerline is followed. The conclusion is based on recordings by the receiving equipment installed in this particular aircraft working in relation to the

ground-based navigation equipment at Svalbard Airport Longyear.

1.16.3.9 The test flying to determine the characteristics of the localizer equisignal zone showed that

- within a range of 2.6° - 2.7° from the approach axis, the course zone signal changed linearly throughout the whole range of the CDI movement.

- there were no sectors in which the CDI reversed its movement within the linear zone.

- (at a point - radial distance 19.56 km with azimuth 041° relative to the approach axis, a reversed CDI indication was registered. This corresponds to the side lobe ('false' beam) at 41° to 42.5° present on Norwegian localizers with six elements antennas and is far removed from the announced usuable sector of ± 10° limiting the allowable use of LLZ 28. It is also in accordance with the provisions of ICAO Annex 6 because the aircraft was outside the zone ± 35° within which coverage of correct indications are demanded.)

1.16.3.10 The IAC and AAIB/N conclude that the results of the test flights show that there were practically no distortions in the localizer equisignal zone for an approach with course 300°. The onboard receiving equipment indicated that the equisignal zone is linear within the range of ± 2.6° - 2.7 ° (with reference to the HSI), thus supplying a stable and safe approach to the Svalbard Airport Longyear tracking the LLZ course 300° under the declared weather minima.

1.16.3.11 The representative from the AAIB/N on the flight deck observed how the crew concept worked in the air, making a note of the navigator controlling the lateral navigation of the aircraft by the Autopilot Turn knob during the approaches. The approach chart stayed with the navigator except when the pilots studied the approach or rechecked information. The pilots did not have approach charts of their own placed in front of them during the approaches.

The compass systems worked in gyro-magnetic mode without any difficulities. The needles on the two compensators in the compass system (two instruments presenting e.g. flux gate movement information) reacted to small roll movements, but quickly stabilized when the wings were level again.

The GPS KLN-90A worked without any difficulty at the Svalbard Airport Longyear latitude.

The fact that both the ADV and LON NDBs are situated a bit to the left of the LLZ 28 approach centerline was of no significance using these beacons to confirm the lateral navigation when tracking the LLZ 28 centerline (except when getting fairly close to the NDBs).

The possibility of checking one's own navigation by the Longyear VDF service was utilized extensively, usually giving QDMs equal to the onboard indications or ± 1° differences.

The test flying was carried out in southwesterly weather conditions.

1.16.3.12 The field strength measurements recorded by the flight inspection crew in relation to positions checked by Differential GPS showed normal values.

1.17 Organizational and management information

1.17.1 Vnukovo Airlines (Vnukovskie Aviallnii)

Vnukovo Airlines was established in March 1993. It was at the forefront of Aeroflot privatization and is one of the major trunk carriers in the Russian air transportation system. The airline renders international, regional and domestic scheduled and charter passenger service. It operates scheduled services to the southern areas of the former Soviet Union, and has also begun worldwide charter services. The airline employees an aircrew staff of 800. The aircraft fleet consists of (March 1997) 22 Ilyushin Il-86, 26 Tupolev Tu-154 (models B, C and M) and 4 Tupolev Tu-204.

1.17.2 Pre-flight preparations at Vnukovo

Before flights like the one to Svalbard, the airline usually requires the crew members to meet the day before the flight in order to prepare. Among other things, the crew will fly the approach on the simulator. However, in this case the crew prepared for and flew only the runway 10 approach to Svalbard Airport Longyear on the simulator. However, documentation given to the IAC shows that the PiC, the co-pilot and the navigator had performed the actual approaches to Svalbard Airport Longyear on the simulator earlier in 1996.

1.17.3 A significant difference in the Air Traffic Service (ATS) concept between Russia and Norway

The AAIB/N has been informed by the IAC that an air traffic controller has a higher status than a PiC in Russia and that he is in charge of the flights in his area of responsibility. As a result, the PiC of a flight will obey the controller's orders. This fact implies that the PiC needs a very good reason to disagree and act contrary to an air traffic controller's instructions. If so, the PiC will have to answer to him afterwards and will have to explain why he acted differently.

In Norway, an Air Traffic Control Service (ATC) is provided at major airports while Aerodrome Flight Information Service (AFIS) is provided at regional airports. At airports where AFIS is provided, e.g. Svalbard Airport Longyear, an

AFIS officer is not authorized to issue clearances controlling the air traffic. Their responsibility is to provide a flight information service and alerting service which include information about known trafffic, meteorological conditions, serviceability of the aerodrome and its facilities, and relay air traffic control clearances issued by a controlling authority. Information regarding 'runway in use,' as given by an AFIS unit, indicates which runway the unit considers most suitable, taking into account the type of aircraft, wind direction and speed, traffic conditions, etc. The PiC is expected to inform the AFIS unit in case 'runway in use' will not be used. As stated in ICAO Annex 11 paragraph 4.1.1 Note: "Flight information service does not relieve the pilot-in-command of an aircraft of any responsibilities and the pilot-in-command has to make the final decision regarding any suggested alteration of flight plan."

1.18 Additional information

1.18.1 Crew duties during cruise, descent and approach for a 4-man crew

The minimum crew to operate the TU-154M comprises a pilot, co-pilot and flight engineer. When the crew is reinforced by a navigator, the Flight Manual refers to a supplement outlining the duties for a 4-man crew on a TU-154M.

The established division of duties relevant to this case include:

After reaching cruising altitude

- with the commander's permission either the co-pilot or the navigator may control the aircraft using the Autopilot Turn knob.

- the navigator handles the communication with ATC.

Before descent

- the commander orders preparations for landing, thinks the descent through from cruising level and responds to and acts on the points of the 'Before descent' checklist.

- the co-pilot compares the landing course and the weather at destination and determines the weather minima for landing, responds to and acts on the points of the 'Before descent' checklist.

- the navigator prepares weather data for the destination and alternatives, calculates fuel for the alternative airport, prepares the landing card, reads the 'Before descent' checklist and responds to and acts on the points, gives 1 - 2

minutes warning of starting the descent and communicates with ATC.

Crew actions during descent

- the commander initiates and controls the descent, if the co-pilot is handling the aircraft the commander monitors his actions and takes care of his duties, checks that the radio altimeter is functioning, resumes control at transition level, sets the altimeter to airport pressure, responds to and acts on the points of the 'After changing to airport pressure' checklist.

- the co-pilot monitors and assists the commander during descent unless he is ordered to control the aircraft, handles the communication with ATC, checks the radio altimeter, relinquishes control of the aircraft to the commander at transition level, sets the altimeter to the airport pressure, responds to and acts on the points of the 'After changing to airport pressure' checklist.

- the navigator checks that the instruments are in the required mode for descent, checks the navigation of the aircraft giving directions and monitors the pilots, monitors especially the aircraft descent warning of required flight levels and altitudes including speed limitation altitudes, monitors the communication with ATC, checks that the correct airport pressure is set on the altimeters and that the flight altitude corresponds to the set pressure, reads the 'After changing to airport pressure' checklist and responds to and acts on the points.

Crew tasks during stick-controlled approach and directed approach mode

- the PiC controls the aircraft the appropriate way ordering extension of landing gear and, after the third turn, orders flaps 28° and 3 km before glide path 36° or 45°, navigates vertically and laterally according to the instrument indications or navigator's instructions, orders checklist and responds to and acts on the points of the 'Before third turn or at distance 22-25 km' and the 'Before entering glidepath' checklists.

- the co-pilot assists and monitors the PiC operation and navigation of the aircraft extends landing gear and flaps, takes care of the time keeping with the stopwatch, sets the radio altimeter bug to 'Decision Altitude' when the light signal lights up at circling altitude, compares the values of the radio altimeter with the values of the pressure altimeter considering the relief of the underlying terrain, handles the communication with ATC, responds to and acts on the points of the 'Before third turn or at distance 22-25 km' and the 'Before entering glidepath' checklists.

- the navigator monitors the operation (including wing devices and stabilizer setting) and navigation of the aircraft calling out deviations from the correct values, calls position in relation to approach beacons or 22-25 km on direct approach and determines the start of the third turn and entering glidepath giving

the calculated rate of descent, calculates and reports the approach speed for the actual landing mass, compares the values of the radio altimeter with the values of the pressure altimeter considering the relief of the underlying terrain, reads the 'Before third turn or at distance 22-25 km' and the 'Before entering glidepath' checklists responds to and acts on the points.

1.18.2 Localizer offset approaches

The AAIB/N has not been informed nor has found in the documentation available whether a specified procedure for a localizer offset approach exists and was known to the Vnukovo flight crews.

1.18.3 Eiscat Svalbard Radar

About 2 km southwest of the Localizer Runway 28 Approach, 16 km from the airfield, there is an incoherent scatter radar constructed to study the ionosphere and atmosphere at auroral latitudes and the polar cap. The AAIB/N investigated into the operation of this radar to check for the possibility of interference with the approach.This investigation concluded that the Eiscat Svalbard radar was not operated in the period between 07:00 hrs on 22 August 1996 and the 20 September 1996. The main transmitter power breaker had been switched off. The antenna was placed in stow position (zenith) with lock-pins in, which activates the interlock system, disabling transmitter operation and the site had been securely closed before the last personnel left on 26 August 1996. Interference with the localizer runway 28 approach was therefore not possible.

1.18.4 Magnetism

1.18.4.1 Because Svalbard Airport Longyear is situated as far north as latitude N 78°, the AAIB/N found it necessary to check the status of the magnetic field the day of the accident. At Svalbard Airport Longyear, the angle of inclination of the magnetic field is 81.9°, giving a horizontal component H of the magnetic field intensity of 7 600 nT (nano Tessla). Even though this is a fairly small component, it is customary to operate the aircraft compass systems in magnetic mode, usually without any difficulty. The fact that a magnetometer is situated close to the airport was a benefit to the investigation.

1.18.4.2 On 29 August 1996, the magnetometer recorded a magnetic field intensity that in general may be characterized as disturbed. It was a magnetic storm of an intensity that usually happens many times a year. When the TU-154M was flying the approach to runway 28, the horizontal component of the field intensity varied about 200 nT i.e. 2-3 % during a few minutes (100 nT = 1 ° divergence). During 10 minutes around the same period, the declination varied about 1°. However, none of these are considered to cause any significant disturbance to compass systems in magnetic mode.

1.18.5 Witnesses

1.18.5.1 A helicopter pilot, who took off from Isfjord at 08:06 hrs on 29 August 1996 and landed at Svalbard Airport Longyear at 08:21 hrs, told the AAIB/N that he had overheard some of the communication between Longyear Information and VKO 2801 on frequency 118.1 MHz. When he was overhead reporting point ALFA at approximately 08:16 - 08:17 hrs, he heard that VKO 2801 had been instructed to report ADV. This was confirmed by VKO 2801. About the same time he heard: 'Climb to 5 000 ft'. At 08:18 hrs (estimated), he overheard VKO 2801 transmit: 'Will report 8 miles'. That was the last transmission he registered. The communication gave him the impression that the Russian crew member taking care of the transmissions had problems understanding the information given. When he landed, he estimated that the weather was a west by westsouthwesterly wind at 20 to 30 kts, fog patches on the mountain tops, scattered layers of clouds below a ceiling of approximately 2 000 ft.

1.18.5.2 A flightcrew departing Svalbard Airport Longyear on 29 august 1996 at 08:04 hrs on a Dornier 228 registered LN-LYR overheard on frequency 118.1 or 119.85 MHZ, the transmission: 'VIKTOR KILO OSCAR 2801 climbing for 5 000 ft'. The voice was high-pitched and sounded quite stressed. The time was approximately 08:15 - 08:16 hrs. The crew didn't register any other transmissions. Later, around 08:30 hrs, they were asked to call for VKO 2801 on frequency 118.1 MHz. No contact was established.

The flight was recalled to take part in the search for VKO 2801. They maintained 8 000 ft and used localizer 28 repeatedly to keep track of their position. When following the localizer, they did not register any anomalies.

At take-off, the ceiling was about 500 ft. When climbing out to the north, they were in clouds all the way up to the cloud tops at 9 000 - 10 000 ft.

Due to the fact that the accident site was on the centerline to runway 28, the crew had tried to fly backbeam approaches in good weather to runway 28 (frequency 110.3 set). The Dornier 228 flight management system had given sensible steering information. This was reported to the AAIB/N.

1.18.5.3 There were no eye witnesses to the accident. However, a witness and his friend who had spent the night in a tent by Innerhytta about 6.5 km from the accident site heard a large aircraft passing overhead. He thought the aircraft flew lower than normal, based on the sound from the engines. A few minutes later, he heard a loud bang followed by a weaker one. The engine sounds stopped at the first bang. He understood that there had been an accident and checked his wristwatch to be 1024 hrs local time. He left the tent to check if he could see something in the Adventdal valley, but he observed nothing unusual. There was cloudcover low enough to conceal the top of the mountain Operafjellet.

1.18.6 Questionnaire

1.18.6.1 To obtain a user-oriented check on the localizer approach to runway 28 at Svalbard Airport Longyear, the AAIB/N prepared a questionnaire to be presented to the three companies flying regularly at or to Svalbard Airport Longyear, i.e. Braathens, AS Lufttransport and Scandinavian Airlines System (SAS). Their pilots were asked to report to the Board how many times they had utilized this localizer approach and if they had experienced any anomalies using this approach aid. The period limiting the answers was from June 1987, when the transmitter had been changed, to the present date. The Board received full cooperation and 140 pilots representing 740 approaches returned the questionnaire. None had experienced any anomalies. Since the weather is usually the deciding factor as to the selection of approach and landing direction, it is reasonable to conclude that many of these approaches have been flown in weather conditions similar to those on 29 August 1996.

1.18.6.2 As a follow-up from Braathens, the AAIB/N received a copy of an occurrence report from a PiC about a localizer approach to runway 28 dated 23 September 1997. When obtaining localizer capture maintaining 5 500 ft before starting approach on the track from SVEA, the crew immediately discovered that there was a difference between the computor input and the raw data presented on the HSI. Reviewing the situation the crew verified that the raw data was correct. Maintaining a safe altitude, the crew selected 'Heading Select', turned right for the localizer and became established on the correct Localizer at 13 NM. The approach was normal after this. The AAIB/N looked into the matter and it became clear that after localizer capture, the localizer signal governs the Flight Management Computor, which means that the aircraft would have been manoeuvred to the localizer centerline given time. However, it would probably have been too late to start the descent at the proper position. The Board concluded that this occurrence was handled correctly by the crew and that there was never any hazard. The occurrence has no bearing on the investigation into the accident to TU-154M RA 85621.

1.18.7 Norwegian Aeronautical Information Publication (AIP)

1.18.7.1 The AAIB/N has confirmed that the information in the Norwegian AIP relevant to operators servicing Svalbard Airport Longyear is valid. The possibility of using the VDF service receiving QDMs is stated both on the approach charts for Svalbard Airport Longyear as well as in general terms on page RAC 1-36 and more specifically on page COM 2-24.

1.18.7.2 Differences from ICAO Provisions on page COM 0-4 with reference to ICAO Annex 10 Volume I point 3.1.3.3.1 list that LLZ to Svalbard Airport Longyear 28 is not to be used outside 10° either side of the LLZ front course.

1.18.7.3 The IAC told the AAIB/N that the general opinion in Russia about foreign AIPs was that these publications contained too much outdated information to be relied upon. For this reason, Vnukovo Airlines had turned to Jeppesen & Co. GmbH to

make certain that updated information was available to the flight crews.

The AAIB/N concludes that this is not relevant for the information listed in the Norwegian AIP relevant to operators flying to Svalbard Airport Longyear.

1.18.8 Jeppesen Approach Charts

1.18.8.1 When the AAIB/N became aware of the fact that Vnukovo Airlines used the Jeppesen approach charts when flying to Svalbard Airport Longyear and that these charts did not contain any information on the VDF service available, it became necessary to investigate the flow of information from the NCAA to Vnukovo Airlines and if the charts used were valid.

1.18.8.2 In a letter to the AAIB/N dated 14 March 1997, Jeppesen & Co. GmbH confirms that:

- the approach chart for Svalbard Airport Longyear 11-2 dated 21 January 1994 (which the crew of VKO 2801 used - AAIB/N comment) was the current edition.

- Jeppesen subscribes to the Norwegian AIP and that any amendments are usually received well in time.

- Vnukovo Airlines is one of our customers, however, and any shipping and/ or invoice-related issues are routed through Russian International Airlines (Aeroflot).

- the Jeppesen policy of reducing information considered as of secondary importance is a permanent issue on the airline seminar agenda.

  (AAIB/N comment: Too much information on the approach charts is considered a flight safety problem. The VDF service available at Svalbard Airport Longyear is considered as secondary information by Jeppesen and therefore omitted on Jeppesen Approach Charts. The AAIB/N has checked with SAS how this airline, which has its own department issuing approach charts, solves the problem of congested charts. The solution has been to add one or more pages containing the secondary information that could prove valuable to the crew in certain situations. For instance, the VDF-service at Longyear is to be found on the self-briefing page connected to the approach charts for this airport.)

1.18.9 NCAA Flight Inspection Section, Airport and Navigation Services Department

1.18.9.1 The NCAA closes down the approach aids to a Norwegian airport after an accident as a matter of routine. The Flight Inspection Aircraft LN-ILS, a DHC-8, was flown

to Svalbard Airport Longyear on 29 August 1996 with the two AAIB/N inspectors on board. A flight check of the approach aids to runway 28 was started by performing a semi-orbit radius 10 NM of LLZ 28 at 7 000 ft. No anomalies were registered and the field strength was measured to 324 μA. A track was flown to/ from ADV with normal registrations. The identification was found to be in order for both navigational aids. The semi-orbit was repeated on LLZ 10 with satisfactory results (331μA). Finally a visual approach following the ILS to runway 10 was flown without any deviations registered. A meeting was held with the airport authorities and it was decided that it was safe to open the airport for normal traffic barring the LLZ 28 instrument approaches. Further testing of LLZ 28 was postponed until the next day due to low cloudcover and poor visibility, making use of the theodolite difficult. The next day, the check flying was completed with normal registrations. The prohibition to use LLZ 28 was lifted.

1.18.9.2 Because of the significance of the report of the backbeam approaches to runway 28 made by the Dornier crew, the AAIB/N and IAC representatives participated in a demonstration flight with the Dornier 228. This flight confirmed the observations of the Dornier crew. It was then decided to recall the NCAA Flight Inspection Aircraft for further evaluation of this finding. Representatives from the AAIB/N and the IAC flew as observers on 05 September 1996, when the flight inspection crew twice tried to fly the backbeam localizer (BB-LLZ) runway 10. Neither the cockpit instrumentation nor the flight inspection system presented flyable indications on the backbeam. A check of Advent NDB was also flown without any anomalies registered.

1.18.9.3 In combination with other duties on 16 October 1996, the Flight Inspection Aircraft flew LLZ 28 (frequency 109.5 MHz) crossovers at distances 7 NM, 10 NM and 13 NM at 5 000 ft between Longyear NDB (LON) QDR 080° and 145°. In addition, LLZ 28 was flown courses other than 300° selected. No anomalies other than those expected to be present due to the system setup were detected.

1.18.9.4 The AAIB/N requested the reports of the last two flight inspections of LLZ 28 performed on 25 June 1996 and 28 February 1996. The test results were normal.

1.18.10 Checks of the approach navigational ground systems

1.18.10.1 When Svalbard Airport Longyear became aware of the crash of VKO 2801, the head of the Electro Technical Services called the LLZ 28, LLZ 10 and GP 10 by modem and the monitoring parameters of the system electronics were transferred to a computor at the office. The data were normal for all units. Advent and Longyear NDBs were checked by a control receiver and found to be normal. DME 28 was checked by a computor connected to the unit later the same day. All data were found to be normal. The test results were tranferred to the NCAA Technical Center at Fornebu for verification. The test results were confirmed as normal.

1.18.10.2 With a police officer as witness, a complete monthly check of LLZ 28 and Advent NDB was carried out on 29 August 1996. All the tests showed normal results.

1.18.10.3 The AAIB/N has also looked at the pertinent logbooks for LLZ 28, DME 28 and Advent and Longyear NDBs. The logbooks showed normal test results.

1.18.11 Airport inspection

1.18.11.1 In connection with an airport inspection carried out by the NCAA Aerodrome Section, the inspector in charge informed the AAIB/N that it was necessary to check if the road from Longyearbyen to the airport passes within the critical zone of the LLZ 28 antenna. The conclusion is that the traffic with heavy vehicles on the road is not close enough to the antenna to cause any signal disturbance. However, large ships sailing past the shoreline where the antenna is located, or being docked at the coal loading quay, could have an influence on the signal.

1.18.11.2 The AAIB/N has checked with the police in Longyearbyen as to whether any ships were recorded docking just after or leaving just before VKO 2801 made the approach, thereby being in the vicinity of the antenna. No such traffic was recorded, nor was any large ship docked at the coal loading quay.

1.18.12 Radio telephony communication

1.18.12.1 Neither the crew of flight VKO 2801 nor the AFIS officer on duty at Svalbard Airport Longyear were communicating in their mother tongue. The fact that English (one of the official ICAO languages) was used, implies that both parties took advantage of standard phrases the ICAO has introduced to minimize difficulties understanding one another. This was particulary true of the Russian crew. One of the standard phrases that caused confusion was 'estimate'. The AFIS officer was used to hear 'estimate' in context with time like 'Estimating INDIA - SIERRA - DELTA at five - niner'. However, the navigator used this phrase differently quite a few times when it would have been better to use 'Request' such as 'Bodø control estimate descent,' '2801 ETA ENSB 08:15 Estimated descent,' 'Estimate descent from level 350 to 60,' 'Estimated approach runway 10. When 'request' was finally used, it was put in context with the phrase 'runway in use' in such a way that confused the request: 'Request runway in use for landing to runway 1---, 10.'

1.18.12.2 In the wreckage, the AAIB/N found a Russian booklet, Manual for Civil Aviation Specialists in Radio Communication in English by the Russian Ministry of Civil Aviation, belonging to the co-pilot, designed to facilitate English-spoken radio telephony for Russian flight crews. The manual gives, for instance, advice on how to use the phrases 'Runway in use' and 'Request'. The booklet is a good assistant, but obviously does not cover the unforseen or unusual situations. This problem is highlighted in an article in the Flight Safety Foundation (FSF) publication 'Airport Operations' September-October 1997 issue 'English-language Training For Air

Traffic Controllers Must Go Beyond Basic ATC Vocabulary' by Shannon Uplinger from Uplinger Translation Services (see Appendix 6). The article is focused on air traffic controllers, but the IAC and AAIB/N consider this could be equally true for many other aircrews as well. The author also points out that:

- Because miscommunication can have serious consequences, air traffic controllers responsible for international flights must have skills in English to communicate more broadly than just to repeat learned phrases. The training and testing of controllers in English should require that controllers be able to respond to unusual, as well as routine, situations

- Dealing with ambiguity in ATC communications is even more complex when flight crews, controllers or both are communicating in English that has been acquired as a second language

- If controllers lack adequate English skills, they cannot resolve ambigous situations by requesting clarification or verification of details

- (And because the article covers a commendable Russian effort to improve English language skill for controllers): Communication broke down most often when Russian controllers moved from strictly formatted exchanges to discuss weather, airport conditions and other topics that require skill in generating sentences

- Lack of practice has great influence on listening and speaking skills.

Although the communication between the ATS and Norwegian flight crews most often is carried out in English, thereby giving a lot of practice, this is a relevant point for the Norwegian aviation community as well.

1.18.13 Radar

1.18.13.1 In the aftermath of this accident, it has been maintained that a radar at Svalbard Airport Longyear could have prevented this accident. The accredited representative has pointed out that an airport situated in similar terrain in Russia would be equipped with radar. Neither the NCAA nor the AAIB/N disagree that radar is a benefit to flight safety. In a report on an accident to a Twin Otter making a non-precision approach to Namsos airport in Norway on 27 October 1993, the AAIB/N referred to a study about the causes of Controlled Flight Into Terrain concluding that precision approaches are 5.2 times safer than non-precision approaches. As a result, the AAIB/N recommended to the NCAA on 26 June 1996 that the Administration 'assesses improvements in navigational approach aids for short field airports based on the need to establish safety barriers which are the result of a risk analysis of each airfield'. The Board has been informed that the NCAA is taking this recommendation seriously and is reviewing the priority list of

navigational equipment to be installed at airports in mountainous terrain. The fact that this issue could be of equal importance to airports other than short field airports was demonstrated on 04 April 1998 when an Aeroflot IL76 strayed during ILS approach in IMC to Evenes airport, Norway. A vigilant air traffic controller monitored the flight on the radar scope in the control tower and probably averted an accident when he used the radar to direct the flight to a safe landing.

1.18.14 Flight Safety Foundation (FSF) Approach-and-Landing Accident Reduction (ALAR) Task Force

The FSF has been worried about the increasing trend of accidents during approach and landing for a long time. An ALAR task force with the mandate to look into this matter was established in 1997 as a follow-up activity of the FSF Controlled -Flight-Into-Terrain (CFIT) Task Force. The conclusions of the work of this group were published in FSF News, dated 17 November 1998:

- No. 1: Establishing and adhering to adequate Standard Operating Procedures (SOPs) and flight-crew decision-making processes improved approach-and-landing safety.

- No. 2: Failure to recognize the need for and to execute a missed approach when appropriate is a major cause of Approach-and-Landing Accidents (ALAs).

- No. 3: Unstabilized and rushed approaches contribute to ALAs.

- No. 4: Improving communication and mutual understanding between air traffic control (ATC) services and flight crews of each other's operational environments will improve approach-and-landing safety.

- No. 5: The risk of ALAs is higher in operations conducted in low light and poor visibility, on wet or otherwise contaminated runways, and with the presence of optical or physiological illusions.

- No. 6: Using the radio altimeter (RA) as an effective tool will help prevent ALAs.

- No. 7: Collection and analysis of in-flight parameters (e.g., flight operational quality assurance [FOQA] programs) identify performance trends that can be used to improve approach-and-landing safety.

- No. 8: Global sharing of aviation information decreases the risk of ALAs.

1.18.15 Physiological-acoustic study of the flight crew

1.18.15.1 In the interest of evaluating the dynamics of the crew members psycho-emotional state during their final flight, IAC made a physiological-acoustic study of speech that could be ascribed to identified members. The acoustic analysis of speech signals were made difficult due to the very unfavourable signal to noise ratio on the open microphone channel of the CVR. Therefore the analysis was supplemented with data from an expert psychometric scaling.

1.18.15.2 The results of the study show that during the approach to the Svalbard Airport Longyear, the crew members experienced a gradual, but not strongly manifested, increase in their psycho-emotional stress. It first became evident in the navigator (at 07:57:26 hrs) and then in the aircraft commander. The co-pilot showed signs of some increased psycho-emotional stress only on the final approach. The manifestation of this stress (up until the last moment) does not go beyond the upper limits for working variations during approaches carried out in difficult conditions for any of the crew members. Only in the last moments of the flight is there is an abrupt increase in emotion of the pilots. The demonstrated dynamics of the general psycho-emotional state of the crew could be a reflection of the flying conditions. It is not likely that this could primarily have initiated inferior performance by the crew members, causing them to make mistakes in their work.

1.18.16 The navigator's cyclogram

The IAC has examined the navigator's duties and tasks and the average time necessary to comply with and perform these accordingly. For an approach like the one the crew carried out towards runway 28 at Svalbard Airport Longyear, about 20 minutes are needed out of the 33 minutes the approach lasted. In addition, time was spent handling the communication with the AFIS, preparing what to transmit and evaluating information received, as well as controlling the aircraft laterally by the Autopilot Turn knob.

1.19 Useful or effective investigation techniques

1.19.1 CVR readout process

The initial readout of the cockpit area microphone of the MARS-BM registration system was only partly successful, as only about 40% - 50% of the intra cockpit conversation was audible and about half of that interpreted. By advice from the IAC, the AAIB/N hired Speech Technology Center, St Petersburg to improve the readout. Experts from the IAC participated in the work and represented the AAIB/N. The content of the original tape had a signal to noise ratio of about -20 dB to -15 dB (i.e. the level of speech is 5 - 10 times less than the level of the background noise). Initially, the content of the tape was converted to digital form

and stored. The second step was a comprehensive signal analysis and then, thirdly, fairly sophisticated noise reduction processes, requiring well-developed operator expertise to be successful, were utilized in addition to speech enhancement. The STC experts determined the preliminary text using headphones and by introducing a time or phase delay between the two ears of the listener, feeding different filtered signals to each ear and by using differing volumes in each ear. Finally, a team from Vnukovo Airlines and the IAC, using the same method under supervision of a STC expert, interpreted the text. This way, 85 - 90% of the communication on the flight deck was made intelligible, of which 90 fragments of speech were new and 30% of the first interpretation had to be changed.

2 ANALYSIS

2.1 Introduction

As a user/reader of this report one must bear in mind that it has not been possible to fully identify and interpret 100% of the intra cockpit communication. Even though the Boards (IAC and AAIB/N) know that no communication of any length is missing from the CVR-readout, the possibility exists that some of the uninterpreted remarks could throw additional light on the course of events and the identified causal factors. However, with reference to ICAO Annex 13, it has not been the object of this investigation to apportion blame or liability, but review the flight safety aspects of the occurrence, based on identified cause factors and or other safety issues. With this principle as the point of departure, the Boards have reviewed this accident based on the information made available as a result of the investigation.

2.2 Elimination of possible causal factors to narrow down the investigation

2.2.1 The actual weather conditions satisfied the PiC minimum requirements to carry out the approaches to Svalbard Airport Longyear. The decision to start the approach for runway 10 and later the approach for runway 28 was sound in relation to the weather in the area. The Boards do not consider the weather that day to be a safety factor.

2.2.2 Because VKO 2801 impacted practically on the extended centerline of runway 28, an obvious cause factor was that the crew in their preparations for the localizer approach to runway 28 had forgotten to change the frequency from 110.3 MHz to 109.5 MHz and had thereby flown a back beam approach. The technical examination shows that the crew had changed to the correct frequency. In addition, the backwards plotting of the aircraft track based on the FDR information from the point of impact indicates that the crew was tracking nearly parallel to the correct

localizer. The Boards therefore rule out the possibility of a back beam approach as a causal factor.

2.2.3 The interpretation of the FDR parameters carried out by the IAC shows that the aircraft was technically sound and that the examination could be limited to checking the installed navigational equipment. The CVR/ FDR interpretation also indicated that the flight was safe until the aircraft was turned to final about 3 km to the right of the localizer centerline. The fact that the aircraft impacted at the correct altitude in addition to the CVR/ FDR information, substantiated the fact that the vertical navigation had been carried out correctly and that the crew performance had not been affected by erronous altimeter indications. The Boards cannot rule out that some of the digits indicating QNH/ QFE had changed during impact. This finding made it possible for the Boards to limit the investigation to causal factors that could have influenced the lateral navigation of the aircraft.

2.2.4 To carry out the lateral navigation, the crew had the following available on board and utilized:

- Two independant compass systems in gyro-magnetic mode.
- Two ADF receivers of which the right one only had been set to relevant frequencies namely ADV and LON and with LON selected to RMI needle no. 2.
- Two localizer/ DME receivers both set to the correct frequency and two HSIs with the inbound course 283° selected.
- One GPS.

2.2.4.1 The wreckage trail on top of the mountain was measured to about 330° and the two compensator needles of the compassystems indicated 310° and 316° respectively, indications contradicting the FDR recorded and calculated magnetic heading of 291°. Because the aircraft impacted the edge of the mountain at an angle of about 45°, it is the opinion of the Boards that the direction of the wreakage trail was a consequence of the parts being deflected to the right. It is possible that this deflection had an influence on the indications of the compensator needles managing to move a bit before the power was cut. However, the Boards are of the opinion that the indications of the two compensator needles were more likely caused by the left roll before impact. This is substantiated by the behavior of the corresponding needles during the test aircraft roll movements. The magnetic storm recorded when VKO 2801 made the approach was not of a magnitude that would have any practical bearing on the lateral navigation of the aircraft. The Boards therefore conclude that the FDR recorded heading of 291° on impact was correct and that the crew did not receive erronous heading information.

2.2.4.2 The technical examination proved that the right ADF only was in use and that RMI needle no. 2 was pointing accurately to LON on impact. The test flight demonstrated that both ADV and LON could be used to check the localizer 28 centerline on final, except when getting close to the antennas.

2.2.4.3 The DME utilized on the localizer 28 approach is colocated with the localizer and is tuned by the same frequency. The investigation has not revealed that the crew experienced any difficulties determining the distances along the inbound and outbound tracks and to the airport. The base turn was started correctly and the descent was started at the proper position. A distance indicated on the DMEs was probably also confirmed by the distance indicated on the GPS display. The Boards conclude that the crew did not receive erronous distance information.

2.2.4.4 The above conclusions indicate to the Boards that readings from the two HSI/ CDIs and the GPS systems were the main sources of information to the crew regarding indications influencing the lateral navigation of the aircraft on final approach.

2.2.5 The test flight carried out by a prepared crew and with an identical TU-154M, proved time and time again that this aircraft type, with its onboard navigational equipment, could function accurately on signals from the ground installations at Svalbard Airport Longyear. The test flight crew demonstrated quite a few times that it was possible to follow the localizer approach procedure to runway 28 accurately.

2.2.6 The records of the status of the ground installations did not indicate any history of technical problems nor did the checks made immediately after the accident. All the different checks carried out by the flight inspection crews have resulted in field strength measurements well above the required minimums. The check flights have been carried out in different weather conditions and the tracking of the flight inspection aircraft has been proved by theodolite, GPS and Differential GPS.

2.2.7 The Boards find the fact significant that the Dornier 228 crew repeatedly used the localizer 28 shortly after the accident to keep track of their position without registering any anomalies. It is also significant that the user-oriented check representing 740 approaches on localizer 28 covering a long period of time did not result in any reports of deviations experienced when these approaches were carried out. Because the ILS to runway 10 is the preferred approach, it is reasonable to conclude that the crew's decision to use the localizer 28 approach was mostly determined by the weather and that, during the years prior to the accident, quite a few approaches to runway 28 were made in weather conditions similar to those at Svalbard Airport Longyear on 29 August 1996. Finally, the VDF reading the AFIS officer received during his last communication with VKO 2801 indicated that the flight was closing in on the localizer centerline. Since this was a reasonable QDM, the timespan following the crew's report of passing ADV outbound was taken into consideration. His statement about this QDM is confirmed by the last communication relating to the FDR plot.

The Boards conclude that when the above-mentioned results of the investigation are taken into consideration, there is no indication that the localizer 28 approach was unsafe to use, providing the ± 10° limitation was adhered to. If so, the possibilities of a system defect in the ILS/ LLZ navigation system limited to this particular aircraft remains.

2.2.8 Although considered remote by the Boards due to previous experience, atmospheric influence or effects of ground reflections on the localizer signal could not, at the beginning, be disregarded entirely. However, the work done by the expert panel on this matter has enabled the Boards to conclude that a horizontal misplacement of the localizer signal of practical importance, and thereby the accident flight, due to atmospheric refraction, ground reflections or a combination of the two, is not likely.

2.2.9 As a result of the above, the Boards have further concentrated the investigation and the analysis on human performance factors and the lateral navigation of the aircraft limited to the onboard HSI/ GPS installations and indications.

2.3 Analysis based on the correlation of CVR/ FDR information reinforced by STEP to systematize and illustrate the search for causal factors and flight safety issues.

2.3.1 The available information during the last 30 minutes of the flight has been divided into five segments, each of which has characteristic psychological and situational features. This has been done to review the psychological aspects of the crew's condition and actions and reveal possible reasons for erronous and inadequate actions commited by the crew during the approach. To accomplish this, an assessment of the crew's condition and actions, elaborated on the basis of a theory of relativistic conception of human mental activity allowing a retrospective psychological reconstruction of a specific situation, has been used. This makes it possible to reveal both situational and truly causal factors leading to the actual outcome.

Sections marked with a Δ and numbers from 0 to 20 refer to safety issues which came to light through the analysis methods and which the Boards mean contain possibilities for improved flight safety. (See Appendix 3 for the STEP method.)

2.3.2 Δ 0 marks safety issues with a potential for improvements that refer to the planning and preparations carried out in Moscow before flight based on available/ unavailable information, as well as radar service at Norwegian airports.

It is the opinion of the Boards that it is commendable that the crew met before the flight to prepare and especially that they flew the approach to runway 10 on the simulator. Because a sudden change of approach happens

quite frequently everywhere for different reasons, it is a good policy to take possible alternate approaches at destinations/ alternative airports into consideration. According to the IAC, documents from the airline's simulator show that the PiC, the co-pilot and the navigator had performed approaches to runway 10 and 28 in 1996.

The Norwegian AIP was not available to the airline's Operations Department nor to the PiC and his crew. This AIP contains valuable safety information concerning the services to be expected, including VDF, and could have given the crew a better understanding of the status of the AFIS officer in comparison with a Russian air traffic controller. The general opinion that AIPs contain too much outdated information to be relied upon is not relevant or the Norwegian AIP information concerning the Svalbard Airport Longyear.

The Boards do not question the procedure and decision of Jeppesen & Co GmbH on how to deal with the safety problem of congested approach charts. However, the Boards challenge the company to look for a different solution on how to deal with secondary flight information that could be of value to a flight crew (for example the SAS solution to this issue). As secondary information was not available to the airline and this crew through Jeppesen, the GPS database provided by Allied Signal did not contain this kind of information either. According to the GPS instruction manual, Allied Signal General Avionics is a Jeppesen Sanderson customer for Nav Data information.

It is the responsibility of any airline or PiC to assess whether the available approach aids at a destination are adequate for a safe flight taking the particular aircraft's equipment and performance into consideration, as well as the flight crew's experience and the expected weather conditions. From this point of departure, the Svalbard Airport Longyear has been serviced safely for years. However, the Boards would like to point out that a radar service would represent an additional safety barrier to this airport with its limitations on the use of the localizers and the non-precision approach to runway 28, in addition to the vicinity of mountainous terrain. The possibility of monitoring the navigation of an aircraft by an outside service, such as radar, is a bonus well demonstrated by the incident of 04 April 1998 with the Aeroflot IL76 at Evenes, Norway. The Boards therefore urge the NCAA to review the priority list of radar installations at Norwegian airports situated in mountainous terrain and continue the work of risk assessment in this respect.

2.3.3 The first segment 07:51:50 hrs - 07:56:19 hrs (4 min 29 sec, the start of preparations for approach - the start of descent from cruising flight level).

2.3.3.1 On this stretch, the PiC organized and the crew carried out preparations for the approach to and landing on runway 10 at Svalbard Airport Longyear. The PiC ordered 'the left pilot' - his co-pilot on this introduction flight - to fly the aircraft, while he himself took responsibility for the communication ('communication from

the right'). However, the co-pilot (who was by profession an aircraft commander and instructor) partly relocated the responsibility of flying the aircraft by saying to the navigator: 'I'll adjust the speed for you while you carry out the approach'. The navigator had been taking care of the communication during the cruise portion of the flight and the PiC never relieved him of this duty as he had just stated. Therefore, the navigator had to take care of the communication as well until the end of the flight. This might possibly have something to do with the level of the navigator's knowledge of the English language compared to the PiC's own abilities in this respect.

2.3.3.2 Δ 1 It is the opinion of the Boards that it is a sound procedure to include in the approach briefing which ground navigational aids are to be tuned and to which receiver onboard (a standard operating procedure for TU 154M crews). Following such a procedure will prevent forgetting to tune a required navigational aid and hinder misunderstandings by crew members as to which needle is indicating which navigational aid. This safety issue was not a causal factor in this accident as the technical examination has proved, but it could easily become a factor under different circumstances.

2.3.3.3 Δ 2 The fact that the PiC did not relieve the navigator of his communication duty had an inauspicious psychological implication that was further aggravated by the fact that, during the approach to the other runway, the navigator had to perform 70 - 75 operations/ duties of varying difficulty and duration demanding his attention for approximately 20 minutes. The allocation of crew duties overloaded the navigator mentally and led to tasks being missed or mistakes being made that had an important role in the development of the final outcome.

The radio communication being taken care of by the navigator during the approach was in contradiction to the requirements of the normative documents, which prescribe that the communication in the airport area should be the duty of the pilot relieved from controlling the aircraft. It also did not comply with the allocation of responsibilities established by the PiC in the approach briefing.

The minimum crew on the flight deck of a TU 154M is two pilots and a flight engineer. When a navigator is added to the crew, the Boards have the impression that he must show that he is 'pulling his weight' by doing additional tasks normally carried out by the pilots in a minimum crew situation. In this case, the Boards think it questionable that the PiC felt it necessary to be relieved from the communication duty due to being an instructor for another experienced commander on an introduction flight only. It is also questionable that the co-pilot gave the navigator the task of controlling the aircraft laterally, even though it was ergonomically convenient, due to all the other tasks the navigator had to set about in this situation. The document 'Four member crew procedure' addition to the Flight Manual gives the PiC the authority to order the navigator to control the

aircraft laterally by the Autopilot Turn knob. That the navigator may be made responsible for controlling the aircraft laterally during approach, is not specified. A PiC must have the authority to organize and utilize his crew members as he deems fit, but it is also his responsibility to ensure that none of them is overloaded. It is the opinion of the Boards that the management of the crew resources was not handled very well and that this fact set the scene for the navigator to make mistakes.

2.3.3.4 At 07:52:49 hrs, the PiC called for 'control survey pages' (pages for self-briefing) and the crew members responded as they should. At 07:53:28 hrs, the PiC called for the 'Before descent' checklist, but the CVR readout does not indicate that the items on this list were carried out except for the PiC responding to the first item 'I have been acquainted.'

2.3.3.5 Δ 3 During the test flight, the crew demonstrated a very good checklist system. It was handled by the navigator who covered the different items of the checklists as they were completed, thereby avoiding omitting items and making it easy to continue correctly after interruptions. In addition to this checklist system, the TU 154M standard operating procedure is that the different checklist items are initiated by challenges from the crew member reading the checklist and controlled by required responses from the crew members carrying out the different items. In this way, they are forced to participate more actively and a procedure for avoiding mistakes is established, fascilitating the monitoring of the other crew members. With reference to the CVR readout, this procedure was not adhered to by the crew at all times.

2.3.3.6 At 07:56:08 hrs, when the AFIS officer answered to the request for descent, he used the phrase 'approved' without reference to an authority approving the descent.

2.3.3.7 Δ 4 An AFIS officer does not have the authority to approve anything, but is limited to relay clearances and give information. Although a minor point, the Boards see the possibility of an unfortunate effect of the use of this word. The Russian crew was flying in unfamiliar airspace with limited knowledge of the air traffic services system and might therefore have misconceived the authority of the AFIS officer.

2.3.4 The second segment 07:56:19 hrs - 08:04:59 hrs (8 min 40 sec, the start of the descent from cruising level to when the decision to fly the approach to runway 28 was taken).

2.3.4.1 After having received information about the traffic situation, transition level and the altimeter setting below from Longyear Information, the descent from FL 350 for altitude 6 000 ft was started at 07:56:19 hrs. When the Navigator informed Svalbard Airport Longyear that the flight was leaving the cruising level, he also tried to

request an approach to runway 10: '2801, roger. Leaving level 350 for level 60. QNH 1005. Estimated approach runway 10'.

2.3.4.2 On this segment, the AFIS officer made an effort to clarify which route VKO 2801 was going to follow, 07:56:38 hrs: 'Are you making an approach via India - - India - Sierra - Delta? over' and 07:59:41 hrs: 'Confirm you will make an approach for runway 28, via Alfa - Delta - Victor?' The crew received information about which runway was in use by the other flights using the airport and the actual weather. The navigator made some small mistakes (underlined) during this period, such as:

- 07:57:26 hrs: 'Making a descent to level 60 , QNH 1005. Reach altitude 4 000 ft'. (Should have been 4 500 ft towards LON NDB or 5 000 ft towards ADV.)

- 07:58:50 hrs: A 10 min error in the estimate for passing ISD (for which he corrected himself 14 seconds later).

- Naming the checkpoint after Isfjord Lima Alfa instead of ADV.

- He also neglected to confirm that VKO 2801 would use the approach to runway 28.

2.3.4.3 The AFIS officer becoming unsure as to whether or not the Russian crew fully understood the information given, tried to clarify the situation at 08:00:07 hrs by suggesting: 'VKO 2801 Longyear, after passing Isfjord suggest you are heading for Alfa - Delta - Victor at 5 000 ft?' to which the Navigator once again mixed up the altitude by answering: '2801, Continue down to 4 000 --- 4 500 feet, QNH 1005.' (Should have been 5 000 ft.)

2.3.4.4 Although the navigator frequently communicated the wrong altitudes, these mistakes did not have any consequence because the flight never violated any minimum altitudes. The causes for his slips of the tongue were probably due to his struggle with the English language, taking a long time to understand the received information and formulating the answers, and that his mind was further occupied with the altitudes prescribed for the approach to runway 10, well established in his memory due to the thorough preparations for this landing direction. On the other hand, the AFIS officer was inattentive to the navigator's mistakes, frequently acknowledging the read back of information with the phrase 'Roger'. (Definition: 'I have received all of your last transmission'.)

2.3.4.5 From 08:00:29 hrs - 08:02:17 hrs, the crew, realizing the need to change the original plan for approach, turned to Jeppesen to study the chart for the LLZ 28 approach. Co-pilot: 'And what's this they have here?' PiC: 'There is a mast here.' Co-pilot: 'Here (somebody is flying) (such high hills)' and 'Is the "radar" an unusual one?' (AAIB/N comment: There is no radar at Svalbard Airport Longyear. The

co-pilot probably meant the localizer?) Unidentified crew member: 'No'. PiC: 'No, it's simply...'. Finally Unidentified crew members at 08:02:40 hrs, uttered their discontent by saying: 'Yeah, that's what I call an approach' and 4 seconds later 'It is'.

2.3.4.6 Δ 5 At this point, according to the requirements of the normative documents, the crew should have made a new approach briefing for runway 28. The first time, the approach briefing lasted about 75 sec. However, during the 78 sec between 08:02:44 hrs and 08:04:02 hrs, no new approach briefing can be heard on the CVR recording. Neither can such a briefing be heard later on.

The Boards consider that the lack of a new approach briefing is a significant factor because meticulous planning is one of the cornerstones of a well-executed flight. Inadequate planning recurs as a cause factor in the statistics for aircraft accidents.

2.3.4.7 At 08:04:40 hrs, the crew, still hoping that an approach to runway 10 would be possible, made a last attempt to obtain a clearance: 'Longyear information 2801, request runway in use for landing to runway 1---, 10'. But as an answer to the request for 'runway in use,' the AFIS officer at 08:04:56 hrs repeated that: 'Runway in use is 28'. This was acknowledged by the Navigator transmitting: 'Roger, 28.'

2.3.4.8 Δ 6 The unfortunate use of the standard phrase 'runway in use' masked the intention of the crew really requesting an approach to runway 10. The word 'estimate' used in the past tense 'estimated' and in an unfamiliar way to the AFIS officer's ear, could also account for the misunderstanding between himself and the navigator concerning the request for approach to runway 10. Therefore, an inadequate knowledge of the English language made it difficult for the crew to handle fairly ordinary, but unexpected information.

The Boards would direct attention to Appendix 6 and the article in the Flight Safety Foundation publication dealing with the necessity to be able to communicate more broadly than just to repeat learned phrases and to have the ability to respond to unusual, as well as routine, situations.

2.3.4.9 Δ 7 Due to insufficient preparations, the crew was unaware of the fact that the PiC was in a position to decide which approach he wanted to carry out and say so. An AFIS officer is, as pointed out above, neither authorized to issue clearances nor control the air traffic. From their experience with the status of the Russian air traffic controller and the inherent unpleasantness of acting against his/ her orders, the crew evidently chose to regard the AFIS officer as some kind of controller and accepted his information as an order.

During the investigation, it has also come to light that some Russian air crews have been reprimanded at home because of mistakes made abroad based on reports from foreign Air Traffic Control authorities. This has led to rumours among Russian aircrews and has had the effect that crews in general avoid

discussion with foreign ATC authorities.

Being in unfamiliar airspace, unfamiliar with the status of the AFIS officer and with a limited knowledge of the English language, it is understandable that the crew discontinued its attempts to achieve a clearance for runway 10.

2.3.4.10 Thus, at the end of the second segment, the crew ended up in a situation where they had to perform an unusual (offset) localizer approach to the opposite runway, which required the various navigational aids (GPS, LLZ, Mode Selector - Kurs MP, HSI and ADF) being reset. The nature of the situation is evident on the one hand in the crew's persistence in trying to obtain a clearance for approach to runway 10, and on the other hand in the Crew member's reaction to the runway 28 approach: 'Yeah, that's what I call an approach.' From the moment the crew made the decision to carry out the approach to runway 28, they were forced to operate in a reasoning mental mode, which is dangerous in conditions of limited time and aggravated by the weather conditions requiring the approach to be carried out under IMC.

2.3.4.11 To be in a reasoning mental mode means that one operates in a mental state where one is so concentrated with the evaluation of the ongoing tasks that the mental capacity is to a great extent occupied. This state leaves less capacity to absorb, evaluate and solve other important aspects of the situation, thereby creating premises for making mistakes.

2.3.5 The third segment 08:04:59 hrs - 08:15:32 hrs (10 min 33 sec, the decision to fly the approach to runway 28 - passing of the NDB Advent).

2.3.5.1 Still descending, the flight was now tracking in the general direction of ADV - at 08:09:11 hrs, the Co-pilot said: 'We have taken in Advent', and, six seconds later, an Unidentified crew member said: 'Go after the pike' (The Boards' comment: apparently the ADF arrowhead).

At 08:09:19 hrs, the navigator stated the airport altimeter setting to be 751 mm, which was the correct QFE calculated from the given QNH. 12 seconds later, the PiC stated: 'New altitude, we're maintaining 5 000 ft,' one minute later confirmed by the Co-pilot: 'We have reached 1 500 m.' Just after that, he stated: 'We'll land by the standard procedure' and the Navigator acknowledged the order by saying: 'Standard'. At 08:13:44 hrs, the resetting of the instruments was apparently completed and the Navigator reported to the rest of the crew: 'We will land by Jeppesen.'

2.3.5.2 Δ 5 As pointed out earlier, no new approach briefing was carried out other than the co-pilot referring to standard procedures for landing and an acknowledgement from the navigator.

2.3.5.3 Apparently, the navigator had set about resetting the instruments during this period. Resetting the radio navigational instruments for the new approach probably did not take long. Most likely, the navigator also reset the GPS as a backup aid using the simplified program. A full programming of the GPS for an approach requires from 5 - 9 minutes of uninterupted work, providing all coordinates of fixed points are known (points for starting and completing turns, start of final descent, navigational aids, etc.). This was demonstrated in an experiment involving three experienced navigators from Vnukovo Airlines. In this case, based on the intra cockpit communication, analysis of the cyclograms, the development of the chain of events, the normative documents as well as the testflying performed, the Boards are of the opinion that the navigator most probably reset the GPS in the OBS mode to the course 283°. This way, the GPS display would show the lateral deviation from the extension of the runway centerline. The points at which the third turn (to the base leg) and the fourth turn (to final) were in all probability not programmed. The coordinates for the NDB ADV were not required in the flight plan and therefore most likely not preprogrammed either.

2.3.5.4 Δ 8 During the period of resetting the radio navigation equipment, the CVR did not record any identity signals. With reference to safety issue Δ 1, the Boards would point out that the reasons for checking the identity of the signals to be used are similar. Again, the investigation has shown that this safety issue isn't a factor in this accident, but it could be important under different circumstances.

2.3.5.5 Δ 9 The technical examination proved that the crew had adhered to the rule and procedure to put the landing course 283° on the two HSIs. Although the HSI/ CDI functions independently of what's set in the course window, the Boards would point out that the CDI centerline in this case was pointing 17° to the left of the approach course of 300°. When flying headings in the vicinity of 300°, a stressed crew could interpret this as indicating they were correcting a wind drift to the left, caused by a local northeasterly wind in the mountains. We will, however, never know if this consequence of the setup influenced the crew on final and made them think that they were correcting for a local wind direction.

2.3.5.6 Δ 10 Another very significant matter in this case is the authorized use of the GPS for backup. Since the installation of the GPS in the airline's fleet of aircraft, the system had demonstrated very good accuracy, building the confidence of the crews in this system. Most likely, the navigator adhered to the setting of the landing course rule for the GPS as well. This is not surprising because a well-trained person, like the navigator, will easily revert to a well-established procedure or habit in a stressed situation. It is, therefore, paramount that the procedure or habit is correct for the situation on hand. As far as the Boards are aware, a specific procedure for an offset approach, like the LLZ 28 approach, does not exist. The Boards agree that on a straight-in approach, the rule of setting the landing course does not contain undesired consequences, but for an

offset approach, the rule is inherently dangerous. Therefore, the Boards consider that the lack of a procedure for offset approaches, coupled with the rule requiring to set the landing course on the HSI, was a latent failure mechanism laying dormant in the system.

Further use of the terminology of professor James Reason, the mistake made by the crew in adhering to the rule in this case, was a typical rule-based mistake.

2.3.5.7 At 08:13:46 hrs, the first of six radio altimeter warnings was registered by the CVR.

2.3.5.8 Δ 11 This warning did not concern the crew at all since they knew the aircraft was maintaining a safe altitude. As far as the Boards are aware, there is no procedure for using the radio altimeter as a ground proximity indication at this stage of the approach, neither is there a procedure for the elimination of nuisance warnings. The flight safety potential of the radio altimeter will be further discussed later in this analysis.

2.3.5.9 At 08:14:54 hrs, the AFIS officer called VKO 2801 for an update on position and altitude. The Navigator replied: 'Maintaining 5 000 ft, QNH 1006 approaching Lima Alfa --- inbound --- outbound'. The AFIS officer acknowledged that and asked for a new report when VKO 2801 passed Alfa Delta Victor outbound, to which the Navigator replied: 'I call you back over Lima Alpha, 2801.'

2.3.5.10 The reply to the request for the position report shows that the navigator had registered that the altimeter setting had changed even though this information had been given to another flight in the area. On the other hand, he again mixed up ADV with LA. This might have been a consequence of the limited time he had to study the chart for the LLZ 28 approach, where D8.0 LA is printed close to the symbol for ADV.

2.3.5.11 At 08:15:32 hrs, VKO 2801 passed overhead ADV. A turn to the outbound track had already started. A sufficient linear turn lead was not carried out, with the result that the aircraft ended up to the northeast of the outbound track from ADV. Due to the limited time getting ready for the new approach, the navigator did not have enough time available to make any sophisticated preparations. He was dealing with the communication with AFIS, he had been studying and resetting the instruments for the new approach and he controlled the aircraft laterally by operating the turn knob of the AFCS (ABSU 154) in the autopilot mode. As pointed out earlier, it is considered convenient from an ergonomical point of view that the navigator operates the turn knob in autopilot mode in addition to his responsibility for the lateral navigation in the approach phase. He had, therefore, little breathing space to recheck his work and detect any mistakes.

2.3.5.12 Δ 12 When VKO 2801 passed ADV and entered the approach procedure, the crew had to deal with a base turn requiring a lot of turning for a large aircraft. Because there is almost no traffic arriving ADV from the east, a base turn placed to the northeast of the centerline would generally require less manoeuvring. In addition, the main reason for using the LLZ 28 approach is westerly weather, which would give a headwind component when turning inbound to final, thereby fascilitating the interception of the centerline.

2.3.6 The fourth segment 08:15 :32 hrs - 08:19:06 hrs (3 min 34 sec, passing of NDB Advent - completion of the fourth (final) turn).

2.3.6.1 From 08:15:32 hrs - 08:16:43 hrs, the following communication was recorded: Navigator - '2801, now over NDB Lima Alfa, altitude 5 000 ft on 1006, turning right, heading 15-155', AFIS officer - 'VKO 2801, say again', Navigator - '2801 passing now NDB Lima Alfa, altitude 5 000 feet, turning right heading 155', AFIS officer - 'VKO 2801 roger, and give me a report passing ADV or abeam ADV inbound', Navigator - '01, call you back over inbound, abeam Alfa Delta Victor, 2801', AFIS officer - 'Yeah, give me a call passing abeam ADV', Navigator - 'Alfa Delta Victor', AFIS officer - 'Call me passing abeam Advent beacon.'

2.3.6.2 The navigator took the aircraft out of the turn on heading 160°, thereby correcting the wind drift. This correction meant that the aircraft was tracking about 155°, but to the left of the outbound track from ADV. Again, the navigator mixed up the identification of Advent NDB with the identification of the LLZ 28/ DME. The exhange of information related to a fairly straightforward position report, lasted a long time, occupying the attention of everybody involved. The AFIS officer got the impression once more that the crew had difficulties understanding him.

2.3.6.3 About this time, the crew of the Dornier 228 and the helicopter pilot think they overheard 'VKO 2801 climbing for 5 000 ft' and 'climb to 5 000' respectively. The recordings of the CVR and in the tower, which are identical, show that this is not entirely correct. But the timing corresponds fairly well with the passing of ADV when the Navigator reported: '2801, passing now NDB Lima Alfa, altitude 5 000 feet turning right heading 155'. It is interesting to notice that the Dornier crew familiar with the R/ T of the Russian helicopter crews at Svalbard, thought the voice of the person reporting sounded highpitched and quite stressed. However, the witness statement by the Dornier crew is contradictory to the IAC investigation about the dynamics of the psycho-emotional state of the crew members.

2.3.6.4 The tracking of the flight was now subject to some remarks from the crew members. 08:16:55 hrs - 08:17:16 hrs Navigator: 'No, seven miles here - I'll adjust it', Co-pilot: ' Where are we...', PiC: 'Did you notice the place?', Navigator: 'Abeam the turning point', PiC: 'A corrective turn will be (?necessary)', Unidentified crew member: 'We're approaching'.

2.3.6.5 This intra-cockpit conversation indicates that the crew were studying the Jeppesen chart, that they were aware of being off to the side of the outbound track from ADV, that a corrective turn would be (?necessary) and that the left turn for final was close.

2.3.6.6 Δ 13 When heading outbound from ADV, the crew made the proper correction for the southeasterly wind, but did not make the substantial heading correction to the right which was required to intercept the 155° track. Parallelling the track to the northeast, just correcting for the wind drift meant that the aircraft would probably have overshot the final when turning inbound - a situation aggravated by the tailwind component in the turn.

2.3.6.7 To check the progression of the flight with his VDF and confirm his mental picture of the position of VKO 2801, the AFIS officer at 08:17:40 hrs renewed his request for a position report passing ADV inbound by calling: 'VKO 2801 give me a call eight miles inbound', to which the Navigator mistakenly answered: 'Call you back ten miles inbound, 2801.' This gave rise to another necessary clarification of what the AFIS officer expected from VKO 2801 and he emphasized eight miles! The Flight engineer was recorded saying to the navigator: 'Eight miles' (in English) leading to the Navigator then stating: 'Ah - abeam eight miles 2801 inbound'. Two seconds later at 08:17:59 hrs, the AFIS officer confirmed this by saying: 'Correct'. This was the last communication with VKO 2801. During this last communication the AFIS officer checked the QDM to be close to 300° and the bearing of the flight to be where he expected it to be in relation to the passage of ADV outbound.

2.3.6.8 Δ 11 During the turn to final, the radio altimeter warning had been triggered three times, but the aircraft was still maintaining 5 000 ft, i.e. a safe clearance of the terrain below.

2.3.6.9 From 08:18:05 hrs, the crew started to register and comment on information given by the instruments receiving the localizer 28 signal: Unidentified crew member - 'Four marks (ind.)' (indecipherable; some experts mean they hear the word 'overslept'), 08:18:08 hrs PiC - 'But here it's already three' and 08:18:19 hrs Co-pilot: - 'The flag disappeared on my instrument'.

2.3.6.10 Most probably the word 'mark' is referring to the five dots across the center of the HSI, which form the scale for the course deviation indicator (CDI), giving the crew an indication of the aircraft being on the equisignal centerline, or to the right or left of it. The flag (the K-flag) disappearing indicates that the CDI could move along the scale since the CDI will move to the neutral position when the K-flag is visible.

2.3.6.11 At 08:18:19 hrs, the aircraft position was about 4° to the left of the localizer centerline. If the meaning of 'overslept four marks' was that the crew had not noticed the movement of the CDI until then, the CDI had moved from the right hand limit of the scale, passed the right two dots, the center dot and the first left dot

on the HSI. This theory means that the aircraft had already passed the LLZ centerline and the reference to the disappearance of the flag must mean the 'ready signal' for the radio-technical navigational aids (RTSP) followed by the reappearance of the K-flag. If so, the consequence is that the LLZ centerline was displaced 13° to the left.

If the meaning is that the crew 'overslept' the fourth mark, and the CDI was moving towards the left of the scale, the consequence is that the HSI was telling the crew that the aircraft was to the right of the LLZ centerline while it was, in reality, approaching the real centerline from the left.

It is not possible to determine the position of the aircraft based on the disappearance of the flag since this will happen when the onboard equipment receives enough μA to satisfy the minimum required to activate the circuit pulling the K-flag out of sight and is not related to the $\pm$ 10° user limitation. The antenna of the LLZ 28 radiates normally for a six elements setup.

2.3.6.12 It is the opinion of the Boards that one should not put to much emphasis on the position related to the CVR recordings because the aircraft was in a turn and the instruments were not necessarily stabilized at this point. This is not an uncommon situation. The test flight with the same type of aircraft proved that this aircraft type with its navigational equipment could follow the LLZ 28 approach accurately. Unstabilized indications, as VKO 2801 experienced, did not occur in the base turns flown by the test aircraft. The history of the ground installations, the checks made after the accident and all the flight inspections carried out do not indicate any anomalies at all. This conclusion is also supported by the 740 LLZ 28 approaches reported to the AAIB/N. The Flight Inspection Section has been able to rule out that traffic on the road passing the LLZ 28 antenna area could influence the signal. Neither did any large ships pass the shoreline in the vicinity of the antenna at the critical period, nor was any ship docked at the coal loading quay. Horizontal misplacement of the localizer signal of practical importance due to atmospheric refraction, ground reflection or a combination of the two, is not likely. One should also bear in mind that the Dornier aircraft was recalled to assist in the search for VKO 2801. The crew used the LLZ 28 to keep track of the aircraft position and without registering any deviations. The QDM reading the AFIS officer received as a result of the last communication with VKO 2801 did not indicate anything wrong. (The frequency used for VDF is close to the localizer frequencies and therefore equally subject to deviations, if any.)

2.3.6.13 A remaining possibility is that something was wrong with the equipment in this particular aircraft, even though the examination of the different navigational instruments/ equipment resulted in no indications in this respect.

2.3.6.14 By 08:19:06 hrs, the crew was a bit uncertain of their position in relation to the LLZ 28 centerline. Indications of this situation are: at 08:18:52 hrs, the PiC asked the Navigator - 'What should I hold?' (This is the second indication that the PiC, for a

while, was operating the Autopilot Turn knob because he said at 08:18:28 hrs 'I am turning just a little bit to the left'), at 08:19:03 hrs, an Unidentified crew member asked - ' So what might the recommendations be?' and, at 08:19:06 hrs, the Co-pilot stated - 'Maybe we took the fourth (final turn) too early'.

2.3.6.15 Δ 14 In retrospect, the crew knew that they had passed overhead ADV at a fairly high speed before turning outbound and that they had been flying to the left of the outbound track from ADV. Besides these facts, the reason for the change of approach was the westerly wind direction, which was even stronger at altitude. Completing the base turn to final meant that they would get a tailwind component in the turn. The scene was set for the flight to pass through the centerline and end up to the right. That was exactly what happened. Questionable indications from the instruments at this stage should not result in confusion. It is the opinion of the Boards that the crew demonstrated a lack of situational awareness in this situation.

When the test flight was carried out, the supervisor from the AAIB/N, a very experienced flight commander, discovered that it was airline policy to have only one approach chart available, mostly in the possession of the navigator during the approaches. The two pilots did not have approach charts in front of them (usually fixed to the control column). From his training and revenue flights, his experience has been that it is very difficult to maintain situational awareness unless he has the chart conveniently placed to refer to at all times. This is the experience of other AAIB/N inspectors as well.

2.3.6.16 The aircraft was approaching a heading corresponding to the final course of 300° at the Co-pilot's last statement 'Maybe we took the fourth too early.' This could imply that the CDI was indicating to him an aircraft position to the left of the approach centerline. It is not very likely that the HSI was not functioning because no remarks were heard indicating this.

2.3.6.17 The CVR readout shows that the crew had indications on the instruments that did not quite tally with each other, and that this led to uncertainty. As a result of the technical examination, the Boards know that the ADF no. 2 was tuned to LON. However, an NDB is not generally considered to be particularly accurate. When a VOR or a localizer is available, an NDB will be used as a backup aid only. The use of LON was probably also influenced by the fact that the position of this NDB is a little to the left of the LLZ 28 centerline. Even though the HSI is considered to be the most important instrument for a localizer approach in IMC, the airline had recently installed GPS and, as mentioned previously, the crews had developed confidence in this system due to the impressive accuracy they had experienced (not more than 100 m - 120 m off to one side on precision approaches). On both HSIs, the magnetic direction of the runway 283° had been set according to regulations. If 283° had been put on the GPS as well, the crew had an indication that they had not yet reached the approach centerline.

2.3.6.18 On the third and fourth segments, during which the crew started to follow the chart for approach to runway 28, the navigator was very busy dealing with the radio communication with the AFIS officer, in addition to making the necessary preparations and navigating the aircraft laterally. Within a period of three minutes, one and a half minutes of his time were occupied by listening to and answering the external radio communication (all in all 17 exchanges). In addition, the received information had to be evaluated and as it was in a foreign language, this required more time than usual. Due to the inadequate preparations for this approach, the navigator was forced to navigate in a desynchronized reasoning mental mode, resulting in his perceptions becoming fragmented and incomplete, as well as leading to a situation when he was 'mentally behind' the aircraft. Having to deal with the communication and controlling the aircraft complicated the situation and, as pointed out previously, gave him little opportunity to check his calculations and actions.

2.3.7 The fifth segment 08:19:06 hrs - 08:22:23 hrs (3 min 17 sec, completion of the turn to final - impact).

2.3.7.1 At 08:19:11 hrs on a heading of about 300°, the PiC gave the command to get out of the turn: 'Let's level out', and three seconds later: 'No (?it should be) to the right', indicating that he wanted a correction to the right. However, the FDR shows that the turn continued another 10° and the aircraft was rolled out on heading 290° immediately followed by a corrective turn to the right. This was obviously a reaction to the repeated orders from the PiC at 08:19:19 hrs: 'To the right' and one second later: 'Let's turn to the right'. These statements indicate that the navigator was controlling the lateral navigation of the aircraft by the Autopilot Turn knob once again. During these seconds, statements from the navigator also tell something about the situation. At 08:19:16 hrs, he told the crew that he expected the situation to clear up: 'Just we'll get it, just now'. However, still a little uncertain, he asked: 'Is the mark (marker) to the right?' to which the Co-pilot answered: 'No, it is still staying.' Most likely the mark (marker) mentioned belonged to the CDI on the HSI and was still staying at the full left deflection and therefore indicating correctly in relation to the LLZ centerline. On the other hand, if he meant the mark (marker) on the GPS, it should have been on the left, provided the GPS had been programmed with an inbound course of 283°.

2.3.7.2 Δ 15 An additional factor of significance at this point was that the crew was not familiar with the possibility of checking the ambiguous navigational information indicated on their instruments by the outside source available, namely the VDF service that would supply the magnetic course to the airport. This information was neither in the Jeppesen approach chart manual nor on the diskette supplying the navigational information for the GPS. The Jeppesen policy of not presenting secondary information and the general lack of confidence in the information in AIPs prevented the crew from being able to solve their confusion.

2.3.7.3 To the PiC's mind, the correct way to make a corrective turn was to the right at this point and the navigator turned the aircraft to, and maintained a heading of, 306°. Adding the wind drift, the aircraft track slowly increased the distance to the LLZ centerline.

2.3.7.4 At 08:19:21 hrs, the radio altimeter warning was again recorded by the CVR, indicating that the aircraft passed above the mountain Møysalen. Because the aircraft was still maintaining the safe altitude of 5 000 ft, this again was no cause for alarm to the crew.

2.3.7.5 Δ 11 It is a known fact that crews are subject to nuisance warnings when they know they are safe, and will tend to ignore the same warning when it is real. It has also been demonstrated that a crew in a stressed working situation might shut out even intense warning sounds completely.

2.3.7.6 As the radio altimeter warning signal started, the PiC, trying to solve the situation, asked for the approach chart from the co-pilot. Around this time, the crew could possibly see that the desired track of 283° appeared in the upper right-hand corner of the GPS display. This was reassuring enough for the two pilots to think about starting the descent. But at 08:19:51 hrs, the Navigator protested: 'But it's fourteen here.' The correction was accepted by the PiC and the aircraft continued at 5 000 ft. Eight seconds later the Navigator stated the rate of descent: 'Five meters', which the co-pilot was to establish when leaving 5 000 ft for the final approach.

2.3.7.7 At 08:20:03 hrs, the Navigator asked for approval to turn to 320°: 'So, I'll keep 320°, OK?'. The Co-pilot asked if that was enough: 'Isn't that too little?' and the Navigator stated the necessity of having to make a correction: 'It should be a corrective turn'. The PiC obviously disagreed in making a significant turn to the right and ordered: 'No! Turn to the left!' Six seconds later, he was supported by the co-pilot and, according to the FDR, the aircraft was turned to the left from heading 306° in accordance with the PiC's orders. Seven seconds later, the aircraft was rolled out of the turn on heading 291°. In the meantime, at 08:20:21 hrs, the Navigator most likely read the DME to be 13 NM and stated so: 'It's thirteen. Let's descend!' and, four seconds later, he said: 'Three degrees, five minutes. We're on the glide path.' The altitude parameter on the FDR readout confirms that the aircraft had started the final descent at this time.

2.3.7.8 On final approach, when the navigator wanted to make a significant correction to the right, while the two pilots agreed that the turn should be to the left, this disagreement again reveals something of the crew's lack of situational awareness. It is the opinion of the Boards that the indications of the two navigational aids - the HSI and the GPS - governed the situation since it is not very likely that the crew members took that much notice of the RMI needle pointing to LON. The GPS programmed with an approach course of 283° must have been the indication that governed the opinion of the navigator and made him ask for permission for the

substantial heading change to 320° just before the descent.

2.3.7.9 Δ 16 The GPS is not permitted as a primary approach aid and should not be utilized as one. It is understandable that the crews of the airline had built confidence in it due to its demonstrated accuracy. It is, however, quite hazardous to assume that a GPS displayed indication must be the correct one, unless it is confirmed by another source.

2.3.7.10 On the other hand, the position of the CDI on the HSI must have convinced the PiC and perhaps the co-pilot as well that they now were to the right of the centerline and the corrective turn should be to the left. The navigator obviously carried out the order, but a heading of 291° was barely enough to take care of the wind drift and certainly not enough to intercept the centerline of the LLZ. The aircraft therefore flew parallel to the centerline only.

2.3.7.11 Δ 17 The crew started descent in mountainous terrain without firm and positive control of the lateral navigation demonstrated by the disagreement within the crew whether to correct left or right. A crew might enter a state of mind in which they continue, expecting everything to fall into place soon, based on their previous flying experience. The crew members, being used to service high traffic-density airports, where missed approaches inevitably lead to delays and inconvenience, could partly explain this. However, the traffic situation at Svalbard Airport Longyear that day was certainly no reason not to abandon the approach. The descent continued.

2.3.7.12 Δ 18 When the Co-pilot at 08:20:29 hrs found it necessary to ask: 'We're on landing course now, correct?' it was another cause for alarm. This is quite disturbing since the aircraft was now descending in a mountainous area on an approach where keeping close to the approach centerline is an absolute safety requirement. The Boards, again, find it necessary to emphasize that, if there is the slightest uncertainty of the aircraft position under such circumstances, it is reason good enough to abandon the approach, climb to a safe altitude and then solve the problem.

2.3.7.13 Four seconds later, when the aircraft just had been rolled out on heading 291°, the PiC obviously saw the need to make a further correction to the left and ordered: 'To get to the landing course, make a slight correction to the left!' Again the HSI with the CDI to the left must have been the instrument telling him they were too far to the right. However, no such turn was made. The navigator continued heading 291°. About this time according to the reconstruction of the track flown the aircraft departed the 10° sector to the right of the LLZ centerline outside which the localizer is not to be used.

2.3.7.14 Δ 19 The aircraft departed the ±10° usable sector of the localizer, but the radiation from the antenna is still well above field strength minimum. There is a

warning about this limitation on the chart, but is not very well highlighted. The Boards consider that this limitation could be overlooked in a stressed situation. In this case, the CVR recorded the crew expressing their feeelings about an odd approach. We will never know if their resentment comprised the user limitation, but, due to the importance of this limitation, the Boards recommend that the appropriate authority assess the presentation and look for a solution that is more conspicuous.

2.3.7.15 At 08:21:00 hrs, we receive confirmation yet again that the navigator was controlling the aircraft laterally when the PiC said: 'You guide us, you guide us!' and the Navigator immediately acknowledged this by stating: 'We're flying by Jeppesen'. Two seconds later, the PiC wanted to check the position in relation to ADV and asked the navigator to select Advent for him. But the navigator did not obey him, probably because he had the distance to the airport on the DME as well as on the GPS and answered at first: 'Not now. Later on!' and secondly: 'I've told you, there is no need'. It is possible that the PiC could have had an indication of how far away the aircraft was tracking in relation to the ADV by watching how fast the RMI needle was moving, but it is more likely that he wanted to check how far they had come because the AFIS officer had asked for a new position report abeam Advent or at eight miles inbound.

2.3.7.16 Δ 20 Even though the selection of ADV instead of LON was not a crucial event, the Boards would point out that it is good airmanship to make full use of all the available approach aids. The other ADF receiver was available and the crew could have had both LON and ADV available at the same time. The testflying demonstrated that the RMI needles gave a good check of the centerline, needle no. 1 indicating the same bearing as needle no. 2, except close to the antenna. On the track flown by VKO 2801, the two ADFs set up like this would have given a clear indication of a track to the right of the centerline, which was also demonstrated during the test flight.

2.3.7.17 At 08:21:19 hrs, an Unidentified crew member (most likely the Navigator) said: 'To the right,' but the PiC expressed his concern by asking: 'What is our radial?' The Navigator then indicated that they were following the approach chart and stated: 'Let's follow the approach chart to the end!' The FDR information shows that a slight turn to the right was carried out and at 08:21:24 hrs, the aircraft was heading 300°.

2.3.7.18 Δ 18 The concern of the PiC is illustrated by the physiological-acoustic analysis of this phrase which shows that he experienced the highest increase in emotional stress found in the crew. (Of all the phrases that were analysed by the IAC.) A pronounced increase in the emotional stress was also found in the phrase uttered by the Unidentified crew member (the Navigator?) - 'To the right.' To the Boards it seems that the mental operative mode of the PiC and the navigator, as well as their stress levels, made it difficult for them to assess the situation they were in (including the level of danger) in an objective and

integrated way. They suffered a loss in their ability to think creatively. This might explain why they did not decide to abandon the approach.

2.3.7.19 The unrest in the crew at this stage of the approach is further indicated by the Unidentified crew member finding it necessary to ask: 'We will be landing, will we not?' and, four seconds later, by the Co-pilot saying: '300° so far! Is it OK?' and at 08:21:47 hrs by asking: 'How are we approaching? Is it correct or not?' (The 300° mentioned by both the PiC and the co-pilot corresponds well with the magnetic heading recorded by the FDR.)

2.3.7.20 Δ 18 The Boards again find it necessary to stress that a crew being uncertain of the accurate position on final approach, especially in mountainous terrain, must climb to a safe altitude according to the missed approach procedure before trying to solve a problem. The Boards also urge the airline to review its procedures for abandoning an approach, bearing in mind the ample danger signals presented in this accident.

2.3.7.21 Again, at 08:21:55 hrs, there was another order by an Unidentified crew member to correct to the right: 'To the right here', but the correction was not carried out. However, 10 seconds later, an Unidentified crew member ordered: 'To the left'. A few seconds later the magnetic heading started to change as the aircraft was turned from 300° to the final heading of 291°, which was maintained the last five seconds before impact.

2.3.7.22 At this stage of the flight, the aircraft was approaching the extended centerline of runway 28. With the assumption that the GPS was programmed with inbound course 283° as indicated by the circumstantial evidence, the reason to correct to the right was no longer present and the correction was reversed to a left turn. It is therefore the opinion of the Boards that the crew crosschecked with the GPS and saw the aircraft mark close enough to the centerline to start the intercept to the left and finally get established on course.

2.3.7.23 During the last 20 seconds or so of flight, the aircraft entered an area of turbulence judging by the changes in the co-pilot's and the autopilot's steering. The co-pilot responded to the jerking flying very actively and managed to keep the roll within 10° together with an uninterrupted increase in pitch angle from about -4° to about +4°, right up to impact at 08:23:23 hrs. Half a minute before impact the co-pilot asked for the landing gear and a voice, most likely the PiC, gave permission to extend the landing gear. This corresponds very well with the fact that the landing gears were in transit on impact.

2.3.7.24 As recorded by the FDR the GPWS was activated about 9 seconds before impact, probably because the aircraft was in mountainous terrain, closer than 400 m to the ground and with a closure rate to the terrain above 5 m/s. Because the intermittent sounding of the warning horn was not recorded by the CVR, the Boards conclude that the horn for some reason was unserviceable. However, because the FDR has

recorded an increase in pitch, an almost immediate movement of the three throttle control levers, an increase in the percentage of the LP rotor speed and the rate of fuel flow for all engines, the Boards conclude that the red light annunciator in front of each pilot was working. On impact, the engines were not yet working at full power, but then the throttle control levers were not yet fully forward according to the FDR registration of this parameter.

2.3.7.25 Six seconds before impact, the CVR recorded the radio altimeter warning again for the last time. The two pilots had at this time reset their altimeters to 70 m (co-pilot) and 260 m (PiC) which meant that the right radio altimeter triggered the warning. Even though the GPWS horn was not functioning, there was nevertheless an aural warning, which verified and reinforced the GPWS visual warning, clearly indicating that they were getting dangerously close to the underlying terrain.

2.3.7.26 Δ 11 It is the opinion of the Boards that a reaction to a GPWS should be as quick and decisive as the handling and performance of the particular aircraft type allows. When evaluating the performance of a crew, one must allow for at least a couple of seconds in reaction time. In this case, it was to the crew's disadvantage that the aural warning of the GPWS did not work. Expecting both a visual and an aural warning at the same time and only getting one of them, might have initiated an evaluation of the situation which could explain the somewhat slow throttle control lever movement and pull-up of the aircraft. When the crew three seconds later got an aural warning, it was not connected to the GPWS, but belonged to a warning system that had already been triggered five times, when the crew knew the aircraft was maintaining a safe altitude. This fact did not support a decision to act with urgency.

The fact that the bugs on the radio altimeters had been reset to 70 m and 260m respectively, altitudes expected to be reached some kilometers ahead, could also have had an influence. The Boards are of the opinion that the FSF ALAR Task Force's conclusion that proper use of the radio altimeter is an effective tool to prevent approach and landing accidents should be seriously considered, together with the procedures regarding the GPWS.

2.3.7.27 Evaluating the final seconds of flight and allowing for a couple of seconds reaction time, it is not likely that the crew, applying full power and maximum pitch-up, would have made the aircraft clear the mountain. The remaining seconds to impact would probably not have been enough time to change the aircraft flight path adequately.

2.3.8 Although unable to carry out a technical examination of the GPS, the Boards are of the opinion that circumstantial evidence points to the GPS most probably being reset with inbound course 283° in accordance with the imposed rule. Due to the demonstrated accuracy of the GPS system, the crew put too much emphasis on the GPS indications to the detriment of those on the HSI, and disregarded the RMI bearing to LON (which was correct on impact).

2.3.9 The Boards would point to the eight conclusions of the FSF ALAR Task Force, reproducing them here:

- No. 1: Establishing and adhering to adequate Standard Operating Procedures (SOPs) and flight-crew decision-making processes improved approach-and-landing safety.

- No. 2: Failure to recognize the need for and to execute a missed approach when appropriate is a major cause of Approach-and-Landing Accidents (ALAs).

- No. 3: Unstabilized and rushed approaches contribute to ALAs.

- No. 4: Improving communication and mutual understanding between air traffic control (ATC) services and flight crews of each other's operational environments will improve approach-and-landing safety.

- No. 5: The risk of ALAs is higher in operations conducted in low light and poor visibility, on wet or otherwise contaminated runways, and with the presence of optical or physiological illusions.

- No. 6: Using the radio altimeter (RA) as an effective tool will help prevent ALAs.

- No. 7: Collection and analysis of in-flight parameters (e.g. flight operational quality assurance [FOQA] programs) identify performance trends that can be used to improve approach-and-landing safety.

- No. 8: Global sharing of aviation information decreases the risk of ALAs.

The Boards find conclusions nos. 1, 2, 3, 4, and 6 to be particularly pertinent to this accident.

2.3.10 The crew of the Dornier 228 demonstrated the fact that the FMS gave flyable signals on the back beam of the ILS to runway 10 to the Boards. The same check made by the Flight Inspection Aircraft showed that that the FMS did not give reasonable steering information at all. As there are obvious differences between the aircraft types and the Dornier crew received useful steering information from their system, the Boards recommend that the NCAA review the policy, having all the ILS/ LLZ at an airport operational simultaneously.

2.3.11 Due to the fact that poor quality CVR recordings hamper investigations from time to time and emphasizing the flight safety importance of such recordings, the Boards are of the opinion that a procedure for checking the quality of CVR recordings at set intervals should be a requirement.

3 CONCLUSIONS

3.1 Introduction

To illustrate the most likely classification of human errors that had an influence on the chain of events leading to the accident, the taxonomy of James Reason, professor of psychology at the University of Manchester (England), has been used to mark the different findings: Lapse = L; Slip = S; Rule-based mistake = R; Knowledge-based mistake = K; and Unintended exceptional violation = V. A lapse is an error of omission, in which an item previously known is forgotten. Lapses are unintended and are often caused by inattention or inadequate association at the time the item was learned. A slip is an error of commission in which the action does not proceed as planned. Slips are unintended and often are caused by inattention at the time of action. A ruled-based mistake is an error of commission in accordance with a rule that is inappropriate for the situation. A knowledge-based mistake arises inter alia from incomplete or incorrect knowledge. It is an error of commission in which the action proceeds as planned, but the plan is inappropriate for the situation. An unintended exceptional violation is a singular violation occurring in a particular set of circumstances.

3.2 Findings

3.2.1 Aircraft

a. The aircraft was airworthy.

b. The FDR shows that the aircraft could have been operated normally by the crew during the approach to Svalbard Airport Longyear.

c. The aircraft's mass and the position of its center of gravity were within the permitted limits both at take off in Moscow and at the time of the accident.

d. The recording of the open microphones in the cockpit has a very unfavourable signal-to-noise ratio, making the deciphering of the intra cockpit conversation extremely difficult. Finally, 80 - 90% of the conversation was interpreted. The remaining 10 - 15% of the communication does not contain any conversations of any length, just short remarks.

e. The FDR parameters recorded were of satisfactory quality, except for channel no. 18, which recorded the position of the right elevator and channel no. 12, which recorded gyro-magnetic heading. This was caused by a functional error in the BR-40 element of the recording channel. The function of the compass systems was not affected.

f. The last radio altimeter warning signal recorded by the FDR started when the aircraft was about 530 m from the impact point and about 270 m above the terrain. The signal was triggered by the right radio altimeter. The other five warning signals were recorded when the aircraft was at safe altitudes less than 750 m above terrain details.

g. The GPS mounted on the central instrument panel, had been torn loose on impact and was observed lying by itself on the ground before the registration of parts started. Somebody removed it from the site and it has not since been returned to the AAIB/N.

h. The most probable frequency set on the two PUR SD-75 units was 109.5 MHz equal to the frequency of the localizer LA for approach to runway 28 at Svalbard Airport Longyear.

i. The mode selector Kurs MP-70 was in the ILS operation mode.

j. ADF no.1 was not in use during the approach. ADF no. 2 frequency selectors indicated 425 kHz, and 326 kHz Advent NDB. The toggle switch was in position 1, indicating that 425 kHz was in use. The damage to the frequency selector indicated that the figures could have changed during impact. Further examination made it possible to conclude that the RMI needles no. 2 were pointing to LON at the time of impact, which implies that the figures had changed from 350 kHz.

k. A copy of the GPS database installed in RA 85621 contained correct information concerning ENSB, Svalbard Airport Longyear and it stated 'No approach for this airport in the database.' The GPS installed in RA 85621 required that the operator typed ENSB and set the landing course in degrees to have a course line displayed in OBS mode.

l. There were enough satellites available to provide good cuts for the GPS receiver on board RA 85621. The satellite geometry was normal and the GPS data show nothing unusual for the period VKO 2801 flew the approach to Svalbard Airport Longyear. The tail did not obstruct any of the available satellites during the approach.

m. The two compass systems in gyro-magnetic mode indicated correct headings to the crew.

n. The crew did not receive erronous distance information.

o. The GPWS was activated about 9 seconds before impact. The warning horn was for some reason unserviceable, but the red light annunciators were working.

3.2.2 Ground-based navigational equipment

a. The reason for the ± 10° user-limitation on the LLZ 28 is less than the required signal strength at 25 NM. The radiation from the 6-element antenna is not limited. It radiates normally.

b. The NCAA's policy is to have all the navigational aids operational at all times to avoid delays when the situations demand their use.

c. A horizontal misplacement of the localizer signal of practical importance, due to atmospheric refraction, ground reflections or a combination of the two, is not likely.

d. The Eiscat radar at Svalbard was not in operation on 29 august 1996. The antenna was in stowed position with lock pins in place and the site was unmanned and securely closed. Interference with the LLZ 28 was therefore not possible.

e. The Dornier 228 crew demonstrated that the FMS on this aircraft gave reasonable steering information on the LLZ back beam to runway 28, frequency set at110.3 MHz.

f. The Dornier 228 crew who were recalled to participate in the search operation for VKO 2801 used the LLZ 28 to keep track of their position without registering any anomalies.

g. None of the flight inspections of the LLZ 28 have revealed any anomalies within the ± 10° sector authorized for use.

h. The checks and tests made on the approach navigational ground systems all showed normal results.

i. The test flight carried out with a TU-154M demonstrated that a similar aircraft to RA 85621 could fly the LLZ 28 approach to the Svalbard Airport Longyear accurately. No anomalies were detected within the ± 10° sector.

j. The test flight demonstrated that the VDF service gave an accurate check of the localizer centerline. The two ADFs onboard tuned to LON and ADV gave good backup indications of the localizer centerline, except when the test aircraft came fairly close to the antennas.

3.2.3 Flight conditions

a. The actual weather conditions satisfied the PiC minimum requirements to carry out the approach to Svalbard Airport Longyear.

b. The approach was carried out in IMC.

c. The magnetic field intensity recorded during the time VKO 2801 approached Svalbard Airport Longyear was characterized as disturbed. However, the variations were not of a magnitude considered to cause any significant disturbances to compass systems in gyro-magnetic mode.

3.2.4 The crew

a. The crew members were properly licensed. Working hours and rest periods prior to the accident were within the limits prescribed by regulations.

b. The post mortems carried out on the crew revealed no anomalies and no traces of chemical substances.

c. Landing on runway 10 was within the aircraft type performance limits.

d. The crew did not attempt to carry out a back beam approach to runway 28.

e. The navigator controlled the aircraft laterally by the Autopilot Turn knob most of the approach, while the co-pilot controlled the vertical navigation.

f. The demonstrated dynamics of the general psycho-emotional state of the crew was not enough to initate inferior performance by the crew members making them commit mistakes in their work.

g. The vertical navigation of the aircraft was carried out correctly except for the fact that the descent was made off the localizer centerline to the right.

h. There were no calls for checklists after 'Before descent' checklist. (L)

i. The crew did not check the identity of the tuned ground navigation aids. (S)

j. The radio altimeter warning signal was triggered five times when the flight was at a safe altitude. When the radio altimeter warning sounded for the sixth time, together with the visual warning of the GPWS, the crew probably became unsure as to whether the situation was urgent or not, leading to a somewhat slower than ideal reaction to the GPWS. However, the aircraft was at this time probably too close to the terrain for the crew to change the flight path sufficiently to avoid the mountain. (S)

k. The crew did not make full use of the ADFs onboard, tuning ADV and LON on separate receivers. (L)

3.2.5 The Airline

a. It is a standard operating procedure that crews from Vnukovo Airlines study

the different approach charts and have to fly these approaches in the simulator when preparing for flights to airports in mountainous terrain.

b. The Norwegian AIP was not available at Vnukovo Airlines, preventing the possibility of obtaining secondary information concerning Svalbard Airport Longyear. (K)

c. The airline relied upon the flight information furnished by Jeppesen & Co. GmbH and the GPS database from Allied Signal General Aviation Avionics/ Jeppesen Sanderson to contain all the necessary and required items in order to plan and carry out safe flights. (K)

d. The flight deck crew did not know of the possibility of checking their own navigation by the VDF service offered at Svalbard Airport Longyear. (K)

3.2.6 The Authorities

a. The AFIS officers at Svalbard Airport Longyear had never been requested by Russian crews not stationed at Svalbard to provide VDF service. (K)

b. The last VDF reading the AFIS officer got while communicating with VKO 2801 indicated that the flight had not yet reached the approach centerline.The CVR/ FDR information supports the observation of the AFIS officer.

c. The information on Svalbard Airport Longyear contained in the Norwegian AIP was correct.

d. Even though it is the responsibility of any airline or PiC to evaluate if the available approach aids at a destination are sufficient for a safe flight, taking into consideration the particular aircraft's equipment and performance, together with the flight crew's experience and expected weather conditions, radar service represents a valuable safety barrier for checking deviations from established tracks.

e. The phrase 'Approved,' uttered by the AFIS officer without adding the approving authority could possibly have given the crew of VKO 2801 an incorrect conception of his status.

3.2.7 Additional factors

a. To avoid congested approach charts, Jeppesen & Co. GmbH's policy is to reduce information considered to be of secondary importance.

b. A user-oriented questionnaire of the LLZ 28 approach at Svalbard Airport Longyear received full cooperation from 140 pilots representing 740 approaches, of which none had experienced any anomalies.

c. In an unprepared and stressed situation, the user limitation on the LLZ 28 could be overlooked.

d. The FSF ALAR Task Force's conclusions 1, 2, 3, 4, and 6, concerning Standard Operating Procedures and decision-making processes, discontinuing unstabilized and rushed approaches, communication between air traffic control and flight crews, and active use of the radio altimeter to avoid controlled flight into terrain were particularly pertinent to this accident.

3.2.8 Significant findings

a. There is no Russian procedure for offset localizer approaches modifying the required rule to set the landing course on the HSI. (R)

b. The course selected on both HSIs was 283° even though the approach course is 300°. This setting does not affect the indication of the CDI. However, the CDI was pointing to 283° on the dial, which is 17° to the left of the approach course, giving a visual impression of wind drift to the left and therefore giving a possible reason for a heading correction to the right. (R)

c. The navigator in a stressed and overloaded working situation most probably followed the rule setting the landing course 283° on the GPS in OBS mode instead of the approach course 300°. (R)

d. The crew was not fully aware of the status of an AFIS officer in comparison with the authority of a Russian air traffic controller with the result that the crew accepted safety information from the AFIS officer as orders. (K)

e. The crew had limited knowledge of the English language with the consequence that they had problems communicating their intentions to the AFIS officer. (K)

f. The navigator was overloaded with tasks leaving little time for rechecking his work, thereby setting the scene for making mistakes. (S)

g. The pilots did not monitor the work of the navigator sufficiently. (L)

h. Leaving the communication with AFIS to the navigator during the approach was not according to the normative documents. (K)

i. Due to the workload of the navigator, the decision of the co-pilot to transfer the responsibility of controlling the aircraft laterally to him, was inappropriate. (K)

j. The crew resource management of the PiC was not satisfactory. (K)

k. When the crew had made the decision to carry out the approach to runway 28, a new approach briefing was not accomplished. (V)

l. The crew made the proper correction for the wind drift, but did not try to intercept the outbound track from ADV with the consquence that they overshot the approach centerline turning inbound. (K)

m. Seemingly confusing indications on the HSIs in the base turn caused the crew to become uncertain of the aircraft position in relation to the LLZ 28 centerline. In this situation, the crew showed a lack of situational awareness. (K)

n. The two pilots did not have the approach chart in front of them at all times during the approach making it difficult for them to maintain situational awareness. (R)

o. The crew did not know of the possibility to check the position of the aircraft in relation to the localizer centerline by the VDF service available. (K)

p. On final approach the crew probably put too much emphasis on the indications displayed on the GPS. (K)

q. The crew started descent in a mountainous area without firm and positive control of the lateral navigation demonstrated by the disagreement within the crew as to whether to correct to the left or right. (V)

r. In spite of the uncertainty within the crew as to whether they were approaching correctly or not, they continued instead of abandoning the approach and climbing to a safe altitude to solve the problem. (V)

4 SAFETY RECOMMENDATIONS

4.1 Introduction

On 19 September 1996, the AAIB/N made a preliminary recommendation to the NCAA concerning the VDF service available at Svalbard Airport Longyear not being printed on Jeppesen approach charts. Further investigation has revealed that Jeppesen consider this service as secondary information, which is left out to resolve the flight safety problem of congested approach charts.

The Interstate Aviation Committee and the Norwegian Aircraft Accident Investigation Board recommend the following:

4.1.1 The RFCAA reassesses the rule of setting the landing course instead of the localizer course on the HSI for ILS/ LLZ approaches in relation to offset approaches. (Recommendation no. 21/99)

4.1.2 The RFCAA assesses the inclusion of a mandatory procedure in NPP GA-85 to request VDF bearings to check own navigation on approaches especially to airports in mountainous terrain (and then a revision of the Federal Aviation Regulations). (Recommendation no. 22/99)

4.1.3 The RFCAA reassesses the crew operation guidelines for TU-154s concerning the tasks ascribed to the navigator, starting with the descent from cruising level. (Recommendation no. 23/99)

4.1.4 The RFCAA assesses the necessity to check the quality of the CVR third channel (open microphone) on the fleet of TU-154s. (Recommendation no. 24/99)

4.1.5 The RFCAA assesses if the English language programme for air traffic controllers could be beneficial for air crews as well. (Recommendation no. 25/99)

4.1.6 Vnukovo Airlines Operations reassesses the present Crew Resource Management on approaches related to the norms in force and assesses if a CRM program could be beneficial to flight crews. (Recommendation no. 26/99)

4.1.7 Vnukovo Airlines Operations assesses the present policy of collecting flight safety information concerning foreign airspace and destination airports. (Recommendation no. 27/99)

4.1.8 Vnukovo Airlines Operations assesses the inclusion of situations with uncertain navigational indications, especially ILS/ LLZ indications, into air crew training to improve situational awareness. (Recommendation no. 28/99)

4.1.9 Vnukovo Airlines Operations assesses whether the present procedure of starting a turn with a linear lead should be extended to include interceptions to ensure that the flight crews regain the track if they overshoot. (Recommendation no. 29 /99)

4.1.10 The RFCAA, Tupolev Design Bureau and Vnukovo Airlines Operations reassesses the present procedure for the use of the radio altimeter to avoid nuisance warnings and to protect against controlled flight into terrain.
(Recommendation no. 30/99)

4.1.11 Vnukovo Airlines Operations assesses whether the pilots should have their own approach charts in front of them during approach to improve their situational awareness.
(Recommendation no. 31/99)

4.1.12 Vnukovo Airlines Operations assesses whether it is necessary to reinforce an instruction to the flight crews to discontinue an approach if any crew member becomes uncertain of the navigation, and climb to a safe altitude before attempting to solve the problem.
(Recommendation no. 32/99)

4.1.13 The NCAA assesses the current policy of giving priority to radar installations at airports in mountainous areas.
(Recommendation no. 33/99)

4.1.14 The NCAA reassesses the approach procedure to runway 28 at Svalbard Airport Longyear with respect to establishing the base turn and the holding pattern on the other side of the centerline.
(Recommendation no. 34/99)

4.1.15 The NCAA assesses whether there is a need for English language and phraseology recurrent training for AFIS officers.
(Recommendation no. 35/99)

4.1.16 The NCAA and Jeppesen & Co. GmbH assess whether the sectors authorized for use on the approaches to Svalbard Airport Longyear should be more conspicuous on the charts (ie. limiting bearings).
(Recommendation no. 36/99)

4.1.17 The NCAA assesses the current policy of having all ground-based navigational aids running at all times with reference to the fact that the FMS of the Dornier 228 gave reasonable steering information on the ILS back beam.
(Recommendation no. 37/99)

4.1.18 Although the Boards recognize the necessity of limiting the amount of information presented to flight crews on the approach charts, the Board recommends that Jeppesen & Co. GmbH evaluates their policy on secondary information and

considers whether this information may be presented differently than on the approach charts. (ref. SAS solution - separate briefing sheets.)
(Recommendation no. 38/99)

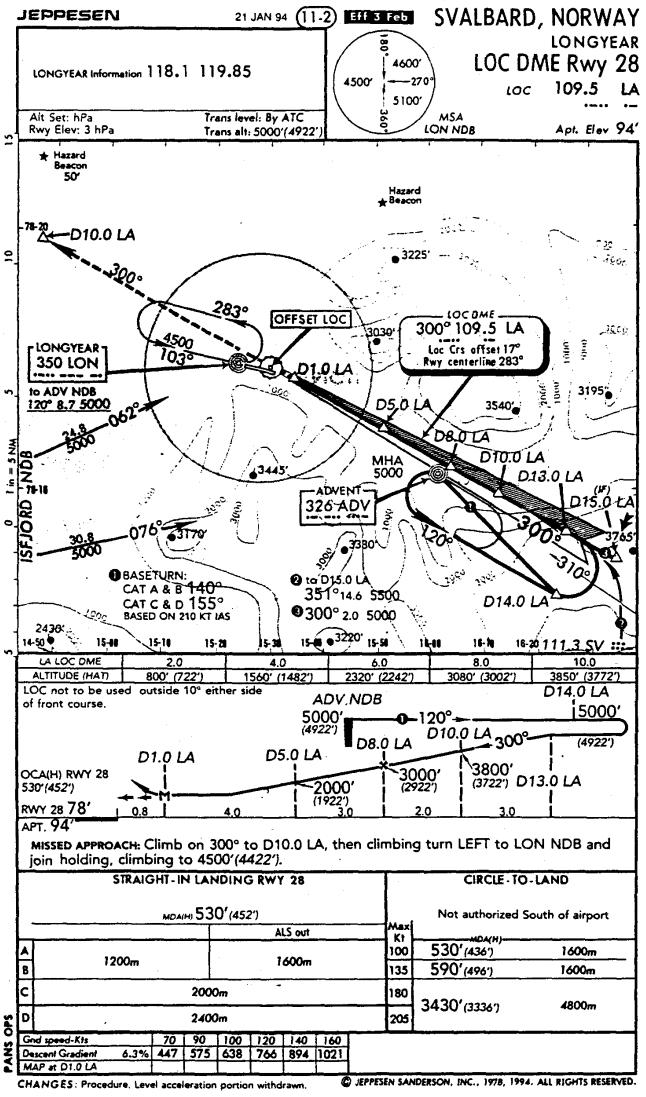
4.1.19 The RFCAA and NCAA assess a requirement to check the quality of CVR recordings at set intervals.
(Recommendation no. 39/99)

5 APPENDICES

1. Jeppesen approach chart Svalbard, Norway 11-2
2. Combined ATS recording and CVR readout interpretation
3. Sequentially Timed Events Plotting (STEP)
4. FDR readout
5. Contour map, with CVR statements depicted
6. FSF paper on English language training
7. Chart of Svalbard, Longyear area
8. Abbreviations

AIRCRAFT ACCIDENT INVESTIGATION BOARD, NORWAY (AAIB/N)

Kjeller, 2 November 1999



'NOT FOR NAVIGATIONAL USE'

REPRODUCED WITH PERMISSION OF JEPPESEN & CO. GmbH

Transcript of CVR Tu-154 No. 85621 and Longyear AFIS sound recordings 29th of August 1996.

CVR communication was recorded/presented originally from time 07:48:35. The revised transcript (From the Speech Technologies Centre (St. Petersburg)) started at time 07:59:12. These two times and all following times are now adjusted in relation to the exact UTC time the accident took place. This time, 08:22:23, was recorded by a seismographic station. The start of the CVR is therefore adjusted to 07:47:23, and the revised transcript starts at 07:58:00. The AFIS recordings were adjusted in a similar way. (Local time was + 2 hours from UTC.)

PiC = commander, Cop = second pilot (the pilot flying the aircraft), Nav = navigator; F/e = Flight engineer; U = unidentified crew member, AFIS = Aerodrome flight information service, Traff. = Other R/T traffic, ( ) = 'sounds like' and (ind.) = indistinct.

Bold letters indicate radio communication between the aircraft and AFIS.

07:47:23	U	So, the 'radar' is surrounded by mountains.
		Comment: There is no radar installed at ENSB. Probably ment localizer.
	Cop	Didn't you fly here at night?
	Cop	It's OK then. Everything is covered by clouds.
49:20	PiC	My first flight here was at night.
	Cop	At what time shall we land?
	PiC	Between 8.10 and 8.20.
	PiC	Wind (ind.) (?15 metres).
	PiC	(ind.) (?up to second outer)... ...(ind.).
49:58	U	Flaps 15? (ind.).
50:01	Cop	Let's extend the spoilers! (ind.).
50:04	U	Reduce the speed somehow (?which).

07:50:08	U	140.
50:31	Cop	But, during the summer what is the maximum temperature here?
	PiC	It's 30 degrees in summer here.
51:18	Cop	Well, that's OK then. Shall we descend?
51:30	PiC	But, you have not estimated the distance yet, have you?
	Nav	22! Just hold on!
	U	(ind.) up to 47.
51:50	PiC	Let's take a briefing before landing! Landing - at Spitzbergen, alternate - Murmansk. Left pilot flying, communications - from the right. Landing course - 103°. Missed approach: Straight, then climbing turn LEFT to (ind.). Landing approach to distance (16) to maintain until gaining the glide path. Estimated landing weight - 78 tons. Flaps - 45. Speed - 275.
52:49	Cop	I'll adjust the speed for you, while you carry out the approach.
	PiC	Pressure 751, check against the check list, report ready!
53:01	F/e	Understood. I'm, ready!
53:02	U	Everything is checked (ind.).
53:28	PiC	751. Ready! Check against Before descent check list.
	PiC	I have been acquainted.
	Cop	Request! It is time to descend.
54:12	Nav	**Bodø control estimate descent.**
54:25	Nav	**Bodø control, 2801 estimate descent.**
54:51	Nav	**Longyear information, Vnukovo 2801. Good morning.**
55:10	Nav	**Longyear information, VKO 2801. Good morning.**

07:55:17	AFIS	**Victor Kilo Oscar 2801 Longyear, could you change to frequency 119.85, 119.85, over.**
55:24	Nav	**119.85, thank you.**
55:31	Nav	**Longyear information, VKO 2801. Good morning.**
55:38	AFIS	**VKO 2801 Longyear information, go ahead.**
55:40	Nav	**2801 ETA ENSB 08.15. Estimated descent.**
55:54	AFIS	**VKO 2801, you are broken, readability is poor, say again.**
55:59	Nav	**Estimated descent from level 350 to level 60.**
56:08	AFIS	**VKO 2801, that is approved, we have no conflicting traffic, TL 65, QNH below is 1005.**
56:19	Nav	**2801, roger. Leaving level 350 for level 60. QNH 1005. Estimated approach runway 10.**
56:38	AFIS	**VKO 2801 Longyear roger. Are you making an approach via INDIA - - - INDIA-SIERRA-DELTA? over.**
56:44	Nav	**INDIA-INDIA-SIERRA-DELTA, 01.**
57:51	AFIS	**VKO 2801 Longyear roger, runway 28 in use. We have wind from 230/16. Weather is: We have visibility more than 10 kilometers in showers of rain, few at 1500 feet and scattered at 2000 and broken at 4000. Temp is 5, dewpoint 0, QNH 1005.**
57:26	Nav	**2801 roger, - - - Making a descent to level 60, QNH 1005. Reach altitude 4000 feet.**
57:43	AFIS	**VKO 2801 Longyear roger, give me a call when you are passing INDIA-SIERRA-DELTA.**
57:50	Nav	**I proceed to INDIA-SIERRA-DELTA, 2801.**
57:56	Cop	There is an altitude margin.
57:59	AFIS	**Call passing INDIA-SIERRA-DELTA, and also now change frequency to 118.1.**

07:58:04	Nav	**118.1, good day.**
58:15	Nav	**Longyear information 2801, continue down to 60, proceed to INDIA-SIERRA-DELTA.**
58:26	AFIS	**VKO 2801 Longyear roger.**
58:44	AFIS	**VKO 2801. Can I have your estimate for INDIA-SIERRA-DELTA?**
58:50	Nav	**Estimating INDIA-SIERRA-DELTA at five-niner.**
58:58	AFIS	**Thank you.**
59:01	U	(ind.).
59:13	AFIS	**VKO 2801 Longyear, roger.**
59:19	Nav	They're always having problems.
59:22	Cop	Passing over.
59:41	AFIS	**VKO 2801 Longyear, confirm you will make an approach for runway 28, via ALFA-DELTA-VICTOR?**
59:50	Nav	**For runway 28, 2801 understand you?**
59:58	Nav	**- - - to LIMA - ALFA?**
08:00:07	AFIS	**VKO 2801 Longyear, after passing ISFJORD, suggest you are heading for ALFA-DELTA-VICTOR at 5000 feet?**
00:17	Nav	**2801 Continue down to 4000 - - - 4500 feet, QNH 1005.**
00:29	Cop	And what's this they have here?
00:30	PiC	There is a mast here.
00:34	Cop	Mast.
00:36	U	(?It should stay).
00:40	U	There is some more traffic.
00:41	Cop	Here (somebody is flying) (such high hills!).

08:00:44	PiC	Keep the course.
00:48	Nav	(?So), Let's turn to the right!
00:52	U	(ind.).
00:55	Traff.	**Longyear, LMQ.**
	AFIS	**LMQ, Longyear.**
	Traff.	**Climb to 6 500 feet, est. Ny-Ålesund at 17.**
	AFIS	**OK, roger that -- contact Ny-Ålesund -- and -- so long.**
	Traff.	**So long!**
01:23	PiC	I've told you, that it should be (to the right - - - (ind.).
02:12	Cop	Is the 'radar' an unusual one?
		Comment: There is no radar installed at ENSB. Probably ment localizer.
02:14	U	No.
02:17	PiC	No, it's simply - - -.
02:40	U	Yeah, that's what I call an approach!
02:44	U	It is!
03:08	Traff.	**Longyear Information, CDS 156 passing abeam BRAVO 600 feet.**
	AFIS	**CDS 156, Longyear information, roger. Check traffic is Dornier, taking off Runway 28 this time for a right circuit for a landing at 28 again, for touch and go.**
	Traff.	**Roger, CDS 156.**
	AFIS	**Coast guard 21, airborne time 03, and did you check the traffic?**
04:02	Nav	(? We've) reached - - -

08:04:28	Nav	**Longyear information, VKO 2801 - - -.**
04:30	AFIS	**Aircraft calling Longyear, say again.**
04:40	Nav	**Longyear information 2801 request runway in use for landing to runway 1 --- 10.**
04:56	AFIS	**VKO 2801 Longyear, runway in use is 28.**
04:59	Nav	**Roger, 28.**
05:52	F/e	I understand the approach will be made in clouds. (Icing).
07:30	Traff.	**Climbing to 80, heading Vangbergøya.**
	AFIS	**Coast Guard 21, Longyear checked.**
07:40	Traff.	**CDS 156, on final (ind.).**
	AFIS	**CDS 156, Longyear (ind.) Runway free.**
	Traff.	**Yes.**
08:34	Traff.	**Longyear, LN-OPP.**
	AFIS	**LPP, Longyear.**
	Traff.	**LPP airborne at Isfjord at 06, 1 POB returning.**
09:03	Nav	We are 'diving' into the 'zone'!
09:11	Cop	We have taken in Advent.
09:13	Nav	Seven thousand? It should be earlier!
09:15	U	Go after the pike (Arrow head).
09:19	Nav	The pressure is 751 mm.
09:20	AFIS	**LPP, Longyear roger. I'll give you a weather report in a minute.**
09:20	PiC	5 minutes and we'll descend.
09:28	U	Six thousand and (?three hundred).

08:09:31	PiC	New altitude, we're maintaining 5 000.
09:37	PiC	Give me the approach chart!
09:45	PiC	The approach chart!
10:24	Cop	What about the speed?
10:28	Cop	Shall we extend the landing gears?
10:29	U	Landing gears.
10:32	PiC	Keep the course!
10:36	Cop	We have reached 1500 m.
10:49	Cop	We'll land by the standard procedure.
10:53	Nav	Standard.
11:06	U	Forty-three degrees.
11:13	U	(ind.).
12:08	U	Forty-three degrees.
12:12	AFIS	**LPP, Longyear, weather at Longyear, wind from 210/17, visibility to the west is about 6-7 km due to rain and - - - otherwise more than 10. We have few at 1 000 and broken at 2 000, temp. is 6, QNH 1006.**
12:40	Cop	What should I keep?
12:46	U	Meanwhile we should keep 500!
12:58	Cop	Switching on that one!
13:05	Traff.	**Coast guard 21, climbing for niner zero.**
	AFIS	**Coast guard 21, Longyear, say again.**
	Traff.	**We are climbing for niner zero.**
	AFIS	**Coast guard 21, Longyear roger.**
13:44	Nav	We will land by Jeppesen!

08:13:46		***Radio altimeter warning, duration 6 seconds.***
14:00	PiC	Check-list!
14:08	U	(? I'm reading - - -) (ind.).
14:13	U	We will go (to the holding area) by the course - - -.
14:54	AFIS	**VKO 2801 Longyear information, what is your position and altitude?**
14:58	Nav	**Maintaining 5000 feet, QNH 1006, approaching Lima-Alfa - - - inbound - - - outbound.**
15:11	AFIS	**VKO 2801 Longyear roger, give me a call passing ALFA-DELTA-VICTOR or Advent outbound.**
15:17	Nav	**I call you back over Lima Alfa, 2801.**
15:32	Nav	**2801 passing now over NDB Lima Alfa, altitude 5000 feet on 1006, turning right, heading 15-155.**
15:53	AFIS	**VKO 2801 Longyear, say again.**
15:57	Nav	**2801 Passing now NDB Lima-Alfa - altitude 5000 feet, turning right, heading 155.**
16:08	AFIS	**VKO 2801 roger, and give me a report passing ADV, or abeam ADV inbound.**
16:19	Nav	**01, call you back over inbound, abeam Alfa-Delta-Victor, 2801.**
16:30	AFIS	**Yeh, give me a call passing abeam ADV.**
16:33	Nav	**ALFA-DELTA-VICTOR.**
16:43	AFIS	**Call me passing abeam Advent beacon.**
16:50	Nav	150.
16:52	PiC	By parallel - - - (ind.).

08:16:55	Nav	No, seven miles here.
16:56	Nav	I'll adjust it.
17:05	Cop	Where are we - - -? - - - (ind.).
17:06	Nav	Meanwhile, keep it like that!
17:08	PiC	Did you notice the place?
17:09	Nav	Abeam the turning point.
17:14	PiC	A corrective turn will be (?necessary).
17:16	U	We're approaching.
17:21	PiC	Now we will be (?the flaps)... (ind.)
17:40	AFIS	**VKO 2801 give me a call eight miles inbound.**
17:43		***Radio altimeter warning, duration 6 seconds.***
17:44	Nav	**Call you back ten miles inbound, 2801.**
17:55	AFIS	**VKO 2801, give me a call eight miles inbound.**
17:57	F/e	Eight miles (In the English language).
17:57	Nav	**Ah - abeam eight miles 2801 inbound - - -.**
17:59	AFIS	**Correct.**
18:05	U	Four marks (ind.).
18:08	PiC	But here it's already three.
18:14	U	There's no need to - - - here!
18:16		***Radio altimeter warning, duration 2 seconds.***
18:17	U	- - - to descend.
18:19	Cop	The flag disappeared on my instrument!
18:21		***Radio altimeter warning, duration 6 seconds.***

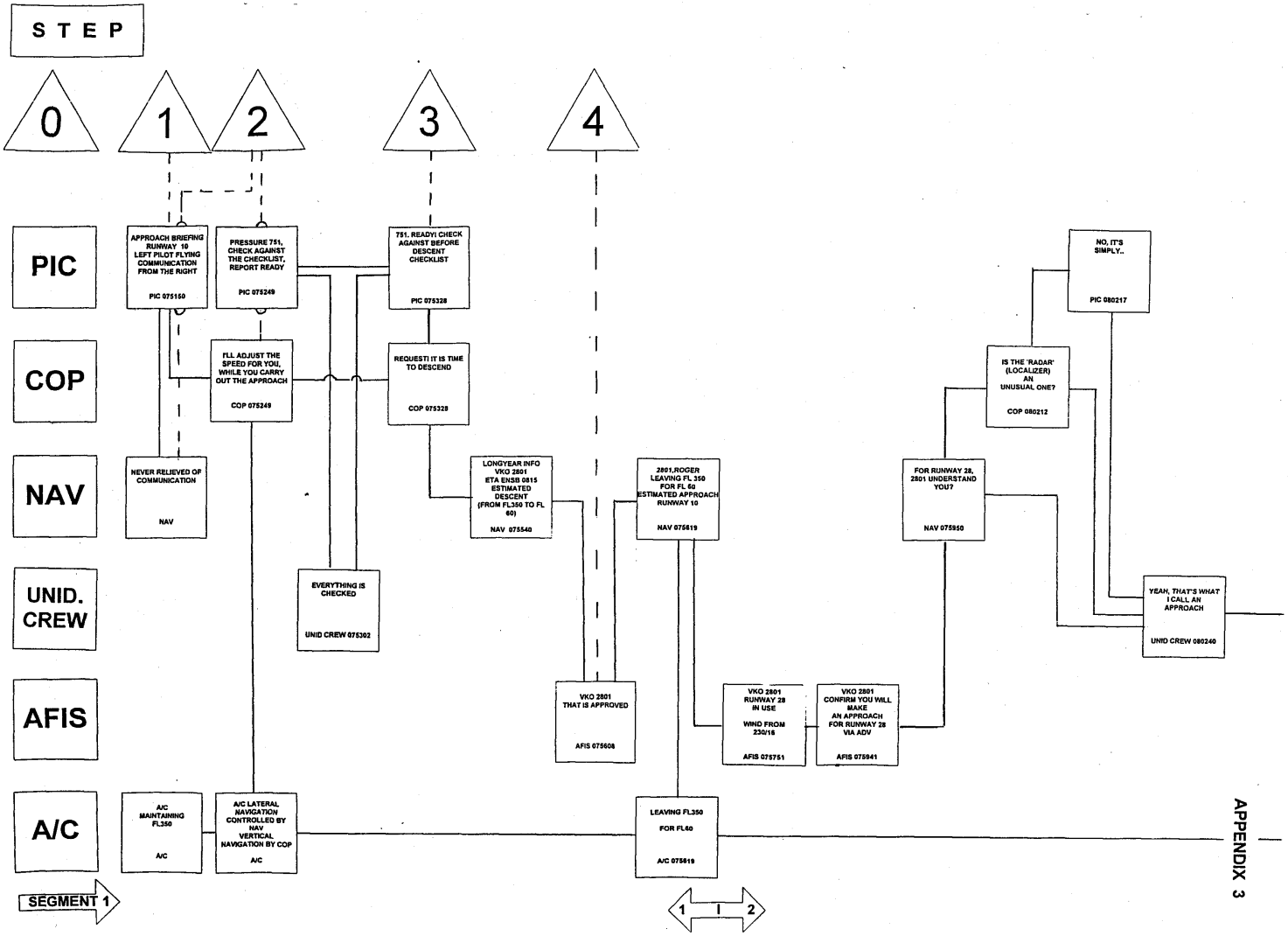
08:18:25	AFIS	**LPP, Longyear roger, we have a traffic inbound Tupolev, suppose he will be passing 8 miles east in a few minutes.**
18:28	PiC	I'm turning just a little bit to the left.
18:32	Cop	Set it straight.
18:37	PiC	15.
18:39	PiC	Borya, have we got it?
18:41	Traff.	**LPP, roger.**
18:45	U	Set it!
18:47	U	How many?
18:50	U	(?Switching off) (?Switching on).
18:51	U	Switched off.
18:52	PiC	What should I hold?
18:59	PiC	OK, leave it!
19:03	U	So, what might the recommendations be?
19:04	PiC	So.
19:06	Cop	Maybe we took the fourth (final turn) too early?
19:11	PiC	Let's level out!
19:14	PiC	No, (?it should be) to the right.
19:16	Nav	Just we'll get it, just now!
19:18	Nav	Is the mark (marker?) to the right?
19:19	Cop	No, it is still staying.
19:19	PiC	To the right!
19:20	PiC	Let's turn to the right
19:21		***Radio altimeter warning, duration 6 seconds***

08:19:21	PiC	Give me the approach chart Borya.
19:22	Cop	Should we descend here?
19:24	PiC	We shall descend!
19:30	Cop	Should we approach?
19:32	PiC	Let's 'dive'!
19:34	PiC	What (?course) did you keep (?now), (?what did you keep?).
19:36	Nav	Three hundred degrees.
19:36	Traff.	**LPP, now crossed centerline and we will stay east of shoreline.**
	AFIS	**PP, Longyear, say again.**
	Traff.	**We have crossed center line and will stay north and east of shoreline, landing on the apron.**
19:51	Nav	But it's fourteen here!
19:52	PiC	OK.
19:54	AFIS	**LPP, sorry about that. Did not copy, could you say again?**
19:54	PiC	So, fix it!
19:59	Nav	Five metres.
20:03	Traff.	**LPP, be landing on the apron.**
20:03	Nav	So, I'll keep about 320°! OK?
20:04	AFIS	**LPP, Longyear, roger. Wind is 230/17 and give me a call passing extended centerline.**
20:14	Traff.	**LPP, will call you right downwind out of the apron.**
20:14	Cop	Isn't that too little?
20:15	Nav	It should be a corrective turn.
20:16	AFIS	**PP, Longyear roger, thank you.**

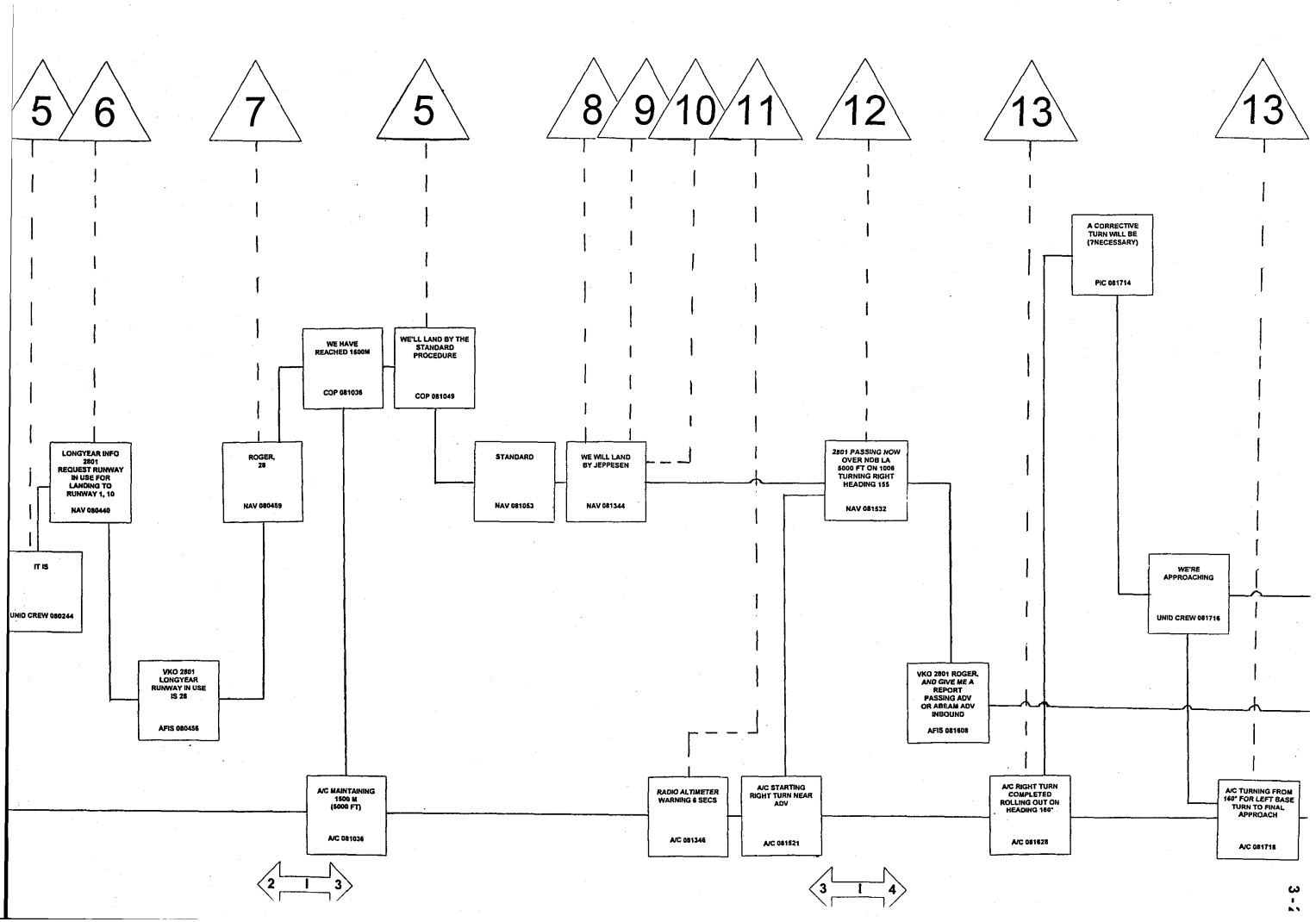
08:20:17	PiC	No! Turn to the left!
20:21	Nav	It's thirteen. Let's descend!
20:24	Cop	To the left!
20:24	Nav	Three degrees and five minutes. We're on the glide path.
20:29	Cop	We're on landing course now, correct?
20:33	PiC	To get the landing course, make a slight correction to the left!
20:41	Nav	Three hundred and thirteen. Let's descend!
20:44	Cop	What about the flaps?
20:52	Cop	28?
20:57	U	(?Keep)... (ind.) 5 metres.
20:58	Nav	(ind.) 2 - 3 miles.
21:00	PiC	You guide us, you guide us!
21:00	Nav	We're flying by Jeppesen
21:02	Nav	(ind.).
21:02	PiC	Igor, set Advent for me.
21:05	U	(ind.).
21:08	Nav	Not now. Later on!
21:09	U	Well, (? now) it's three hundred - - - meters (just now)
21:14	U	No
21:15	Nav	I've told you there is no need.
21:19	U	To the right.
21:22	PiC	What is our radial?
21:24	Nav	Let's follow the approach chart to the end!

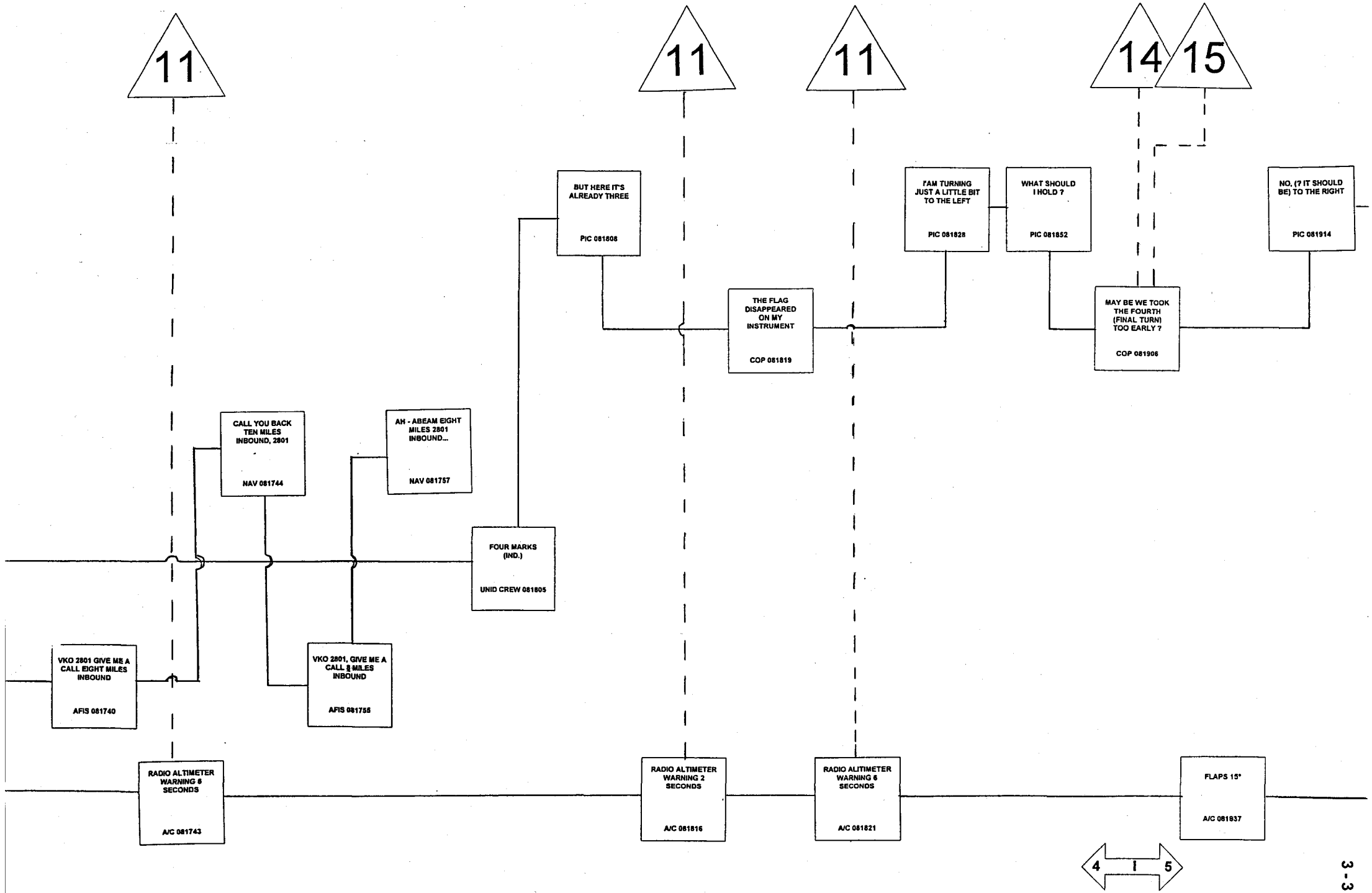
08:21:25	Traff.	**LPP, landed 21.**
21:29	U	So, - - - (ind.).
21:31	U	We will be landing, will we not?
21:32	PiC	Well, that is OK.
21:33	PiC	300°
21:35	Cop	300° so far! Is it OK?
21:36	Nav	Flying through 1150. It's too high, we have to descend.
21:41	PiC	We have to descend.
21:43	PiC	So.
21:47	Cop	How are we approaching? Is it correct or not?
21:49	Cop	Landing gears?
21:51	U	The landing gears may be extended.
21:55	U	To the right here.
22:05	U	To the left.
22:07	Cop	So. How are we going for altitude?
22:09	Nav	Three hundred, five metres. Descending!
22:13	Cop	That's about five metres, is it not?
22:17		***Radio altimeter warning, duration 6 seconds.***
22:22	PiC	Horizon!
22:23	Cop	Mountains!!!
22:23		***Sound effect of impact with ground against background of radio altimeter warning signal.***

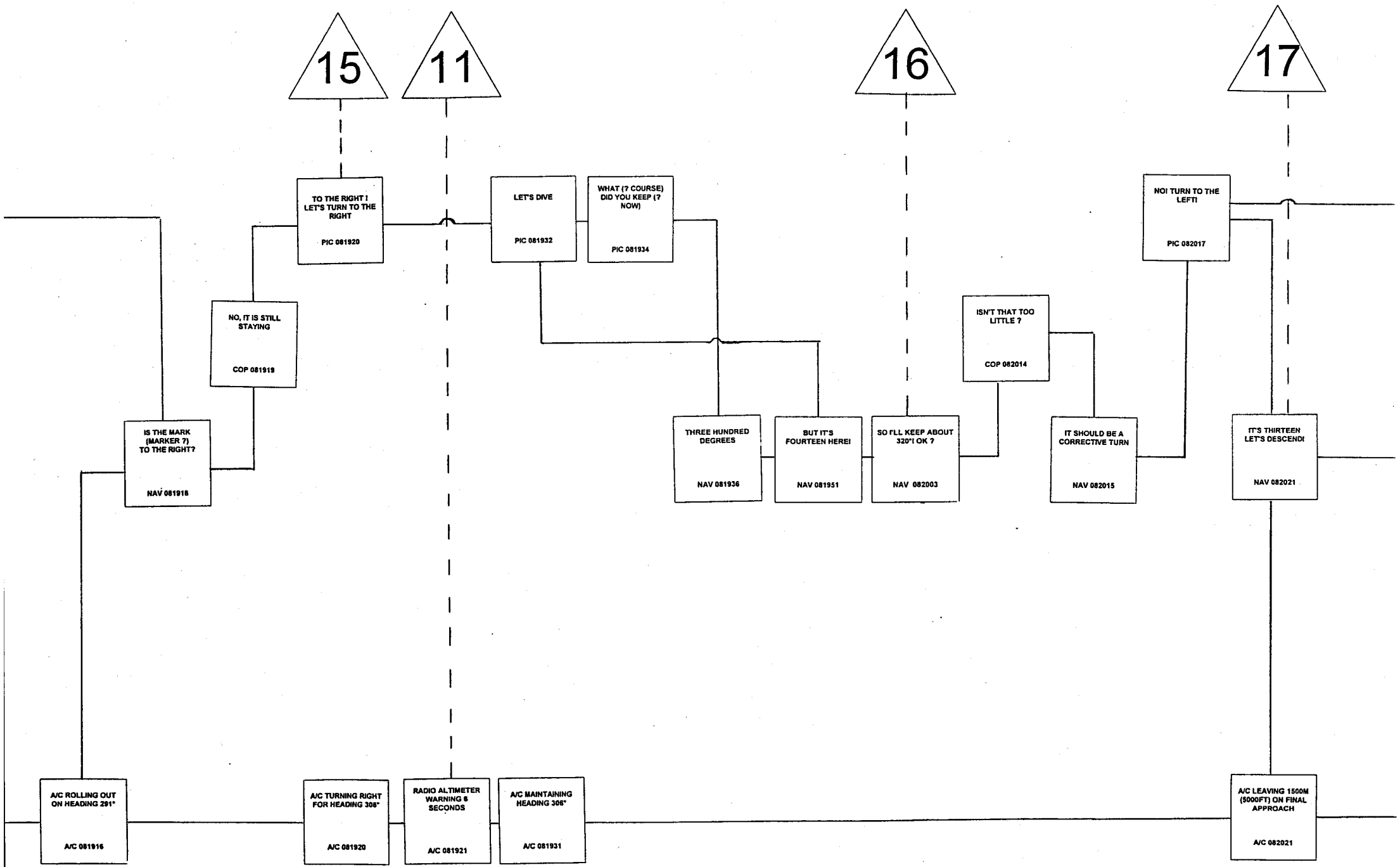
08:22:25	AFIS	**VKO 2801, weather is wind from 231/17, visibility still more than 10 in rain, we have few at 900 feet and broken at 2000.**
22:58	AFIS	**VKO 2801 did you copy latest weather?**

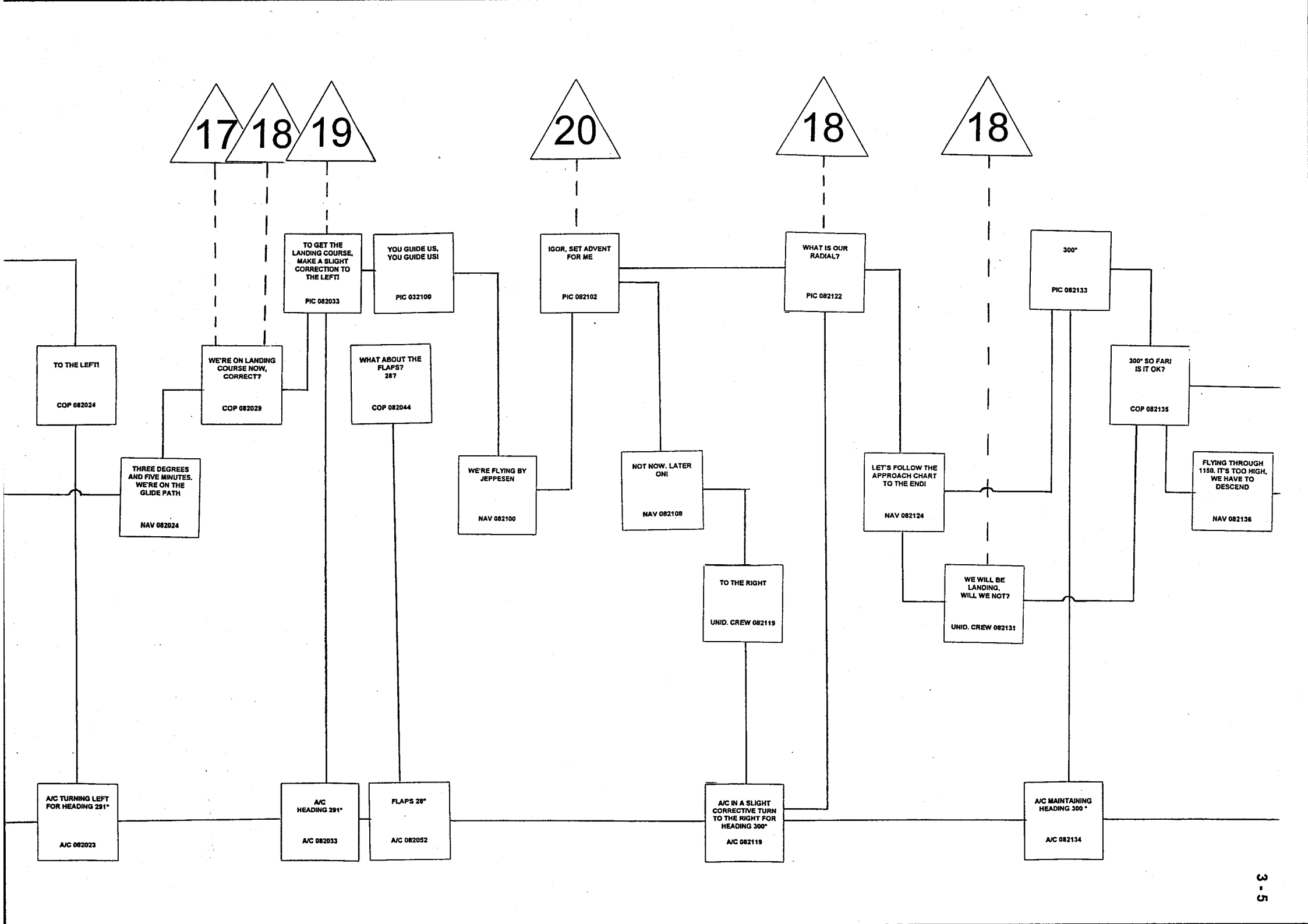

STEP
0
1
2
3
4
PIC
COP
NAV
UNID. CREW
AFIS
A/C
APPROACH BRIEFING RUNWAY 10 LEFT PILOT FLYING COMMUNICATION FROM THE RIGHT
PIC 075150
PRESSURE 751, CHECK AGAINST THE CHECKLIST, REPORT READY
PIC 075249
751, READY! CHECK AGAINST BEFORE DESCENT CHECKLIST
PIC 075328
NO, IT'S SIMPLY..
PIC 080217
I'LL ADJUST THE SPEED FOR YOU, WHILE YOU CARRY OUT THE APPROACH
COP 075249
REQUEST! IT IS TIME TO DESCEND
COP 075328
IS THE 'RADAR' (LOCALIZER) AN UNUSUAL ONE?
COP 080212
NEVER RELIEVED OF COMMUNICATION
NAV
LONGYEAR INFO VKO 2801 ETA ENSB 0815 ESTIMATED DESCENT (FROM FL350 TO FL 60)
NAV 075540
2801,ROGER LEAVING FL 350 FOR FL 60 ESTIMATED APPROACH RUNWAY 10
NAV 075619
FOR RUNWAY 28, 2801 UNDERSTAND YOU?
NAV 075950
EVERYTHING IS CHECKED
UNID CREW 075302
YEAH, THAT'S WHAT I CALL AN APPROACH
UNID CREW 080240
VKO 2801 THAT IS APPROVED
AFIS 075608
VKO 2801 RUNWAY 28 IN USE
WIND FROM 230/18
AFIS 075751
VKO 2801 CONFIRM YOU WILL MAKE AN APPROACH FOR RUNWAY 28 VIA ADV
AFIS 075941
A/C MAINTAINING FL350
A/C
A/C LATERAL NAVIGATION CONTROLLED BY NAV VERTICAL NAVIGATION BY COP
A/C
LEAVING FL350 FOR FL60
A/C 075619
SEGMENT 1
1
2

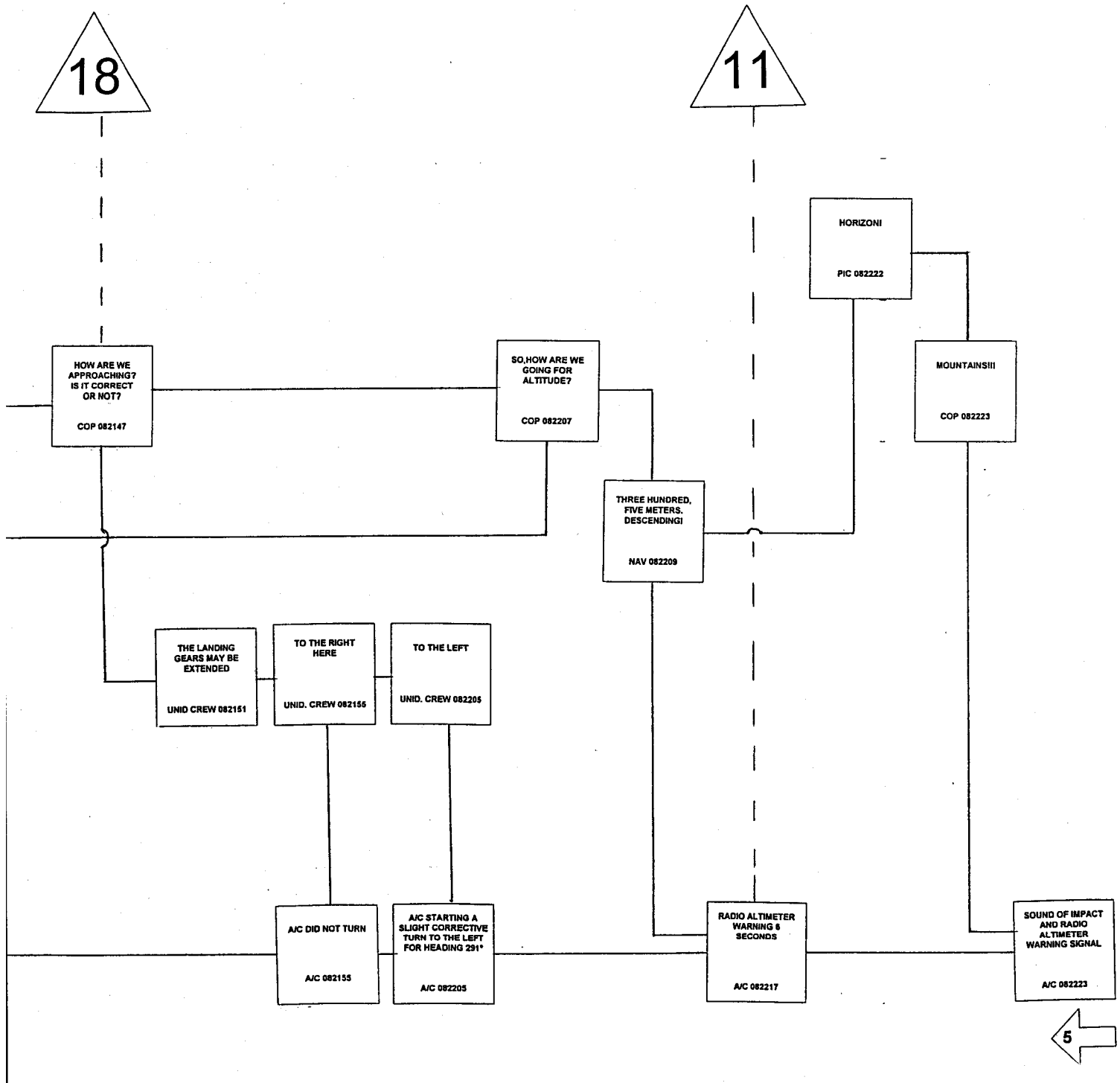
APPENDIX 3


5
6
7
5
8
9
10
11
12
13
13
A CORRECTIVE TURN WILL BE (?NECESSARY)
PIC 081714
WE HAVE REACHED 1500M
COP 081036
WE'LL LAND BY THE STANDARD PROCEDURE
COP 081049
LONGYEAR INFO 2801 REQUEST RUNWAY IN USE FOR LANDING TO RUNWAY 1, 10
NAV 080440
ROGER, 28
NAV 080459
STANDARD
NAV 081053
WE WILL LAND BY JEPPESEN
NAV 081344
2801 PASSING NOW OVER NDB LA 5000 FT ON 1006 TURNING RIGHT HEADING 155
NAV 081532
WE'RE APPROACHING
UNID CREW 081716
IT IS
UNID CREW 080244
VKO 2801 LONGYEAR RUNWAY IN USE IS 28
AFIS 080456
VKO 2801 ROGER, AND GIVE ME A REPORT PASSING ADV OR ABEAM ADV INBOUND
AFIS 081608
A/C MAINTAINING 1500 M (5000 FT)
A/C 081036
RADIO ALTIMETER WARNING 8 SECS
A/C 081346
A/C STARTING RIGHT TURN NEAR ADV
A/C 081521
A/C RIGHT TURN COMPLETED ROLLING OUT ON HEADING 180°
A/C 081628
A/C TURNING FROM 140° FOR LEFT BASE TURN TO FINAL APPROACH
A/C 081718
2
1
3
3
1
4


11
11
11
14
15
BUT HERE IT'S ALREADY THREE
PIC 081808
I'AM TURNING JUST A LITTLE BIT TO THE LEFT
PIC 081828
WHAT SHOULD I HOLD ?
PIC 081852
NO, (? IT SHOULD BE) TO THE RIGHT
PIC 081914
THE FLAG DISAPPEARED ON MY INSTRUMENT
COP 081819
MAY BE WE TOOK THE FOURTH (FINAL TURN) TOO EARLY ?
COP 081906
CALL YOU BACK TEN MILES INBOUND, 2801
NAV 081744
AH - ABEAM EIGHT MILES 2801 INBOUND...
NAV 081757
FOUR MARKS (IND.)
UNID CREW 081805
VKO 2801 GIVE ME A CALL EIGHT MILES INBOUND
AFIS 081740
VKO 2801, GIVE ME A CALL 8 MILES INBOUND
AFIS 081755
RADIO ALTIMETER WARNING 6 SECONDS
A/C 081743
RADIO ALTIMETER WARNING 2 SECONDS
A/C 081816
RADIO ALITIMETER WARNING 6 SECONDS
A/C 081821
FLAPS 15°
A/C 081937
4
5


15
11
16
17
TO THE RIGHT ! LET'S TURN TO THE RIGHT
PIC 081920
LET'S DIVE
PIC 081932
WHAT (? COURSE) DID YOU KEEP (? NOW)
PIC 081934
NO! TURN TO THE LEFT!
PIC 082017
NO, IT IS STILL STAYING
COP 081919
ISN'T THAT TOO LITTLE ?
COP 082014
IS THE MARK (MARKER ?) TO THE RIGHT?
NAV 081918
THREE HUNDRED DEGREES
NAV 081936
BUT IT'S FOURTEEN HERE!
NAV 081951
SO I'LL KEEP ABOUT 320°! OK ?
NAV 082003
IT SHOULD BE A CORRECTIVE TURN
NAV 082015
IT'S THIRTEEN LET'S DESCEND!
NAV 082021
A/C ROLLING OUT ON HEADING 291°
A/C 081916
A/C TURNING RIGHT FOR HEADING 306°
A/C 081920
RADIO ALTIMETER WARNING 6 SECONDS
A/C 081921
A/C MAINTAINING HEADING 306°
A/C 081931
A/C LEAVING 1500M (5000FT) ON FINAL APPROACH
A/C 082021


17
18
19
20
18
18
TO THE LEFT!
COP 082024
WE'RE ON LANDING COURSE NOW, CORRECT?
COP 082029
TO GET THE LANDING COURSE, MAKE A SLIGHT CORRECTION TO THE LEFT!
PIC 082033
YOU GUIDE US, YOU GUIDE US!
PIC 032100
WHAT ABOUT THE FLAPS? 28?
COP 082044
IGOR, SET ADVENT FOR ME
PIC 082102
WHAT IS OUR RADIAL?
PIC 082122
300°
PIC 082133
300° SO FAR! IS IT OK?
COP 082135
THREE DEGREES AND FIVE MINUTES. WE'RE ON THE GLIDE PATH
NAV 082024
WE'RE FLYING BY JEPPESEN
NAV 082100
NOT NOW. LATER ON!
NAV 082108
LET'S FOLLOW THE APPROACH CHART TO THE END!
NAV 082124
FLYING THROUGH 1150, IT'S TOO HIGH, WE HAVE TO DESCEND
NAV 082136
TO THE RIGHT
UNID. CREW 082119
WE WILL BE LANDING, WILL WE NOT?
UNID. CREW 082131
A/C TURNING LEFT FOR HEADING 291°
A/C 082023
A/C HEADING 291°
A/C 082033
FLAPS 28°
A/C 082052
A/C IN A SLIGHT CORRECTIVE TURN TO THE RIGHT FOR HEADING 300°
A/C 082119
A/C MAINTAINING HEADING 300 °
A/C 082134


18
11
HORIZONI
PIC 082222
HOW ARE WE APPROACHING? IS IT CORRECT OR NOT?
COP 082147
SO,HOW ARE WE GOING FOR ALTITUDE?
COP 082207
MOUNTAINS!!!
COP 082223
THREE HUNDRED, FIVE METERS. DESCENDING!
NAV 082209
THE LANDING GEARS MAY BE EXTENDED
UNID CREW 082151
TO THE RIGHT HERE
UNID. CREW 082155
TO THE LEFT
UNID. CREW 082205
A/C DID NOT TURN
A/C 082155
A/C STARTING A SLIGHT CORRECTIVE TURN TO THE LEFT FOR HEADING 291°
A/C 082205
RADIO ALTIMETER WARNING 6 SECONDS
A/C 082217
SOUND OF IMPACT AND RADIO ALTIMETER WARNING SIGNAL
A/C 082223
5

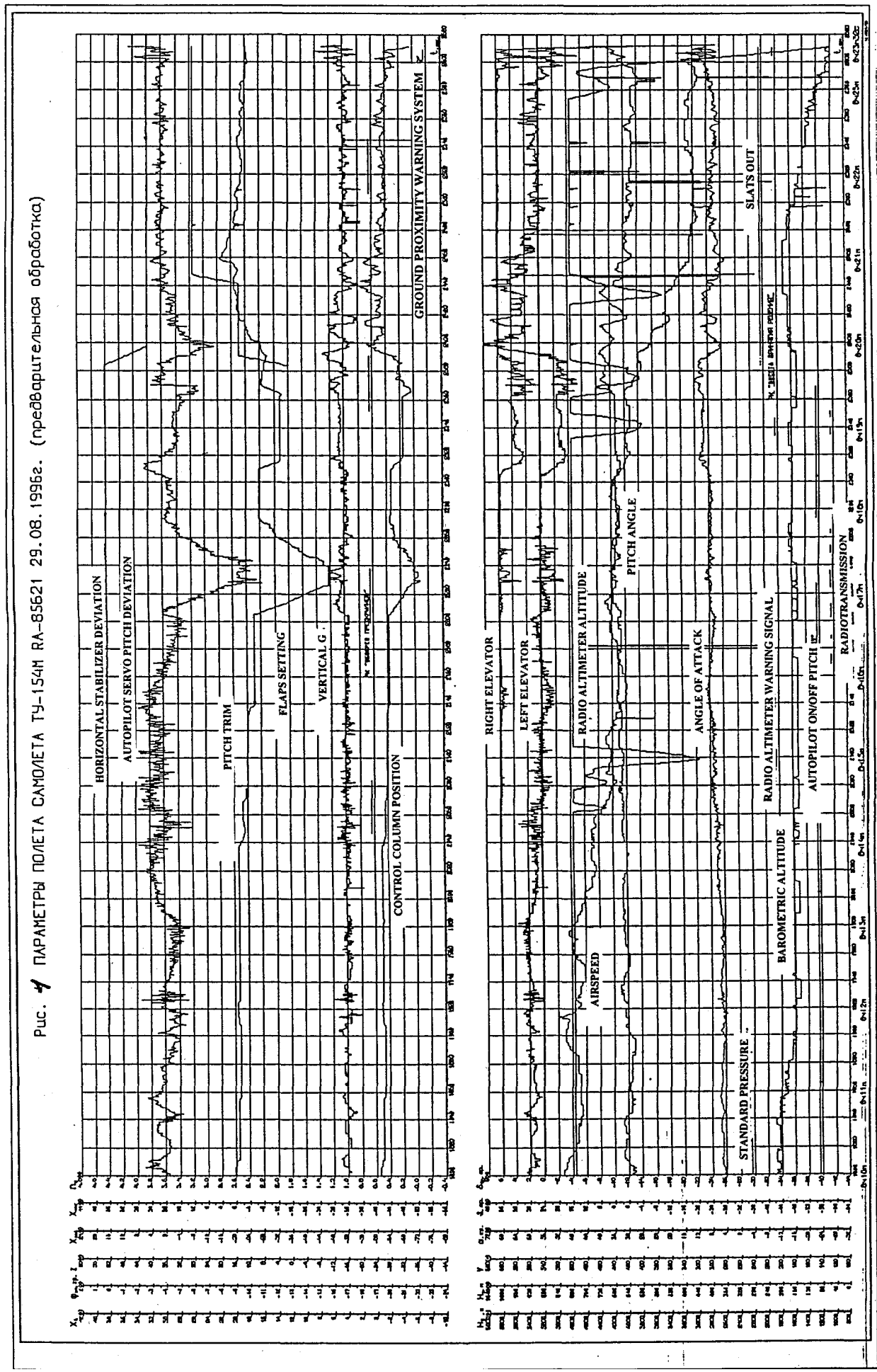


Рис. 4 ПАРАМЕТРЫ ПОЛЕТА САМОЛЕТА ТУ-154М RA-85621 29.08.1996г. (предварительная обработка)

Рис. 2 ПАРАМЕТРЫ ПОЛЕТА САМОЛЕТА ТУ-154М RA-85621 29.08.1996г. (предварительная обработка)

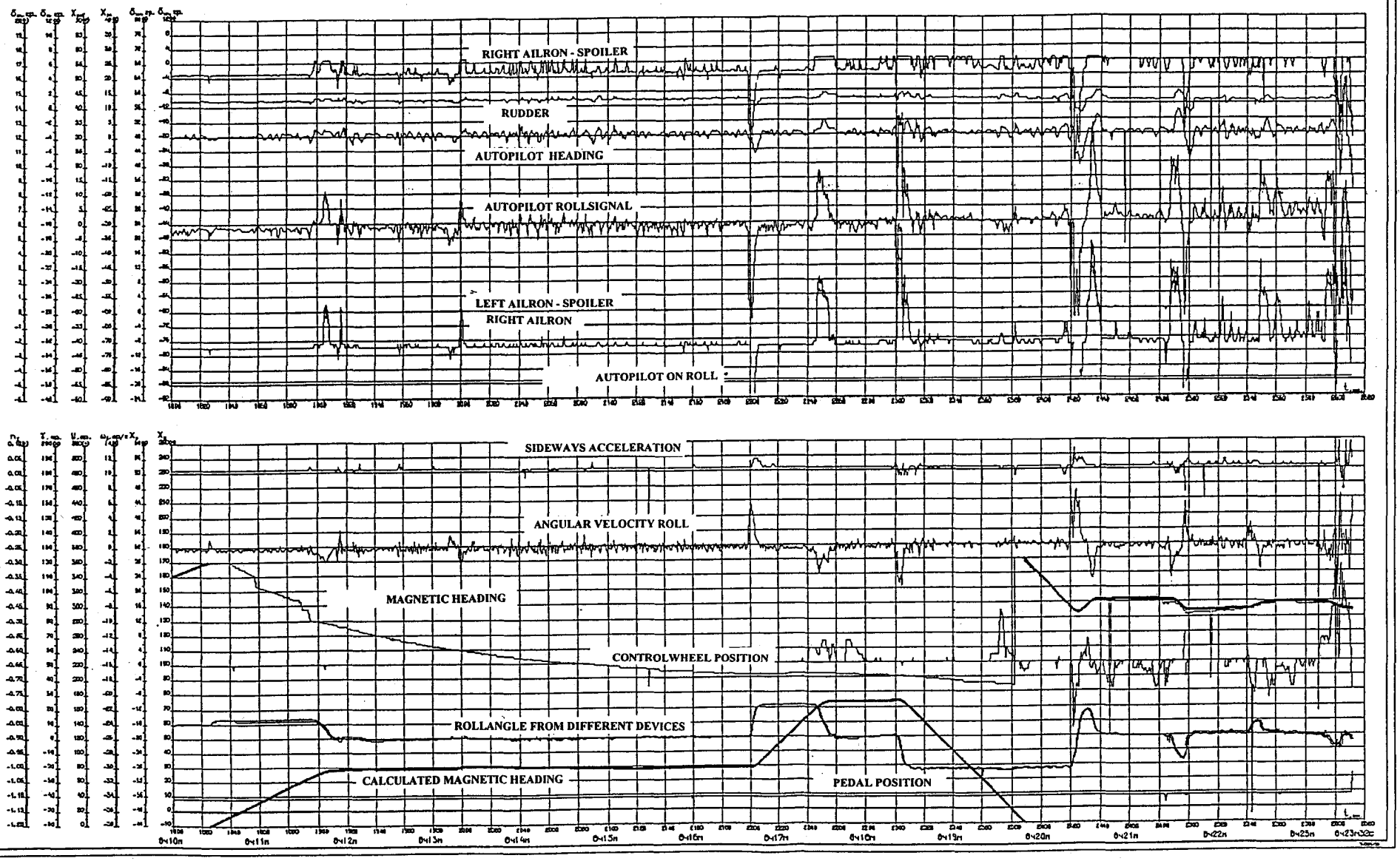
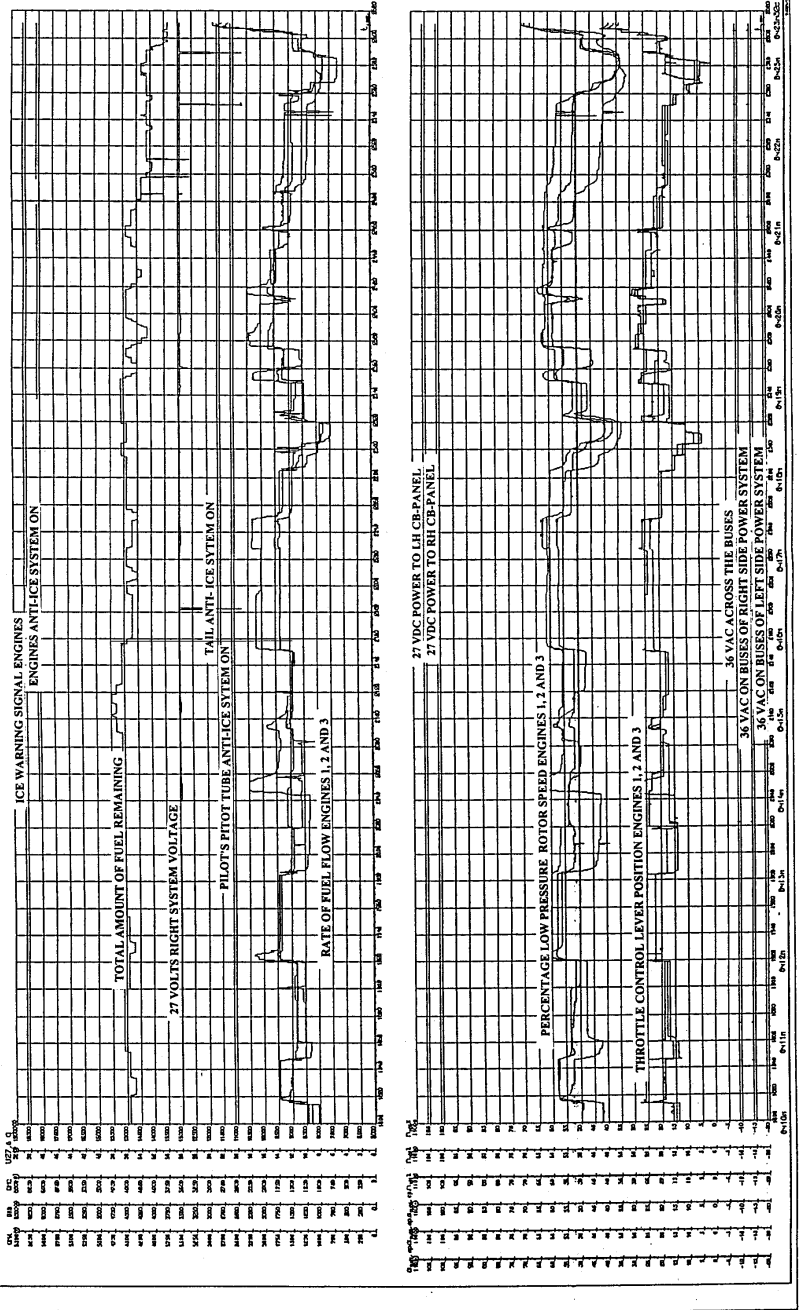
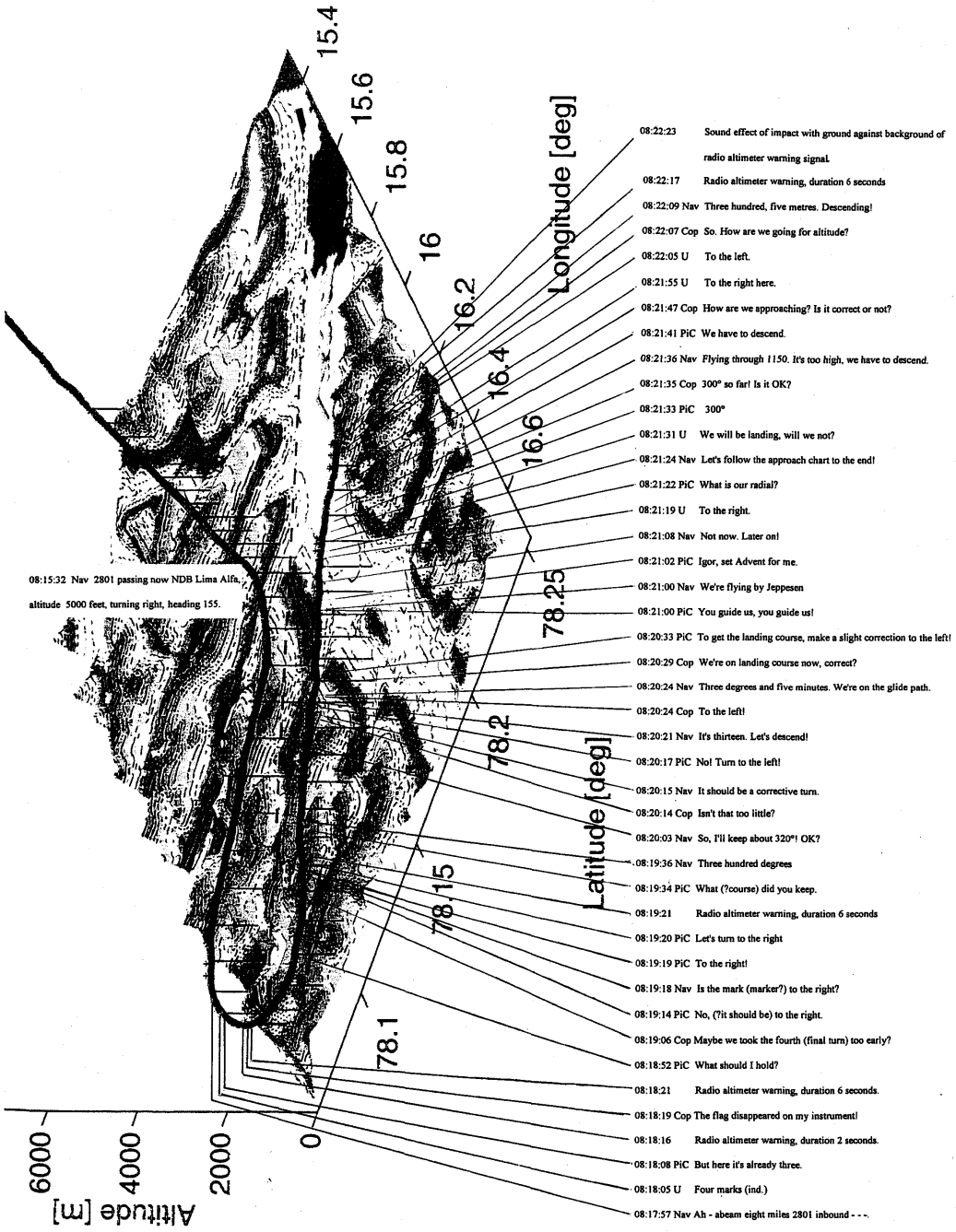


Рис. 3 ПАРАМЕТРЫ ПОЛЕТА САМОЛЕТА ТУ-154М RA-85621 29.08.1996г. (предварительная обработка)



APPENDIX 5



08:15:32 Nav 2801 passing now NDB Lima Alfa, altitude 5000 feet, turning right, heading 155.

08:22:23 Sound effect of impact with ground against background of radio altimeter warning signal.
08:22:17 Radio altimeter warning, duration 6 seconds
08:22:09 Nav Three hundred, five metres. Descending!
08:22:07 Cop So. How are we going for altitude?
08:22:05 U To the left.
08:21:55 U To the right here.
08:21:47 Cop How are we approaching? Is it correct or not?
08:21:41 PiC We have to descend.
08:21:36 Nav Flying through 1150. It's too high, we have to descend.
08:21:35 Cop 300° so far! Is it OK?
08:21:33 PiC 300°
08:21:31 U We will be landing, will we not?
08:21:24 Nav Let's follow the approach chart to the end!
08:21:22 PiC What is our radial?
08:21:19 U To the right.
08:21:08 Nav Not now. Later on!
08:21:02 PiC Igor, set Advent for me.
08:21:00 Nav We're flying by Jeppesen
08:21:00 PiC You guide us, you guide us!
08:20:33 PiC To get the landing course, make a slight correction to the left!
08:20:29 Cop We're on landing course now, correct?
08:20:24 Nav Three degrees and five minutes. We're on the glide path.
08:20:24 Cop To the left!
08:20:21 Nav It's thirteen. Let's descend!
08:20:17 PiC No! Turn to the left!
08:20:15 Nav It should be a corrective turn.
08:20:14 Cop Isn't that too little?
08:20:03 Nav So, I'll keep about 320°! OK?
08:19:36 Nav Three hundred degrees
08:19:34 PiC What (?course) did you keep.
08:19:21 Radio altimeter warning, duration 6 seconds
08:19:20 PiC Let's turn to the right
08:19:19 PiC To the right!
08:19:18 Nav Is the mark (marker?) to the right?
08:19:14 PiC No, (?it should be) to the right.
08:19:06 Cop Maybe we took the fourth (final turn) too early?
08:18:52 PiC What should I hold?
08:18:21 Radio altimeter warning, duration 6 seconds.
08:18:19 Cop The flag disappeared on my instrument!
08:18:16 Radio altimeter warning, duration 2 seconds.
08:18:08 PiC But here it's already three.
08:18:05 U Four marks (ind.)
08:17:57 Nav Ah - abeam eight miles 2801 inbound - - -.

FLIGHT SAFETY FOUNDATION
Airport Operations
Vol. 23 No. 5 *For Everyone Concerned with the Safety of Flight* September–October 1997

English-language Training For Air Traffic Controllers Must Go Beyond Basic ATC Vocabulary

Because miscommunication can have serious consequences, air traffic controllers responsible for international flights must have the skills in English to communicate more broadly than just to repeat learned phrases. The training and testing of controllers in English should require that controllers be able to respond to unusual, as well as routine, situations.

Shannon Uplinger
Uplinger Translation Services

In ordinary speech situations, we interpret spoken content by processing visual cues, such as gestures, and use these cues to supplement verbal information. As a last resort, we ask questions and obtain further information needed to make the meaning clear.

Context also plays an important role in understanding a speaker's message. Even if we miss a word or two of a speaker's presentation, we can still construct what the speaker said based on the usual context of the situation. Large amounts of spoken communication can be processed while we think about other things nearly simultaneously because context often makes much of the semantic content predictable.

Visual cues and contexts help make ordinary speech adequate for most of the things we do. Because pilots and air traffic controllers are invisible to one another they cannot depend on visual cues to facilitate communication. Furthermore, while communicating with each other, both pilots and controllers also process large amounts of visual information and perform other linguistic tasks — pilots communicating with other crew members, controllers communicating with other flights and both groups monitoring their instruments.

Context can be misinterpreted. In pilot–air traffic control (ATC) radio communication, the term "two five zero" can be an altitude, an airspeed or a heading. Expecting, for example, to receive heading instructions from a controller, and perhaps hearing only the words "two five zero," a pilot might mistake an altitude clearance for a heading.

To compensate for distractions and the ambiguity of context, pilots and controllers use highly formatted exchanges and rely on readback to ensure that the intended meaning of their messages has been understood. Despite using readback, miscommunication can occur, especially when the listener's expectations influence what is heard.

In high-risk situations, such as those that can arise during ATC communication, the result of a miscommunication can be serious.

Steven Cushing presents examples of miscommunication that have caused or contributed to aviation accidents. In these accidents, visual, contextual and other redundant cues were unavailable, and the speakers failed to recognize or resolve the ambiguities in their exchanges.[1]

Cushing cites the March 27, 1977, KLM Royal Dutch Airlines Boeing 747 collision with a Pan American World Airways B-747 in the Canary Islands, which resulted in 583 deaths; 61 survived. A pilot of the KLM aircraft said that he was "at takeoff," which the controller assumed to mean that the pilot was ready for takeoff and was awaiting further instructions. Actually, the KLM aircraft was taking off and was about to collide with the Pan American aircraft, which was taxiing on the runway toward the KLM aircraft.

Dealing with ambiguity in ATC communications is even more complex when flight crews, controllers or both are communicating in non-native English, that is, English that has been acquired as a second language.

The International Civil Aviation Organization (ICAO) does not mandate the use of English internationally for ATC communications, but recommends communication in the language "normally used by the station on the ground." Somewhat equivocally, ICAO recommends the use of English "pending the development and adoption of a more suitable form of speech for universal use in aeronautical radiotelephony communications."[2]

ICAO further recommends that English-language support should be available from ATC facilities serving designated routes and airports that are used by international flights. This ambiguous situation has resulted in *de facto* use of English as the international language of ATC without a requirement that it serve as such, and without the development of standards for training and testing controller use of English.

Given the challenges of ATC communication and the lack of regulatory specifications for English as the international language of aviation, it is not surprising that a number of aviation accidents have involved non-native English in pilot-controller communications. As Cushing noted concerning the accident in which the KLM pilot informed the controller that the B-747 was "at takeoff," the grammar of the pilot's native language, Dutch, interfered with his ability to construct the English statement "I am taking off," which would have had a different meaning to the controller.[1]

Other accidents involving misinterpretation of meaning have occurred more recently. On Jan. 25, 1990, the first officer of an Avianca airliner failed to translate to the air traffic controller the captain's statement that the aircraft was in an emergency situation, instead saying, "We're running out of fuel." The controller responded to a low-fuel situation, but not to a low-fuel emergency. The plane impacted terrain at Cove Neck, New York, U.S., killing 73 persons aboard the flight; 85 survived.

In December 1995, the American Airlines Flight 965 accident near Cali, Colombia, might have been prevented if the Colombian controller had been fluent in English.[3] The Colombian government has officially determined flight crew error as the probable cause of the accident. Nevertheless, the Cali controller said that he did not have adequate English skills to ask questions when the crew made illogical statements about the plane's location. The Boeing 757 aircraft flew into a mountain and 160 were killed; four survived.

Problems arising from lack of fluency in English received considerable attention at a three-day Communicating for Safety Conference, sponsored by a number of major aviation professional groups, held May 15–17, 1997, near Phoenix, Arizona, U.S.

Dealing with ambiguity in ATC communications is even more complex when flight crews, controllers or both are communicating in English that has been acquired as a second language.

Speaking at the conference, Capt. John Cox of US Airways said, "Ours is a lexicon of abbreviations, acronyms and jargon, and just consider how many different versions of English we have. Often our language can be confusing — we have problems with oxymorons. slang, homonyms (to, too, two) and so forth."[4]

At the same conference, Frank Price, manager of Air Traffic International Staff of the U.S. Federal Aviation Administration (FAA), said, "Unlike [in] the past, international traffic is now flying into the [U.S.] heartland. Every [FAA Air Route Traffic Control] Center now works international traffic."[4] Outside the United States, air routes — such as those over Russia and China — that were severely restricted or prohibited from use by western air carriers during the Cold War have been opened, increasing the potential for pilot-ATC language problems.

At the special aviation safety conference convened by the U.S. Secretary of Transportation in early 1995 following several highly publicized accidents in the last five months of 1994, proposals were made to require all airline transport pilots to pass a test of English-speaking proficiency. This led to the drafting of a standardized test, which included three parts: written, listening and speaking, and using model airplanes to demonstrate understanding of flight-maneuver terminology. The FAA has reportedly not taken action to require such testing of non-U.S. pilots who fly to the United States, although one private company that teaches "aviation English" uses testing in its own proficiency assessments of non-U.S. pilots that it trains.[5]

At the recommendation of the U.S. National Transportation Safety Board (NTSB), the FAA in April 1997 sent ICAO a letter proposing the establishment of English standards, and ICAO is expected to respond before the end of 1997. The U.S. Congress has also expressed concern about the issue. In connection with appropriations for the FAA, the House of Representatives Transportation Appropriations Subcommittee urged the FAA to work with the NTSB and ICAO to standardize training and evaluation procedures for English proficiency in the worldwide aviation system and approved funding for such a program. A House-Senate conference committee has recently approved a US$500,000 set-aside as part of the FAA budget for fiscal year 1998.

Several U.S.-based air carriers took the initiative to foster training of controllers, despite the absence of an international standard addressing skill levels. United Airlines, Northwest Airlines, Delta Air Lines, Alaska Airlines and FedEx supported English-proficiency programs for Russian and Chinese controllers at U.S. universities.[5]

Training programs to improve controller English skills face a variety of challenges. Because skill-level requirements have never been defined, training has emphasized mastery of standardized terminology. Nevertheless, the acquisition and use of language skill is complex and involves learning grammar, pronunciation, intonation and usage. Developing functionality in a foreign language is a difficult task.

Effective pilot-controller communication depends on the ability of the speakers to avoid ambiguity, at best, or at least to resolve ambiguous situations when they occur. If controllers lack adequate English skills, they cannot resolve ambiguous situations by requesting clarification or verification of details, as happened at Cali. Therefore, English proficiency needs to exceed the level required to reproduce memorized phrases and terms. The mastery of specialized terminology is insufficient.

If controllers lack adequate English skills, they cannot resolve ambiguous situations by requesting clarification or verification of details.

Contrary to the method used in many countries, ATC terminology should be taught not to beginners, but only to students who have at least a relatively advanced knowledge of English. Jack C. Richards suggests that special terminology is best learned in the context of the general language in which it is used.[6]

ATC terminology is highly specialized and occurs infrequently in the general language, so mastery of ATC terminology alone does not produce functional proficiency in English. A fairly high level of functional proficiency is needed to master ATC terminology, because as Richards says, knowing a word includes:

- Knowing the probability of encountering that word in speech or print;
- For many words, knowing the type of words most likely to be associated with the word;
- Knowing the limitations imposed on the use of the word according to variations in function and situation; and,
- Knowing the syntax associated with the word.[6]

Knowledge of specialized terms is also easier to acquire when aspects of the language have been mastered first, such as principles of word formation and sentence structure. Teaching and testing knowledge of ATC terminology with lists of terms turns controllers into parrots, who are handicapped in unusual or stressful ATC situations, rather than skilled users of English who can apply the language in a range of contexts.

One solution to English-proficiency and other communication problems suggested by Cushing is an "intelligent voice interface," which would provide some callouts automatically; monitor voice transmissions for accuracy, completeness, plausibility and similar factors; and question the speaker as needed before transmitting communications. But, as Cushing acknowledges, we lack the technology and a complete understanding of how language is interpreted by the brain. For the present, he recommends development of other visual back-up systems to voice.

Although many advocate the use of datalink to avoid the complexities of voice communication, datalink might be a questionable replacement of voice communication for controlled approaches and other nonroutine situations. Reading and typing English language exchanges in free text, if required for datalink systems, will be a time-consuming and challenging linguistic task for non-native speakers. Moreover, datalink and voice interface systems might discourage active monitoring of other flight crews' and controllers' voice communication, which often provides additional information. The resulting atrophy of verbal skills may impede the ability of controllers and pilots to respond to verbal information, especially when they are communicating in non-native English.

Although technical solutions have their appeal, the solution for the moment should be training that will give every pilot and controller the skills to serve as his or her own "intelligent voice interface." Technical systems should be used for back-up and augmentation, and should replace voice communication only for routine ATC exchanges.

For air traffic controllers, international English performance requirements need to be more clearly defined, and then re-evaluated as new technology is introduced that will change the use of natural language for communication between pilots and controllers. Because international standards have not been

developed, countries presently train and certify controllers according to their own standards, so different kinds of programs produce varying results.

For example, Russia and China, two countries training large numbers of controllers in English, face development of their own national standards for training and proficiency certification. In some Latin American countries, standards exist but should be reviewed. Without international policy and guidance, however, there is nothing to direct that various national standards should be similar.

Despite the lack of an international standard, Russian aviation authorities are working to develop the necessary standardization, testing and training programs to improve and maintain the English skill levels of Russian controllers. The same process may be used by other countries to establish local and eventually regional standardization, and these standards could ultimately provide the basis for a unified international standard for controllers' general English skills.

One of the first questions that Russian authorities have had to address is how much English air traffic controllers need to know. Here the Cali accident is instructive, because the controller's technical language proficiency was not adequate to meet the requirements of his job, although he was apparently fully trained. A controller who knows 200 or 300 English ATC terms may have very little functional ability to communicate in English, and therefore the requirement for general language skills must be defined clearly.

Communication broke down most often when Russian controllers moved from strictly formatted exchanges to discuss weather, airport conditions and other topics that require skill in generating sentences.

Results of surveys of U.S. flight crews who fly in Russia indicated that communication broke down most often when Russian controllers moved from strictly formatted exchanges to discuss weather, airport conditions and other topics that require skill in generating sentences. Some Russian textbooks introduce ATC language to controllers with only the most rudimentary English skills, or none at all,[7] so it is not surprising that a Russian controller would know terminology in English but not have a wider command of the language.

As part of an initiative to measure Russian controller English proficiency and to design training to raise skill levels, Russian authorities have used standardized English testing to determine controllers' baseline scores. This process involves testing large numbers of controllers in different regions and observing controller performance to establish a minimum proficiency standard that can be applied to all controllers or selected groups of controllers based on job requirements.

This testing program, the first step toward development of a national standard, will enable the Russian authorities to identify weaknesses in training, select and prioritize personnel for training, measure the impact of training in terms of cost, and guarantee the capabilities of personnel to perform job duties using English.

This process will ensure that controllers can respond to a variety of nonroutine and emergency scenarios using English — for instance, to respond to questionable transmissions from the cockpit, to identify ambiguous situations and causes of ambiguity, and to provide the flight crews with appropriate instructions when these situations occur. In other words, job proficiency should provide a basis for the standard, and testing should be accomplished with respect to operational scenarios that a controller might encounter.

English courses that the Russian controllers attended in the past were primarily oriented toward development of conversational skills, because of the importance of speaking skills for job performance. Not surprisingly, Russian controller test scores have been higher for listening skills than reading skills.

Nevertheless, although speaking and listening skills might be used most by air traffic controllers, reading and writing skills must also be developed in training, even if to a lesser degree. For language learning, all these skills reinforce each other. Some controllers, for example, learn general and technical vocabularies best with visual reinforcement from reading and writing. To acquire general English proficiency as well as a knowledge of ATC applications, controllers must also acquire and use the full range of language skills.

Another language-training problem of special importance to Russia is attrition caused by lack of practice, which has its greatest influence on listening and speaking skills. Most people who have studied a foreign language are aware of how quickly skills are lost if not used regularly. For Russian controllers in particularly remote locations such as the Far East, the rarity of occasions to use English on the job may not be adequate to maintain their skills, and soon proficiency becomes reduced.

The English training program in these parts of Russia, like programs in other countries where English use is limited, will need to include mechanisms such as regular testing to identify skill attrition, with maintenance and refresher programs to counteract attrition. The value of costly training for controllers is lost when language skills atrophy and the training system does not respond by restoring proficiencies.

Examples from Russia show that the English problem is not easy to solve, but that the problem is solvable. Large-scale baseline testing is planned, as is the development of standards, training and testing to produce, measure, maintain and certify language skills. Such a comprehensive and systematic approach will provide the basis for a program that can be easily managed and evaluated for cost-effectiveness.

Even the best-managed English training will not eliminate inherent ambiguities in language, and such training will not compensate for poor discipline, fatigue and other problems in the workplace. But training will improve the ability of air traffic controllers to perform their jobs and greatly reduce the risk that controllers and pilots will communicate with, but not understand, one another.

Like the controllers and pilots who use English language for ATC communications, the aviation industry needs to be more aware of language issues so that it can design training systems to produce and maintain the necessary language skills.

This will ensure that English training will be provided to controllers as thoroughly and systematically as the other training that they receive, and that continued international use of English for pilot-controller communications will support, rather than undermine, the safety of flight.♦

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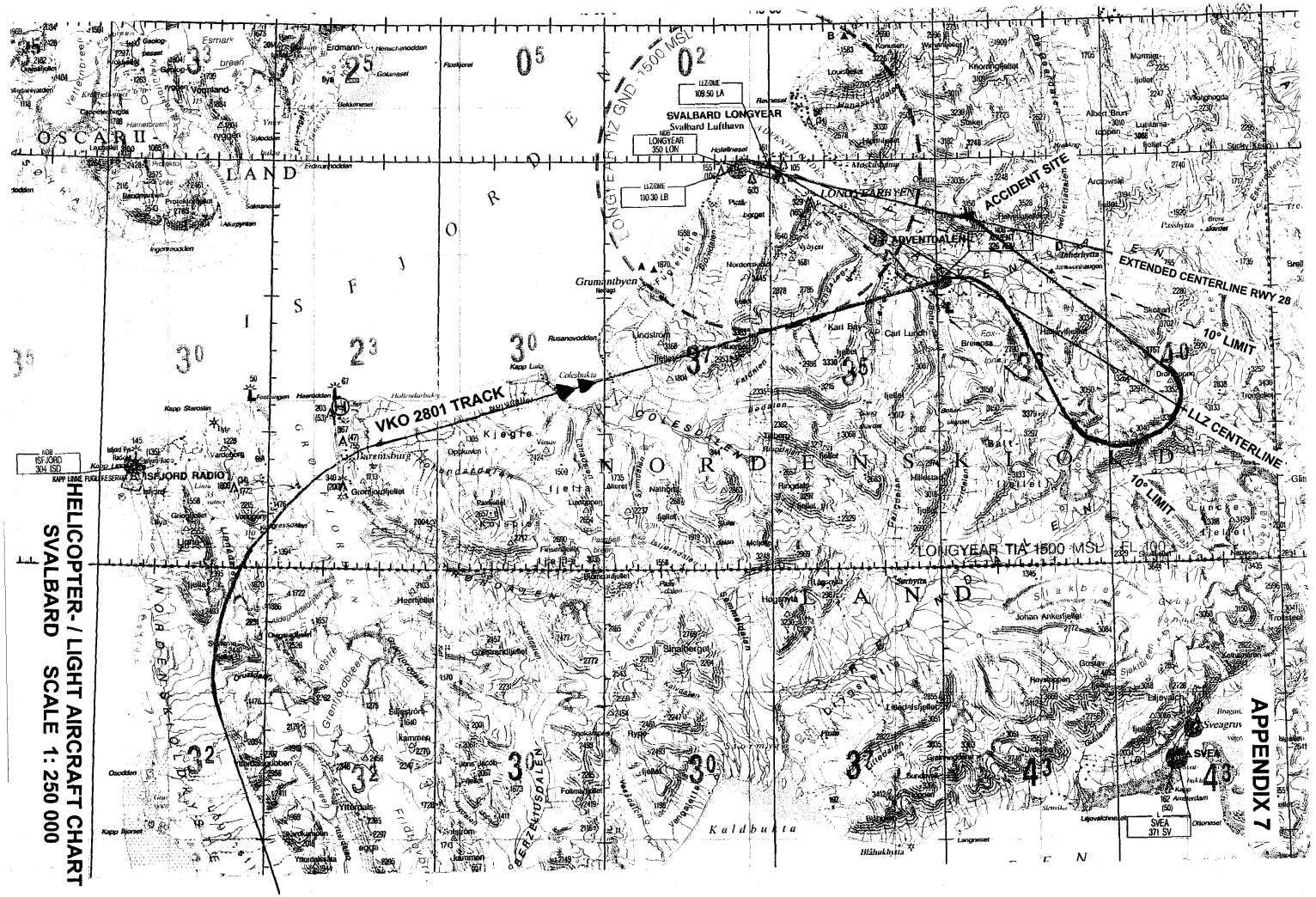
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About the Author

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LONGYEAR TIA 1500 MSL
FL 100
SVALBARD LONGYEAR
Svalbard Lufthavn
LONGYEARBYEN
ADVENTDALEN
ACCIDENT SITE
EXTENDED CENTERLINE RWY 28
10° LIMIT
LLZ CENTERLINE
VKO 2801 TRACK
ISFJORD RADIO
HELICOPTER- / LIGHT AIRCRAFT CHART
SVALBARD SCALE 1: 250 000
APPENDIX 7

APPENDIX 8

ABBEVIATIONS

AAIB/N	Aircraft Accident Investigation Board/ Norway
ACC	Area Control Centre
ADF	Automatic Direction Finding
ADV	Advent
AFCS	Automatic Flight Control System
AFIS	Aerodrome Flight Information Service
AIP	Aerodrome Information Publication
ASGAA	Allied Signal General Aviation Avionics
ATC	Air Traffic Control
ATCC	Air Traffic Control Centre
ATS	Air Traffic Service
AUTO	Automatic
BJO	Bjørnøya
BKN	Broken
CAT	Category
CDI	Course Deviation Indicator
COM	Communication
CVR	Cockpit Voice Recorder
DME	Distance Measuring Equipment
E	East
FDR	Flight Data Recorder
FIR	Flight Information Region
FIS	Flight Inspection Section
FM	Flight Manual
ft	feet
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
hPa	hecto Pascal
hrs	hours
HSI	Horizontal Situation Indicator
IAC	Interstate Aviation Committee
IAP	Instrument Approach Procedure
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
ISD	Isfjord
JAN	January
km	kilometer
kN	kilo Newton
kt	knot
LLZ	Localizer

LON	Longyear
LP	Low Pressure
MAN	Manual
MHz	Mega Hertz
N	North
NAV	Navigation
NCAA	Norwegian Civil Aviation Administration
NDB	Non-Directional Beacon
NM	Nautical Miles
NOSIG	No significant change
nT	nano Tessla
OBS	Omni Bearing Selector
OCA	Oceanic Control Area
PAPI	Precision Approach Path Indicator
PiC	Pilot-in-Command
Prob	Probability
QDM	Magnetic heading ('to the station')
QFE	Atmospheric pressure at airport elevation
QNH	Altimeter sub-scale setting to obtain elevation when on the ground
RAC	Rules of the air and air traffic services
RADZ	Rain and Drizzle
RESH	Recent Shower
RFCAA	Russian Federation Civil Aviation Administration
RMI	Radio Magnetic Indicator
SCT	Scattered
SHRA	Rain shower
STEP	Sequentially Timed Events Plotting
SV	Svea
TEMPO	Temporary
TIA	Traffic Information Area
TIZ	Traffic Information Zone
TU	Tupolev
UTC	Universal Time Coordinated
V	Volt
VHF	Very High Frequency
VDF	VHF Direction Finding
VKO	Vnukovo
VOR	VHF Omnidirectional Receiver
VRB	Variable

2.3.6.18 On the third and fourth segments, during which the crew started to follow the chart for approach to runway 28, the navigator was very busy dealing with the radio communication with the AFIS officer, in addition to making the necessary preparations and navigating the aircraft laterally. Within a period of three minutes, one and a half minutes of his time were occupied by listening to and answering the external radio communication (all in all 17 exchanges). In addition, the received information had to be evaluated and as it was in a foreign language, this required more time than usual. Due to the inadequate preparations for this approach, the navigator was forced to navigate in a desynchronized reasoning mental mode, resulting in his perceptions becoming fragmented and incomplete, as well as leading to a situation when he was 'mentally behind' the aircraft. Having to deal with the communication and controlling the aircraft complicated the situation and, as pointed out previously, gave him little opportunity to check his calculations and actions.

2.3.7 The fifth segment 08:19:06 hrs - 08:22:23 hrs (3 min 17 sec, completion of the turn to final - impact).

2.3.7.1 At 08:19:11 hrs on a heading of about 300°, the PiC gave the command to get out of the turn: 'Let's level out', and three seconds later: 'No (?it should be) to the right', indicating that he wanted a correction to the right. However, the FDR shows that the turn continued another 10° and the aircraft was rolled out on heading 290° immediately followed by a corrective turn to the right. This was obviously a reaction to the repeated orders from the PiC at 08:19:19 hrs: 'To the right' and one second later: 'Let's turn to the right'. These statements indicate that the navigator was controlling the lateral navigation of the aircraft by the Autopilot Turn knob once again. During these seconds, statements from the navigator also tell something about the situation. At 08:19:16 hrs, he told the crew that he expected the situation to clear up: 'Just we'll get it, just now'. However, still a little uncertain, he asked: 'Is the mark (marker) to the right?' to which the Co-pilot answered: 'No, it is still staying.' Most likely the mark (marker) mentioned belonged to the CDI on the HSI and was still staying at the full left deflection and therefore indicating correctly in relation to the LLZ centerline. On the other hand, if he meant the mark (marker) on the GPS, it should have been on the left, provided the GPS had been programmed with an inbound course of 283°.

2.3.7.2 Δ 15 An additional factor of significance at this point was that the crew was not familiar with the possibility of checking the ambiguous navigational information indicated on their instruments by the outside source available, namely the VDF service that would supply the magnetic course to the airport. This information was neither in the Jeppesen approach chart manual nor on the diskette supplying the navigational information for the GPS. The Jeppesen policy of not presenting secondary information and the general lack of confidence in the information in AIPs prevented the crew from being able to solve their confusion.

2.3.7.3 To the PiC's mind, the correct way to make a corrective turn was to the right at this point and the navigator turned the aircraft to, and maintained a heading of, 306°. Adding the wind drift, the aircraft track slowly increased the distance to the LLZ centerline.

2.3.7.4 At 08:19:21 hrs, the radio altimeter warning was again recorded by the CVR, indicating that the aircraft passed above the mountain Møysalen. Because the aircraft was still maintaining the safe altitude of 5 000 ft, this again was no cause for alarm to the crew.

2.3.7.5 Δ 11 It is a known fact that crews are subject to nuisance warnings when they know they are safe, and will tend to ignore the same warning when it is real. It has also been demonstrated that a crew in a stressed working situation might shut out even intense warning sounds completely.

2.3.7.6 As the radio altimeter warning signal started, the PiC, trying to solve the situation, asked for the approach chart from the co-pilot. Around this time, the crew could possibly see that the desired track of 283° appeared in the upper right-hand corner of the GPS display. This was reassuring enough for the two pilots to think about starting the descent. But at 08:19:51 hrs, the Navigator protested: 'But it's fourteen here.' The correction was accepted by the PiC and the aircraft continued at 5 000 ft. Eight seconds later the Navigator stated the rate of descent: 'Five meters', which the co-pilot was to establish when leaving 5 000 ft for the final approach.

2.3.7.7 At 08:20:03 hrs, the Navigator asked for approval to turn to 320°: 'So, I'll keep 320°, OK?'. The Co-pilot asked if that was enough: 'Isn't that too little?' and the Navigator stated the necessity of having to make a correction: 'It should be a corrective turn'. The PiC obviously disagreed in making a significant turn to the right and ordered: 'No! Turn to the left!' Six seconds later, he was supported by the co-pilot and, according to the FDR, the aircraft was turned to the left from heading 306° in accordance with the PiC's orders. Seven seconds later, the aircraft was rolled out of the turn on heading 291°. In the meantime, at 08:20:21 hrs, the Navigator most likely read the DME to be 13 NM and stated so: 'It's thirteen. Let's descend!' and, four seconds later, he said: 'Three degrees, five minutes. We're on the glide path.' The altitude parameter on the FDR readout confirms that the aircraft had started the final descent at this time.

2.3.7.8 On final approach, when the navigator wanted to make a significant correction to the right, while the two pilots agreed that the turn should be to the left, this disagreement again reveals something of the crew's lack of situational awareness. It is the opinion of the Boards that the indications of the two navigational aids - the HSI and the GPS - governed the situation since it is not very likely that the crew members took that much notice of the RMI needle pointing to LON. The GPS programmed with an approach course of 283° must have been the indication that governed the opinion of the navigator and made him ask for permission for the

substantial heading change to 320° just before the descent.

2.3.7.9 Δ 16 The GPS is not permitted as a primary approach aid and should not be utilized as one. It is understandable that the crews of the airline had built confidence in it due to its demonstrated accuracy. It is, however, quite hazardous to assume that a GPS displayed indication must be the correct one, unless it is confirmed by another source.

2.3.7.10 On the other hand, the position of the CDI on the HSI must have convinced the PiC and perhaps the co-pilot as well that they now were to the right of the centerline and the corrective turn should be to the left. The navigator obviously carried out the order, but a heading of 291° was barely enough to take care of the wind drift and certainly not enough to intercept the centerline of the LLZ. The aircraft therefore flew parallel to the centerline only.

2.3.7.11 Δ 17 The crew started descent in mountainous terrain without firm and positive control of the lateral navigation demonstrated by the disagreement within the crew whether to correct left or right. A crew might enter a state of mind in which they continue, expecting everything to fall into place soon, based on their previous flying experience. The crew members, being used to service high traffic-density airports, where missed approaches inevitably lead to delays and inconvenience, could partly explain this. However, the traffic situation at Svalbard Airport Longyear that day was certainly no reason not to abandon the approach. The descent continued.

2.3.7.12 Δ 18 When the Co-pilot at 08:20:29 hrs found it necessary to ask: 'We're on landing course now, correct?' it was another cause for alarm. This is quite disturbing since the aircraft was now descending in a mountainous area on an approach where keeping close to the approach centerline is an absolute safety requirement. The Boards, again, find it necessary to emphasize that, if there is the slightest uncertainty of the aircraft position under such circumstances, it is reason good enough to abandon the approach, climb to a safe altitude and then solve the problem.

2.3.7.13 Four seconds later, when the aircraft just had been rolled out on heading 291°, the PiC obviously saw the need to make a further correction to the left and ordered: 'To get to the landing course, make a slight correction to the left!' Again the HSI with the CDI to the left must have been the instrument telling him they were too far to the right. However, no such turn was made. The navigator continued heading 291°. About this time according to the reconstruction of the track flown the aircraft departed the 10° sector to the right of the LLZ centerline outside which the localizer is not to be used.

2.3.7.14 Δ 19 The aircraft departed the ±10° usable sector of the localizer, but the radiation from the antenna is still well above field strength minimum. There is a

warning about this limitation on the chart, but is not very well highlighted. The Boards consider that this limitation could be overlooked in a stressed situation. In this case, the CVR recorded the crew expressing their feeelings about an odd approach. We will never know if their resentment comprised the user limitation, but, due to the importance of this limitation, the Boards recommend that the appropriate authority assess the presentation and look for a solution that is more conspicuous.

2.3.7.15 At 08:21:00 hrs, we receive confirmation yet again that the navigator was controlling the aircraft laterally when the PiC said: 'You guide us, you guide us!' and the Navigator immediately acknowledged this by stating: 'We're flying by Jeppesen'. Two seconds later, the PiC wanted to check the position in relation to ADV and asked the navigator to select Advent for him. But the navigator did not obey him, probably because he had the distance to the airport on the DME as well as on the GPS and answered at first: 'Not now. Later on!' and secondly: 'I've told you, there is no need'. It is possible that the PiC could have had an indication of how far away the aircraft was tracking in relation to the ADV by watching how fast the RMI needle was moving, but it is more likely that he wanted to check how far they had come because the AFIS officer had asked for a new position report abeam Advent or at eight miles inbound.

2.3.7.16 Δ 20 Even though the selection of ADV instead of LON was not a crucial event, the Boards would point out that it is good airmanship to make full use of all the available approach aids. The other ADF receiver was available and the crew could have had both LON and ADV available at the same time. The testflying demonstrated that the RMI needles gave a good check of the centerline, needle no. 1 indicating the same bearing as needle no. 2, except close to the antenna. On the track flown by VKO 2801, the two ADFs set up like this would have given a clear indication of a track to the right of the centerline, which was also demonstrated during the test flight.

2.3.7.17 At 08:21:19 hrs, an Unidentified crew member (most likely the Navigator) said: 'To the right,' but the PiC expressed his concern by asking: 'What is our radial?' The Navigator then indicated that they were following the approach chart and stated: 'Let's follow the approach chart to the end!' The FDR information shows that a slight turn to the right was carried out and at 08:21:24 hrs, the aircraft was heading 300°.

2.3.7.18 Δ 18 The concern of the PiC is illustrated by the physiological-acoustic analysis of this phrase which shows that he experienced the highest increase in emotional stress found in the crew. (Of all the phrases that were analysed by the IAC.) A pronounced increase in the emotional stress was also found in the phrase uttered by the Unidentified crew member (the Navigator?) - 'To the right.' To the Boards it seems that the mental operative mode of the PiC and the navigator, as well as their stress levels, made it difficult for them to assess the situation they were in (including the level of danger) in an objective and

integrated way. They suffered a loss in their ability to think creatively. This might explain why they did not decide to abandon the approach.

2.3.7.19 The unrest in the crew at this stage of the approach is further indicated by the Unidentified crew member finding it necessary to ask: 'We will be landing, will we not?' and, four seconds later, by the Co-pilot saying: '300° so far! Is it OK?' and at 08:21:47 hrs by asking: 'How are we approaching? Is it correct or not?' (The 300° mentioned by both the PiC and the co-pilot corresponds well with the magnetic heading recorded by the FDR.)

2.3.7.20 Δ 18 The Boards again find it necessary to stress that a crew being uncertain of the accurate position on final approach, especially in mountainous terrain, must climb to a safe altitude according to the missed approach procedure before trying to solve a problem. The Boards also urge the airline to review its procedures for abandoning an approach, bearing in mind the ample danger signals presented in this accident.

2.3.7.21 Again, at 08:21:55 hrs, there was another order by an Unidentified crew member to correct to the right: 'To the right here', but the correction was not carried out. However, 10 seconds later, an Unidentified crew member ordered: 'To the left'. A few seconds later the magnetic heading started to change as the aircraft was turned from 300° to the final heading of 291°, which was maintained the last five seconds before impact.

2.3.7.22 At this stage of the flight, the aircraft was approaching the extended centerline of runway 28. With the assumption that the GPS was programmed with inbound course 283° as indicated by the circumstantial evidence, the reason to correct to the right was no longer present and the correction was reversed to a left turn. It is therefore the opinion of the Boards that the crew crosschecked with the GPS and saw the aircraft mark close enough to the centerline to start the intercept to the left and finally get established on course.

2.3.7.23 During the last 20 seconds or so of flight, the aircraft entered an area of turbulence judging by the changes in the co-pilot's and the autopilot's steering. The co-pilot responded to the jerking flying very actively and managed to keep the roll within 10° together with an uninterrupted increase in pitch angle from about -4° to about +4°, right up to impact at 08:23:23 hrs. Half a minute before impact the co-pilot asked for the landing gear and a voice, most likely the PiC, gave permission to extend the landing gear. This corresponds very well with the fact that the landing gears were in transit on impact.

2.3.7.24 As recorded by the FDR the GPWS was activated about 9 seconds before impact, probably because the aircraft was in mountainous terrain, closer than 400 m to the ground and with a closure rate to the terrain above 5 m/s. Because the intermittent sounding of the warning horn was not recorded by the CVR, the Boards conclude that the horn for some reason was unserviceable. However, because the FDR has

recorded an increase in pitch, an almost immediate movement of the three throttle control levers, an increase in the percentage of the LP rotor speed and the rate of fuel flow for all engines, the Boards conclude that the red light annunciator in front of each pilot was working. On impact, the engines were not yet working at full power, but then the throttle control levers were not yet fully forward according to the FDR registration of this parameter.

2.3.7.25 Six seconds before impact, the CVR recorded the radio altimeter warning again for the last time. The two pilots had at this time reset their altimeters to 70 m (co-pilot) and 260 m (PiC) which meant that the right radio altimeter triggered the warning. Even though the GPWS horn was not functioning, there was nevertheless an aural warning, which verified and reinforced the GPWS visual warning, clearly indicating that they were getting dangerously close to the underlying terrain.

2.3.7.26 Δ 11 It is the opinion of the Boards that a reaction to a GPWS should be as quick and decisive as the handling and performance of the particular aircraft type allows. When evaluating the performance of a crew, one must allow for at least a couple of seconds in reaction time. In this case, it was to the crew's disadvantage that the aural warning of the GPWS did not work. Expecting both a visual and an aural warning at the same time and only getting one of them, might have initiated an evaluation of the situation which could explain the somewhat slow throttle control lever movement and pull-up of the aircraft. When the crew three seconds later got an aural warning, it was not connected to the GPWS, but belonged to a warning system that had already been triggered five times, when the crew knew the aircraft was maintaining a safe altitude. This fact did not support a decision to act with urgency.

The fact that the bugs on the radio altimeters had been reset to 70 m and 260m respectively, altitudes expected to be reached some kilometers ahead, could also have had an influence. The Boards are of the opinion that the FSF ALAR Task Force's conclusion that proper use of the radio altimeter is an effective tool to prevent approach and landing accidents should be seriously considered, together with the procedures regarding the GPWS.

2.3.7.27 Evaluating the final seconds of flight and allowing for a couple of seconds reaction time, it is not likely that the crew, applying full power and maximum pitch-up, would have made the aircraft clear the mountain. The remaining seconds to impact would probably not have been enough time to change the aircraft flight path adequately.

2.3.8 Although unable to carry out a technical examination of the GPS, the Boards are of the opinion that circumstantial evidence points to the GPS most probably being reset with inbound course 283° in accordance with the imposed rule. Due to the demonstrated accuracy of the GPS system, the crew put too much emphasis on the GPS indications to the detriment of those on the HSI, and disregarded the RMI bearing to LON (which was correct on impact).

2.3.9 The Boards would point to the eight conclusions of the FSF ALAR Task Force, reproducing them here:

- No. 1: Establishing and adhering to adequate Standard Operating Procedures (SOPs) and flight-crew decision-making processes improved approach-and-landing safety.

- No. 2: Failure to recognize the need for and to execute a missed approach when appropriate is a major cause of Approach-and-Landing Accidents (ALAs).

- No. 3: Unstabilized and rushed approaches contribute to ALAs.

- No. 4: Improving communication and mutual understanding between air traffic control (ATC) services and flight crews of each other's operational environments will improve approach-and-landing safety.

- No. 5: The risk of ALAs is higher in operations conducted in low light and poor visibility, on wet or otherwise contaminated runways, and with the presence of optical or physiological illusions.

- No. 6: Using the radio altimeter (RA) as an effective tool will help prevent ALAs.

- No. 7: Collection and analysis of in-flight parameters (e.g. flight operational quality assurance [FOQA] programs) identify performance trends that can be used to improve approach-and-landing safety.

- No. 8: Global sharing of aviation information decreases the risk of ALAs.

The Boards find conclusions nos. 1, 2, 3, 4, and 6 to be particularly pertinent to this accident.

2.3.10 The crew of the Dornier 228 demonstrated the fact that the FMS gave flyable signals on the back beam of the ILS to runway 10 to the Boards. The same check made by the Flight Inspection Aircraft showed that that the FMS did not give reasonable steering information at all. As there are obvious differences between the aircraft types and the Dornier crew received useful steering information from their system, the Boards recommend that the NCAA review the policy, having all the ILS/ LLZ at an airport operational simultaneously.

2.3.11 Due to the fact that poor quality CVR recordings hamper investigations from time to time and emphasizing the flight safety importance of such recordings, the Boards are of the opinion that a procedure for checking the quality of CVR recordings at set intervals should be a requirement.

3 CONCLUSIONS

3.1 Introduction

To illustrate the most likely classification of human errors that had an influence on the chain of events leading to the accident, the taxonomy of James Reason, professor of psychology at the University of Manchester (England), has been used to mark the different findings: Lapse = L; Slip = S; Rule-based mistake = R; Knowledge-based mistake = K; and Unintended exceptional violation = V. A lapse is an error of omission, in which an item previously known is forgotten. Lapses are unintended and are often caused by inattention or inadequate association at the time the item was learned. A slip is an error of commission in which the action does not proceed as planned. Slips are unintended and often are caused by inattention at the time of action. A ruled-based mistake is an error of commission in accordance with a rule that is inappropriate for the situation. A knowledge-based mistake arises inter alia from incomplete or incorrect knowledge. It is an error of commission in which the action proceeds as planned, but the plan is inappropriate for the situation. An unintended exceptional violation is a singular violation occurring in a particular set of circumstances.

3.2 Findings

3.2.1 Aircraft

a. The aircraft was airworthy.

b. The FDR shows that the aircraft could have been operated normally by the crew during the approach to Svalbard Airport Longyear.

c. The aircraft's mass and the position of its center of gravity were within the permitted limits both at take off in Moscow and at the time of the accident.

d. The recording of the open microphones in the cockpit has a very unfavourable signal-to-noise ratio, making the deciphering of the intra cockpit conversation extremely difficult. Finally, 80 - 90% of the conversation was interpreted. The remaining 10 - 15% of the communication does not contain any conversations of any length, just short remarks.

e. The FDR parameters recorded were of satisfactory quality, except for channel no. 18, which recorded the position of the right elevator and channel no. 12, which recorded gyro-magnetic heading. This was caused by a functional error in the BR-40 element of the recording channel. The function of the compass systems was not affected.

f. The last radio altimeter warning signal recorded by the FDR started when the aircraft was about 530 m from the impact point and about 270 m above the terrain. The signal was triggered by the right radio altimeter. The other five warning signals were recorded when the aircraft was at safe altitudes less than 750 m above terrain details.

g. The GPS mounted on the central instrument panel, had been torn loose on impact and was observed lying by itself on the ground before the registration of parts started. Somebody removed it from the site and it has not since been returned to the AAIB/N.

h. The most probable frequency set on the two PUR SD-75 units was 109.5 MHz equal to the frequency of the localizer LA for approach to runway 28 at Svalbard Airport Longyear.

i. The mode selector Kurs MP-70 was in the ILS operation mode.

j. ADF no.1 was not in use during the approach. ADF no. 2 frequency selectors indicated 425 kHz, and 326 kHz Advent NDB. The toggle switch was in position 1, indicating that 425 kHz was in use. The damage to the frequency selector indicated that the figures could have changed during impact. Further examination made it possible to conclude that the RMI needles no. 2 were pointing to LON at the time of impact, which implies that the figures had changed from 350 kHz.

k. A copy of the GPS database installed in RA 85621 contained correct information concerning ENSB, Svalbard Airport Longyear and it stated 'No approach for this airport in the database.' The GPS installed in RA 85621 required that the operator typed ENSB and set the landing course in degrees to have a course line displayed in OBS mode.

l. There were enough satellites available to provide good cuts for the GPS receiver on board RA 85621. The satellite geometry was normal and the GPS data show nothing unusual for the period VKO 2801 flew the approach to Svalbard Airport Longyear. The tail did not obstruct any of the available satellites during the approach.

m. The two compass systems in gyro-magnetic mode indicated correct headings to the crew.

n. The crew did not receive erronous distance information.

o. The GPWS was activated about 9 seconds before impact. The warning horn was for some reason unserviceable, but the red light annunciators were working.

3.2.2 Ground-based navigational equipment

a. The reason for the ± 10° user-limitation on the LLZ 28 is less than the required signal strength at 25 NM. The radiation from the 6-element antenna is not limited. It radiates normally.

b. The NCAA's policy is to have all the navigational aids operational at all times to avoid delays when the situations demand their use.

c. A horizontal misplacement of the localizer signal of practical importance, due to atmospheric refraction, ground reflections or a combination of the two, is not likely.

d. The Eiscat radar at Svalbard was not in operation on 29 august 1996. The antenna was in stowed position with lock pins in place and the site was unmanned and securely closed. Interference with the LLZ 28 was therefore not possible.

e. The Dornier 228 crew demonstrated that the FMS on this aircraft gave reasonable steering information on the LLZ back beam to runway 28, frequency set at110.3 MHz.

f. The Dornier 228 crew who were recalled to participate in the search operation for VKO 2801 used the LLZ 28 to keep track of their position without registering any anomalies.

g. None of the flight inspections of the LLZ 28 have revealed any anomalies within the ± 10° sector authorized for use.

h. The checks and tests made on the approach navigational ground systems all showed normal results.

i. The test flight carried out with a TU-154M demonstrated that a similar aircraft to RA 85621 could fly the LLZ 28 approach to the Svalbard Airport Longyear accurately. No anomalies were detected within the ± 10° sector.

j. The test flight demonstrated that the VDF service gave an accurate check of the localizer centerline. The two ADFs onboard tuned to LON and ADV gave good backup indications of the localizer centerline, except when the test aircraft came fairly close to the antennas.

3.2.3 Flight conditions

a. The actual weather conditions satisfied the PiC minimum requirements to carry out the approach to Svalbard Airport Longyear.

b. The approach was carried out in IMC.

c. The magnetic field intensity recorded during the time VKO 2801 approached Svalbard Airport Longyear was characterized as disturbed. However, the variations were not of a magnitude considered to cause any significant disturbances to compass systems in gyro-magnetic mode.

3.2.4 The crew

a. The crew members were properly licensed. Working hours and rest periods prior to the accident were within the limits prescribed by regulations.

b. The post mortems carried out on the crew revealed no anomalies and no traces of chemical substances.

c. Landing on runway 10 was within the aircraft type performance limits.

d. The crew did not attempt to carry out a back beam approach to runway 28.

e. The navigator controlled the aircraft laterally by the Autopilot Turn knob most of the approach, while the co-pilot controlled the vertical navigation.

f. The demonstrated dynamics of the general psycho-emotional state of the crew was not enough to initate inferior performance by the crew members making them commit mistakes in their work.

g. The vertical navigation of the aircraft was carried out correctly except for the fact that the descent was made off the localizer centerline to the right.

h. There were no calls for checklists after 'Before descent' checklist. (L)

i. The crew did not check the identity of the tuned ground navigation aids. (S)

j. The radio altimeter warning signal was triggered five times when the flight was at a safe altitude. When the radio altimeter warning sounded for the sixth time, together with the visual warning of the GPWS, the crew probably became unsure as to whether the situation was urgent or not, leading to a somewhat slower than ideal reaction to the GPWS. However, the aircraft was at this time probably too close to the terrain for the crew to change the flight path sufficiently to avoid the mountain. (S)

k. The crew did not make full use of the ADFs onboard, tuning ADV and LON on separate receivers. (L)

3.2.5 The Airline

a. It is a standard operating procedure that crews from Vnukovo Airlines study

the different approach charts and have to fly these approaches in the simulator when preparing for flights to airports in mountainous terrain.

b. The Norwegian AIP was not available at Vnukovo Airlines, preventing the possibility of obtaining secondary information concerning Svalbard Airport Longyear. (K)

c. The airline relied upon the flight information furnished by Jeppesen & Co. GmbH and the GPS database from Allied Signal General Aviation Avionics/ Jeppesen Sanderson to contain all the necessary and required items in order to plan and carry out safe flights. (K)

d. The flight deck crew did not know of the possibility of checking their own navigation by the VDF service offered at Svalbard Airport Longyear. (K)

3.2.6 The Authorities

a. The AFIS officers at Svalbard Airport Longyear had never been requested by Russian crews not stationed at Svalbard to provide VDF service. (K)

b. The last VDF reading the AFIS officer got while communicating with VKO 2801 indicated that the flight had not yet reached the approach centerline.The CVR/ FDR information supports the observation of the AFIS officer.

c. The information on Svalbard Airport Longyear contained in the Norwegian AIP was correct.

d. Even though it is the responsibility of any airline or PiC to evaluate if the available approach aids at a destination are sufficient for a safe flight, taking into consideration the particular aircraft's equipment and performance, together with the flight crew's experience and expected weather conditions, radar service represents a valuable safety barrier for checking deviations from established tracks.

e. The phrase 'Approved,' uttered by the AFIS officer without adding the approving authority could possibly have given the crew of VKO 2801 an incorrect conception of his status.

3.2.7 Additional factors

a. To avoid congested approach charts, Jeppesen & Co. GmbH's policy is to reduce information considered to be of secondary importance.

b. A user-oriented questionnaire of the LLZ 28 approach at Svalbard Airport Longyear received full cooperation from 140 pilots representing 740 approaches, of which none had experienced any anomalies.

c. In an unprepared and stressed situation, the user limitation on the LLZ 28 could be overlooked.

d. The FSF ALAR Task Force's conclusions 1, 2, 3, 4, and 6, concerning Standard Operating Procedures and decision-making processes, discontinuing unstabilized and rushed approaches, communication between air traffic control and flight crews, and active use of the radio altimeter to avoid controlled flight into terrain were particularly pertinent to this accident.

3.2.8 Significant findings

a. There is no Russian procedure for offset localizer approaches modifying the required rule to set the landing course on the HSI. (R)

b. The course selected on both HSIs was 283° even though the approach course is 300°. This setting does not affect the indication of the CDI. However, the CDI was pointing to 283° on the dial, which is 17° to the left of the approach course, giving a visual impression of wind drift to the left and therefore giving a possible reason for a heading correction to the right. (R)

c. The navigator in a stressed and overloaded working situation most probably followed the rule setting the landing course 283° on the GPS in OBS mode instead of the approach course 300°. (R)

d. The crew was not fully aware of the status of an AFIS officer in comparison with the authority of a Russian air traffic controller with the result that the crew accepted safety information from the AFIS officer as orders. (K)

e. The crew had limited knowledge of the English language with the consequence that they had problems communicating their intentions to the AFIS officer. (K)

f. The navigator was overloaded with tasks leaving little time for rechecking his work, thereby setting the scene for making mistakes. (S)

g. The pilots did not monitor the work of the navigator sufficiently. (L)

h. Leaving the communication with AFIS to the navigator during the approach was not according to the normative documents. (K)

i. Due to the workload of the navigator, the decision of the co-pilot to transfer the responsibility of controlling the aircraft laterally to him, was inappropriate. (K)

j. The crew resource management of the PiC was not satisfactory. (K)

k. When the crew had made the decision to carry out the approach to runway 28, a new approach briefing was not accomplished. (V)

l. The crew made the proper correction for the wind drift, but did not try to intercept the outbound track from ADV with the consquence that they overshot the approach centerline turning inbound. (K)

m. Seemingly confusing indications on the HSIs in the base turn caused the crew to become uncertain of the aircraft position in relation to the LLZ 28 centerline. In this situation, the crew showed a lack of situational awareness. (K)

n. The two pilots did not have the approach chart in front of them at all times during the approach making it difficult for them to maintain situational awareness. (R)

o. The crew did not know of the possibility to check the position of the aircraft in relation to the localizer centerline by the VDF service available. (K)

p. On final approach the crew probably put too much emphasis on the indications displayed on the GPS. (K)

q. The crew started descent in a mountainous area without firm and positive control of the lateral navigation demonstrated by the disagreement within the crew as to whether to correct to the left or right. (V)

r. In spite of the uncertainty within the crew as to whether they were approaching correctly or not, they continued instead of abandoning the approach and climbing to a safe altitude to solve the problem. (V)

4 SAFETY RECOMMENDATIONS

4.1 Introduction

On 19 September 1996, the AAIB/N made a preliminary recommendation to the NCAA concerning the VDF service available at Svalbard Airport Longyear not being printed on Jeppesen approach charts. Further investigation has revealed that Jeppesen consider this service as secondary information, which is left out to resolve the flight safety problem of congested approach charts.

The Interstate Aviation Committee and the Norwegian Aircraft Accident Investigation Board recommend the following:

4.1.1 The RFCAA reassesses the rule of setting the landing course instead of the localizer course on the HSI for ILS/ LLZ approaches in relation to offset approaches. (Recommendation no. 21/99)

4.1.2 The RFCAA assesses the inclusion of a mandatory procedure in NPP GA-85 to request VDF bearings to check own navigation on approaches especially to airports in mountainous terrain (and then a revision of the Federal Aviation Regulations). (Recommendation no. 22/99)

4.1.3 The RFCAA reassesses the crew operation guidelines for TU-154s concerning the tasks ascribed to the navigator, starting with the descent from cruising level. (Recommendation no. 23/99)

4.1.4 The RFCAA assesses the necessity to check the quality of the CVR third channel (open microphone) on the fleet of TU-154s. (Recommendation no. 24/99)

4.1.5 The RFCAA assesses if the English language programme for air traffic controllers could be beneficial for air crews as well. (Recommendation no. 25/99)

4.1.6 Vnukovo Airlines Operations reassesses the present Crew Resource Management on approaches related to the norms in force and assesses if a CRM program could be beneficial to flight crews. (Recommendation no. 26/99)

4.1.7 Vnukovo Airlines Operations assesses the present policy of collecting flight safety information concerning foreign airspace and destination airports. (Recommendation no. 27/99)

4.1.8 Vnukovo Airlines Operations assesses the inclusion of situations with uncertain navigational indications, especially ILS/ LLZ indications, into air crew training to improve situational awareness. (Recommendation no. 28/99)

4.1.9 Vnukovo Airlines Operations assesses whether the present procedure of starting a turn with a linear lead should be extended to include interceptions to ensure that the flight crews regain the track if they overshoot. (Recommendation no. 29 /99)

4.1.10 The RFCAA, Tupolev Design Bureau and Vnukovo Airlines Operations reassesses the present procedure for the use of the radio altimeter to avoid nuisance warnings and to protect against controlled flight into terrain.
(Recommendation no. 30/99)

4.1.11 Vnukovo Airlines Operations assesses whether the pilots should have their own approach charts in front of them during approach to improve their situational awareness.
(Recommendation no. 31/99)

4.1.12 Vnukovo Airlines Operations assesses whether it is necessary to reinforce an instruction to the flight crews to discontinue an approach if any crew member becomes uncertain of the navigation, and climb to a safe altitude before attempting to solve the problem.
(Recommendation no. 32/99)

4.1.13 The NCAA assesses the current policy of giving priority to radar installations at airports in mountainous areas.
(Recommendation no. 33/99)

4.1.14 The NCAA reassesses the approach procedure to runway 28 at Svalbard Airport Longyear with respect to establishing the base turn and the holding pattern on the other side of the centerline.
(Recommendation no. 34/99)

4.1.15 The NCAA assesses whether there is a need for English language and phraseology recurrent training for AFIS officers.
(Recommendation no. 35/99)

4.1.16 The NCAA and Jeppesen & Co. GmbH assess whether the sectors authorized for use on the approaches to Svalbard Airport Longyear should be more conspicuous on the charts (ie. limiting bearings).
(Recommendation no. 36/99)

4.1.17 The NCAA assesses the current policy of having all ground-based navigational aids running at all times with reference to the fact that the FMS of the Dornier 228 gave reasonable steering information on the ILS back beam.
(Recommendation no. 37/99)

4.1.18 Although the Boards recognize the necessity of limiting the amount of information presented to flight crews on the approach charts, the Board recommends that Jeppesen & Co. GmbH evaluates their policy on secondary information and

considers whether this information may be presented differently than on the approach charts. (ref. SAS solution - separate briefing sheets.)
(Recommendation no. 38/99)

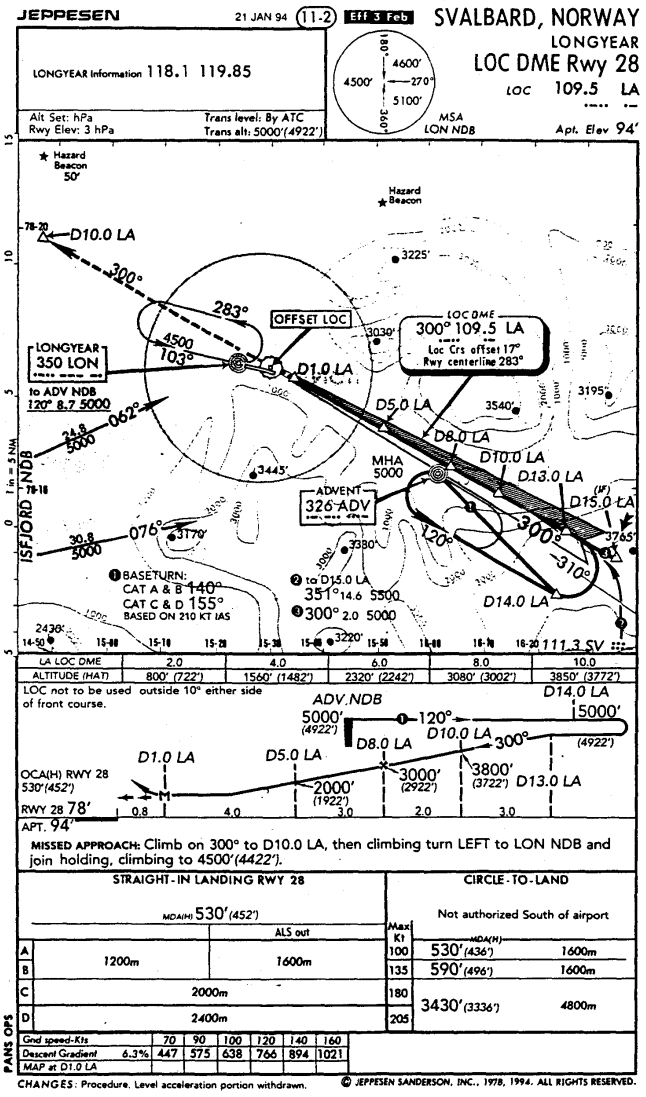
4.1.19 The RFCAA and NCAA assess a requirement to check the quality of CVR recordings at set intervals.
(Recommendation no. 39/99)

5 APPENDICES

1. Jeppesen approach chart Svalbard, Norway 11-2
2. Combined ATS recording and CVR readout interpretation
3. Sequentially Timed Events Plotting (STEP)
4. FDR readout
5. Contour map, with CVR statements depicted
6. FSF paper on English language training
7. Chart of Svalbard, Longyear area
8. Abbreviations

AIRCRAFT ACCIDENT INVESTIGATION BOARD, NORWAY (AAIB/N)

Kjeller, 2 November 1999



'NOT FOR NAVIGATIONAL USE'

REPRODUCED WITH PERMISSION OF JEPPESEN & CO. GmbH

Transcript of CVR Tu-154 No. 85621 and Longyear AFIS sound recordings 29th of August 1996.

CVR communication was recorded/presented originally from time 07:48:35. The revised transcript (From the Speech Technologies Centre (St. Petersburg)) started at time 07:59:12. These two times and all following times are now adjusted in relation to the exact UTC time the accident took place. This time, 08:22:23, was recorded by a seismographic station. The start of the CVR is therefore adjusted to 07:47:23, and the revised transcript starts at 07:58:00. The AFIS recordings were adjusted in a similar way. (Local time was + 2 hours from UTC.)

PiC = commander, Cop = second pilot (the pilot flying the aircraft), Nav = navigator; F/e = Flight engineer; U = unidentified crew member, AFIS = Aerodrome flight information service, Traff. = Other R/T traffic, ( ) = 'sounds like' and (ind.) = indistinct.

Bold letters indicate radio communication between the aircraft and AFIS.

07:47:23	U	So, the 'radar' is surrounded by mountains.
		Comment: There is no radar installed at ENSB. Probably ment localizer.
	Cop	Didn't you fly here at night?
	Cop	It's OK then. Everything is covered by clouds.
49:20	PiC	My first flight here was at night.
	Cop	At what time shall we land?
	PiC	Between 8.10 and 8.20.
	PiC	Wind (ind.) (?15 metres).
	PiC	(ind.) (?up to second outer)... ...(ind.).
49:58	U	Flaps 15? (ind.).
50:01	Cop	Let's extend the spoilers! (ind.).
50:04	U	Reduce the speed somehow (?which).

07:50:08	U	140.
50:31	Cop	But, during the summer what is the maximum temperature here?
	PiC	It's 30 degrees in summer here.
51:18	Cop	Well, that's OK then. Shall we descend?
51:30	PiC	But, you have not estimated the distance yet, have you?
	Nav	22! Just hold on!
	U	(ind.) up to 47.
51:50	PiC	Let's take a briefing before landing! Landing - at Spitzbergen, alternate - Murmansk. Left pilot flying, communications - from the right. Landing course - 103°. Missed approach: Straight, then climbing turn LEFT to (ind.). Landing approach to distance (16) to maintain until gaining the glide path. Estimated landing weight - 78 tons. Flaps - 45. Speed - 275.
52:49	Cop	I'll adjust the speed for you, while you carry out the approach.
	PiC	Pressure 751, check against the check list, report ready!
53:01	F/e	Understood. I'm, ready!
53:02	U	Everything is checked (ind.).
53:28	PiC	751. Ready! Check against Before descent check list.
	PiC	I have been acquainted.
	Cop	Request! It is time to descend.
54:12	Nav	**Bodø control estimate descent.**
54:25	Nav	**Bodø control, 2801 estimate descent.**
54:51	Nav	**Longyear information, Vnukovo 2801. Good morning.**
55:10	Nav	**Longyear information, VKO 2801. Good morning.**

07:55:17	AFIS	**Victor Kilo Oscar 2801 Longyear, could you change to frequency 119.85, 119.85, over.**
55:24	Nav	**119.85, thank you.**
55:31	Nav	**Longyear information, VKO 2801. Good morning.**
55:38	AFIS	**VKO 2801 Longyear information, go ahead.**
55:40	Nav	**2801 ETA ENSB 08.15. Estimated descent.**
55:54	AFIS	**VKO 2801, you are broken, readability is poor, say again.**
55:59	Nav	**Estimated descent from level 350 to level 60.**
56:08	AFIS	**VKO 2801, that is approved, we have no conflicting traffic, TL 65, QNH below is 1005.**
56:19	Nav	**2801, roger. Leaving level 350 for level 60. QNH 1005. Estimated approach runway 10.**
56:38	AFIS	**VKO 2801 Longyear roger. Are you making an approach via INDIA - - - INDIA-SIERRA-DELTA? over.**
56:44	Nav	**INDIA-INDIA-SIERRA-DELTA, 01.**
57:51	AFIS	**VKO 2801 Longyear roger, runway 28 in use. We have wind from 230/16. Weather is: We have visibility more than 10 kilometers in showers of rain, few at 1500 feet and scattered at 2000 and broken at 4000. Temp is 5, dewpoint 0, QNH 1005.**
57:26	Nav	**2801 roger, - - - Making a descent to level 60, QNH 1005. Reach altitude 4000 feet.**
57:43	AFIS	**VKO 2801 Longyear roger, give me a call when you are passing INDIA-SIERRA-DELTA.**
57:50	Nav	**I proceed to INDIA-SIERRA-DELTA, 2801.**
57:56	Cop	There is an altitude margin.
57:59	AFIS	**Call passing INDIA-SIERRA-DELTA, and also now change frequency to 118.1.**

07:58:04	Nav	**118.1, good day.**
58:15	Nav	**Longyear information 2801, continue down to 60, proceed to INDIA-SIERRA-DELTA.**
58:26	AFIS	**VKO 2801 Longyear roger.**
58:44	AFIS	**VKO 2801. Can I have your estimate for INDIA-SIERRA-DELTA?**
58:50	Nav	**Estimating INDIA-SIERRA-DELTA at five-niner.**
58:58	AFIS	**Thank you.**
59:01	U	(ind.).
59:13	AFIS	**VKO 2801 Longyear, roger.**
59:19	Nav	They're always having problems.
59:22	Cop	Passing over.
59:41	AFIS	**VKO 2801 Longyear, confirm you will make an approach for runway 28, via ALFA-DELTA-VICTOR?**
59:50	Nav	**For runway 28, 2801 understand you?**
59:58	Nav	**- - - to LIMA - ALFA?**
08:00:07	AFIS	**VKO 2801 Longyear, after passing ISFJORD, suggest you are heading for ALFA-DELTA-VICTOR at 5000 feet?**
00:17	Nav	**2801 Continue down to 4000 - - - 4500 feet, QNH 1005.**
00:29	Cop	And what's this they have here?
00:30	PiC	There is a mast here.
00:34	Cop	Mast.
00:36	U	(?It should stay).
00:40	U	There is some more traffic.
00:41	Cop	Here (somebody is flying) (such high hills!).

08:00:44	PiC	Keep the course.
00:48	Nav	(?So), Let's turn to the right!
00:52	U	(ind.).
00:55	Traff.	**Longyear, LMQ.**
	AFIS	**LMQ, Longyear.**
	Traff.	**Climb to 6 500 feet, est. Ny-Ålesund at 17.**
	AFIS	**OK, roger that -- contact Ny-Ålesund -- and -- so long.**
	Traff.	**So long!**
01:23	PiC	I've told you, that it should be (to the right - - - (ind.).
02:12	Cop	Is the 'radar' an unusual one?
		Comment: There is no radar installed at ENSB. Probably ment localizer.
02:14	U	No.
02:17	PiC	No, it's simply - - -.
02:40	U	Yeah, that's what I call an approach!
02:44	U	It is!
03:08	Traff.	**Longyear Information, CDS 156 passing abeam BRAVO 600 feet.**
	AFIS	**CDS 156, Longyear information, roger. Check traffic is Dornier, taking off Runway 28 this time for a right circuit for a landing at 28 again, for touch and go.**
	Traff.	**Roger, CDS 156.**
	AFIS	**Coast guard 21, airborne time 03, and did you check the traffic?**
04:02	Nav	(? We've) reached - - -

08:04:28	Nav	**Longyear information, VKO 2801 - - -.**
04:30	AFIS	**Aircraft calling Longyear, say again.**
04:40	Nav	**Longyear information 2801 request runway in use for landing to runway 1 --- 10.**
04:56	AFIS	**VKO 2801 Longyear, runway in use is 28.**
04:59	Nav	**Roger, 28.**
05:52	F/e	I understand the approach will be made in clouds. (Icing).
07:30	Traff.	**Climbing to 80, heading Vangbergøya.**
	AFIS	**Coast Guard 21, Longyear checked.**
07:40	Traff.	**CDS 156, on final (ind.).**
	AFIS	**CDS 156, Longyear (ind.) Runway free.**
	Traff.	**Yes.**
08:34	Traff.	**Longyear, LN-OPP.**
	AFIS	**LPP, Longyear.**
	Traff.	**LPP airborne at Isfjord at 06, 1 POB returning.**
09:03	Nav	We are 'diving' into the 'zone'!
09:11	Cop	We have taken in Advent.
09:13	Nav	Seven thousand? It should be earlier!
09:15	U	Go after the pike (Arrow head).
09:19	Nav	The pressure is 751 mm.
09:20	AFIS	**LPP, Longyear roger. I'll give you a weather report in a minute.**
09:20	PiC	5 minutes and we'll descend.
09:28	U	Six thousand and (?three hundred).

08:09:31	PiC	New altitude, we're maintaining 5 000.
09:37	PiC	Give me the approach chart!
09:45	PiC	The approach chart!
10:24	Cop	What about the speed?
10:28	Cop	Shall we extend the landing gears?
10:29	U	Landing gears.
10:32	PiC	Keep the course!
10:36	Cop	We have reached 1500 m.
10:49	Cop	We'll land by the standard procedure.
10:53	Nav	Standard.
11:06	U	Forty-three degrees.
11:13	U	(ind.).
12:08	U	Forty-three degrees.
12:12	AFIS	**LPP, Longyear, weather at Longyear, wind from 210/17, visibility to the west is about 6-7 km due to rain and - - - otherwise more than 10. We have few at 1 000 and broken at 2 000, temp. is 6, QNH 1006.**
12:40	Cop	What should I keep?
12:46	U	Meanwhile we should keep 500!
12:58	Cop	Switching on that one!
13:05	Traff.	**Coast guard 21, climbing for niner zero.**
	AFIS	**Coast guard 21, Longyear, say again.**
	Traff.	**We are climbing for niner zero.**
	AFIS	**Coast guard 21, Longyear roger.**
13:44	Nav	We will land by Jeppesen!

08:13:46		***Radio altimeter warning, duration 6 seconds.***
14:00	PiC	Check-list!
14:08	U	(? I'm reading - - -) (ind.).
14:13	U	We will go (to the holding area) by the course - - -.
14:54	AFIS	**VKO 2801 Longyear information, what is your position and altitude?**
14:58	Nav	**Maintaining 5000 feet, QNH 1006, approaching Lima-Alfa - - - inbound - - - outbound.**
15:11	AFIS	**VKO 2801 Longyear roger, give me a call passing ALFA-DELTA-VICTOR or Advent outbound.**
15:17	Nav	**I call you back over Lima Alfa, 2801.**
15:32	Nav	**2801 passing now over NDB Lima Alfa, altitude 5000 feet on 1006, turning right, heading 15-155.**
15:53	AFIS	**VKO 2801 Longyear, say again.**
15:57	Nav	**2801 Passing now NDB Lima-Alfa - altitude 5000 feet, turning right, heading 155.**
16:08	AFIS	**VKO 2801 roger, and give me a report passing ADV, or abeam ADV inbound.**
16:19	Nav	**01, call you back over inbound, abeam Alfa-Delta-Victor, 2801.**
16:30	AFIS	**Yeh, give me a call passing abeam ADV.**
16:33	Nav	**ALFA-DELTA-VICTOR.**
16:43	AFIS	**Call me passing abeam Advent beacon.**
16:50	Nav	150.
16:52	PiC	By parallel - - - (ind.).

08:16:55	Nav	No, seven miles here.
16:56	Nav	I'll adjust it.
17:05	Cop	Where are we - - -? - - - (ind.).
17:06	Nav	Meanwhile, keep it like that!
17:08	PiC	Did you notice the place?
17:09	Nav	Abeam the turning point.
17:14	PiC	A corrective turn will be (?necessary).
17:16	U	We're approaching.
17:21	PiC	Now we will be (?the flaps)... (ind.)
17:40	AFIS	**VKO 2801 give me a call eight miles inbound.**
17:43		***Radio altimeter warning, duration 6 seconds.***
17:44	Nav	**Call you back ten miles inbound, 2801.**
17:55	AFIS	**VKO 2801, give me a call eight miles inbound.**
17:57	F/e	Eight miles (In the English language).
17:57	Nav	**Ah - abeam eight miles 2801 inbound - - -.**
17:59	AFIS	**Correct.**
18:05	U	Four marks (ind.).
18:08	PiC	But here it's already three.
18:14	U	There's no need to - - - here!
18:16		***Radio altimeter warning, duration 2 seconds.***
18:17	U	- - - to descend.
18:19	Cop	The flag disappeared on my instrument!
18:21		***Radio altimeter warning, duration 6 seconds.***

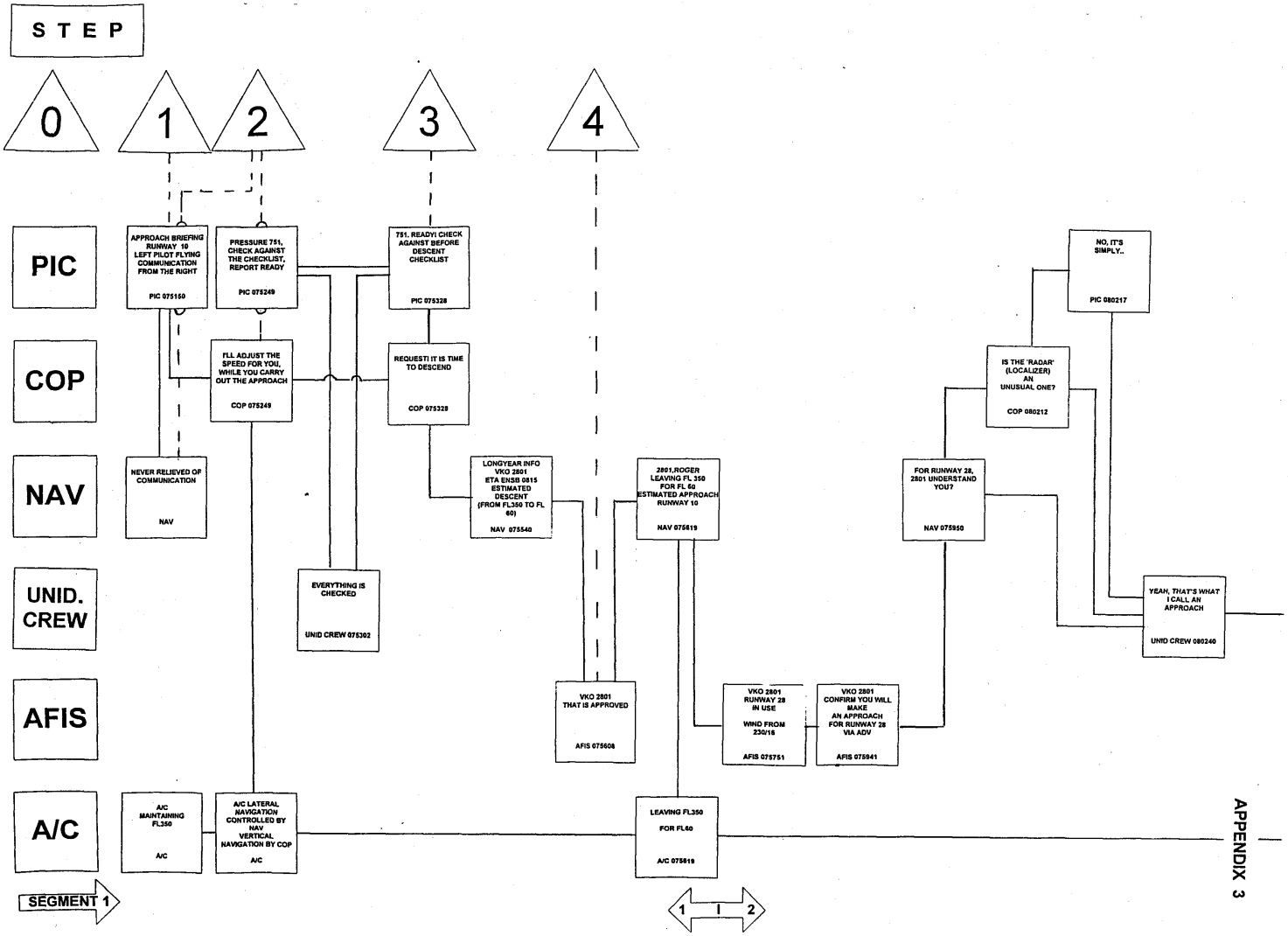
08:18:25	AFIS	**LPP, Longyear roger, we have a traffic inbound Tupolev, suppose he will be passing 8 miles east in a few minutes.**
18:28	PiC	I'm turning just a little bit to the left.
18:32	Cop	Set it straight.
18:37	PiC	15.
18:39	PiC	Borya, have we got it?
18:41	Traff.	**LPP, roger.**
18:45	U	Set it!
18:47	U	How many?
18:50	U	(?Switching off) (?Switching on).
18:51	U	Switched off.
18:52	PiC	What should I hold?
18:59	PiC	OK, leave it!
19:03	U	So, what might the recommendations be?
19:04	PiC	So.
19:06	Cop	Maybe we took the fourth (final turn) too early?
19:11	PiC	Let's level out!
19:14	PiC	No, (?it should be) to the right.
19:16	Nav	Just we'll get it, just now!
19:18	Nav	Is the mark (marker?) to the right?
19:19	Cop	No, it is still staying.
19:19	PiC	To the right!
19:20	PiC	Let's turn to the right
19:21		***Radio altimeter warning, duration 6 seconds***

08:19:21	PiC	Give me the approach chart Borya.
19:22	Cop	Should we descend here?
19:24	PiC	We shall descend!
19:30	Cop	Should we approach?
19:32	PiC	Let's 'dive'!
19:34	PiC	What (?course) did you keep (?now), (?what did you keep?).
19:36	Nav	Three hundred degrees.
19:36	Traff.	**LPP, now crossed centerline and we will stay east of shoreline.**
	AFIS	**PP, Longyear, say again.**
	Traff.	**We have crossed center line and will stay north and east of shoreline, landing on the apron.**
19:51	Nav	But it's fourteen here!
19:52	PiC	OK.
19:54	AFIS	**LPP, sorry about that. Did not copy, could you say again?**
19:54	PiC	So, fix it!
19:59	Nav	Five metres.
20:03	Traff.	**LPP, be landing on the apron.**
20:03	Nav	So, I'll keep about 320°! OK?
20:04	AFIS	**LPP, Longyear, roger. Wind is 230/17 and give me a call passing extended centerline.**
20:14	Traff.	**LPP, will call you right downwind out of the apron.**
20:14	Cop	Isn't that too little?
20:15	Nav	It should be a corrective turn.
20:16	AFIS	**PP, Longyear roger, thank you.**

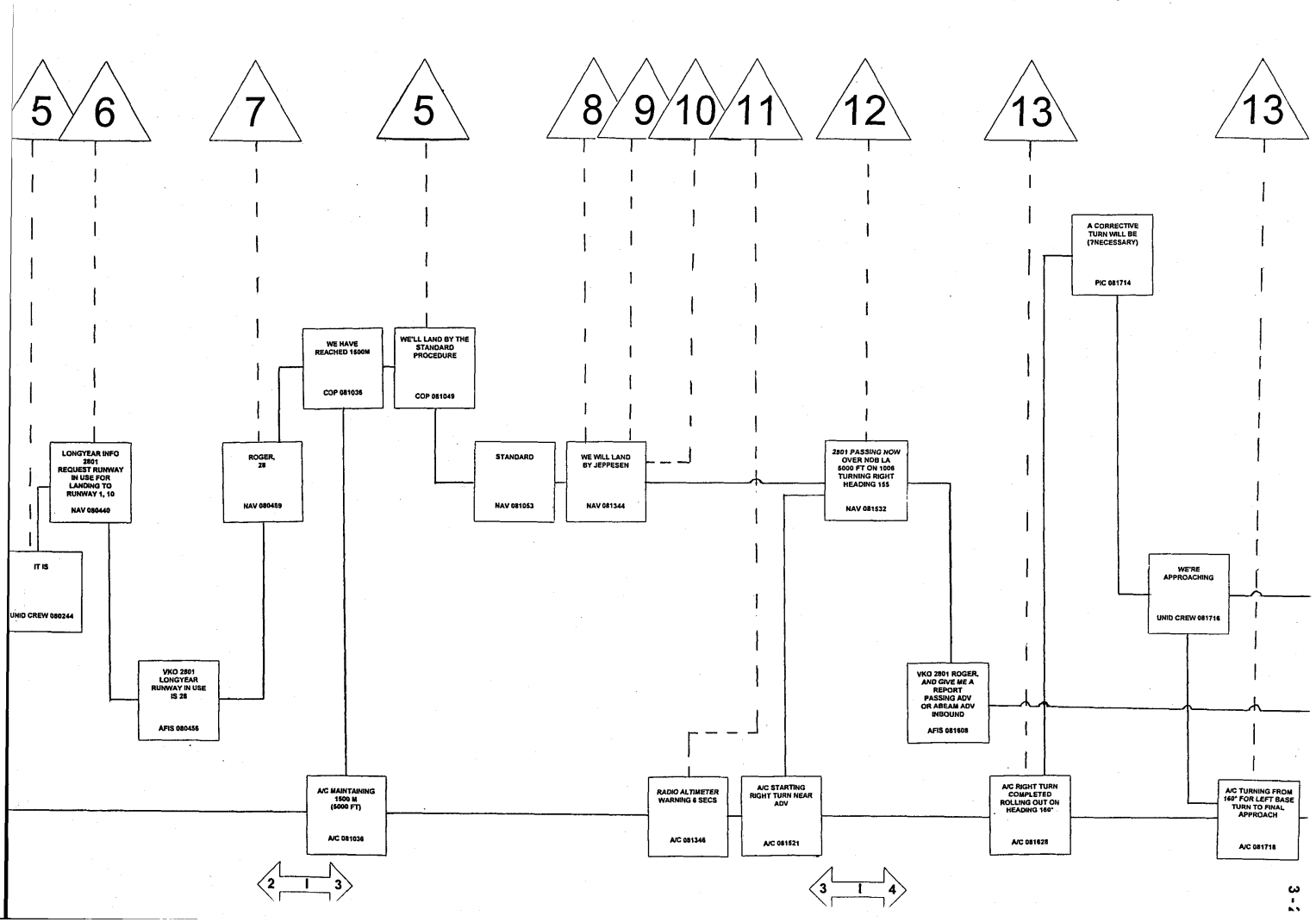
08:20:17	PiC	No! Turn to the left!
20:21	Nav	It's thirteen. Let's descend!
20:24	Cop	To the left!
20:24	Nav	Three degrees and five minutes. We're on the glide path.
20:29	Cop	We're on landing course now, correct?
20:33	PiC	To get the landing course, make a slight correction to the left!
20:41	Nav	Three hundred and thirteen. Let's descend!
20:44	Cop	What about the flaps?
20:52	Cop	28?
20:57	U	(?Keep)... (ind.) 5 metres.
20:58	Nav	(ind.) 2 - 3 miles.
21:00	PiC	You guide us, you guide us!
21:00	Nav	We're flying by Jeppesen
21:02	Nav	(ind.).
21:02	PiC	Igor, set Advent for me.
21:05	U	(ind.).
21:08	Nav	Not now. Later on!
21:09	U	Well, (? now) it's three hundred - - - meters (just now)
21:14	U	No
21:15	Nav	I've told you there is no need.
21:19	U	To the right.
21:22	PiC	What is our radial?
21:24	Nav	Let's follow the approach chart to the end!

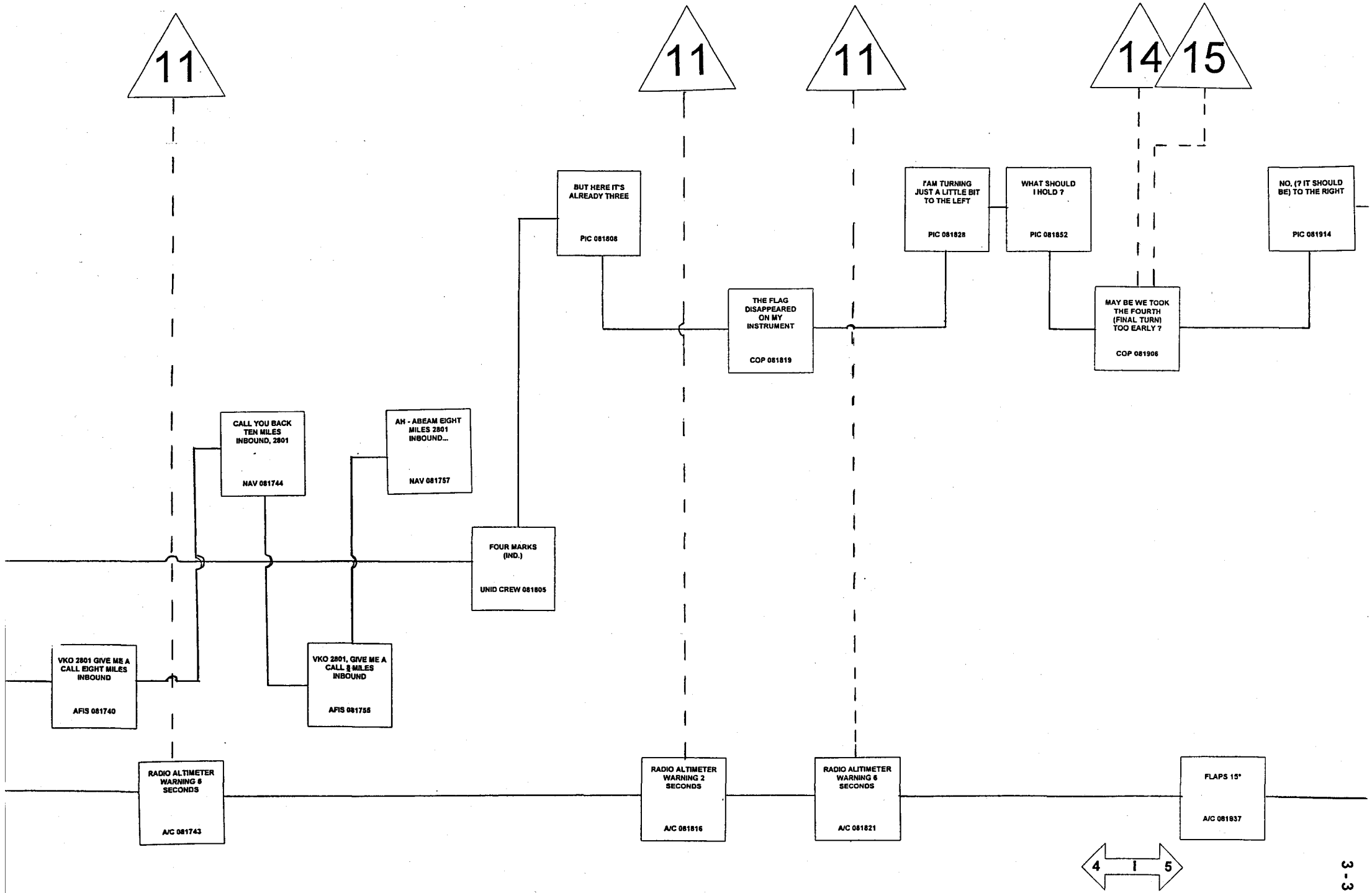
08:21:25	Traff.	**LPP, landed 21.**
21:29	U	So, - - - (ind.).
21:31	U	We will be landing, will we not?
21:32	PiC	Well, that is OK.
21:33	PiC	300°
21:35	Cop	300° so far! Is it OK?
21:36	Nav	Flying through 1150. It's too high, we have to descend.
21:41	PiC	We have to descend.
21:43	PiC	So.
21:47	Cop	How are we approaching? Is it correct or not?
21:49	Cop	Landing gears?
21:51	U	The landing gears may be extended.
21:55	U	To the right here.
22:05	U	To the left.
22:07	Cop	So. How are we going for altitude?
22:09	Nav	Three hundred, five metres. Descending!
22:13	Cop	That's about five metres, is it not?
22:17		***Radio altimeter warning, duration 6 seconds.***
22:22	PiC	Horizon!
22:23	Cop	Mountains!!!
22:23		***Sound effect of impact with ground against background of radio altimeter warning signal.***

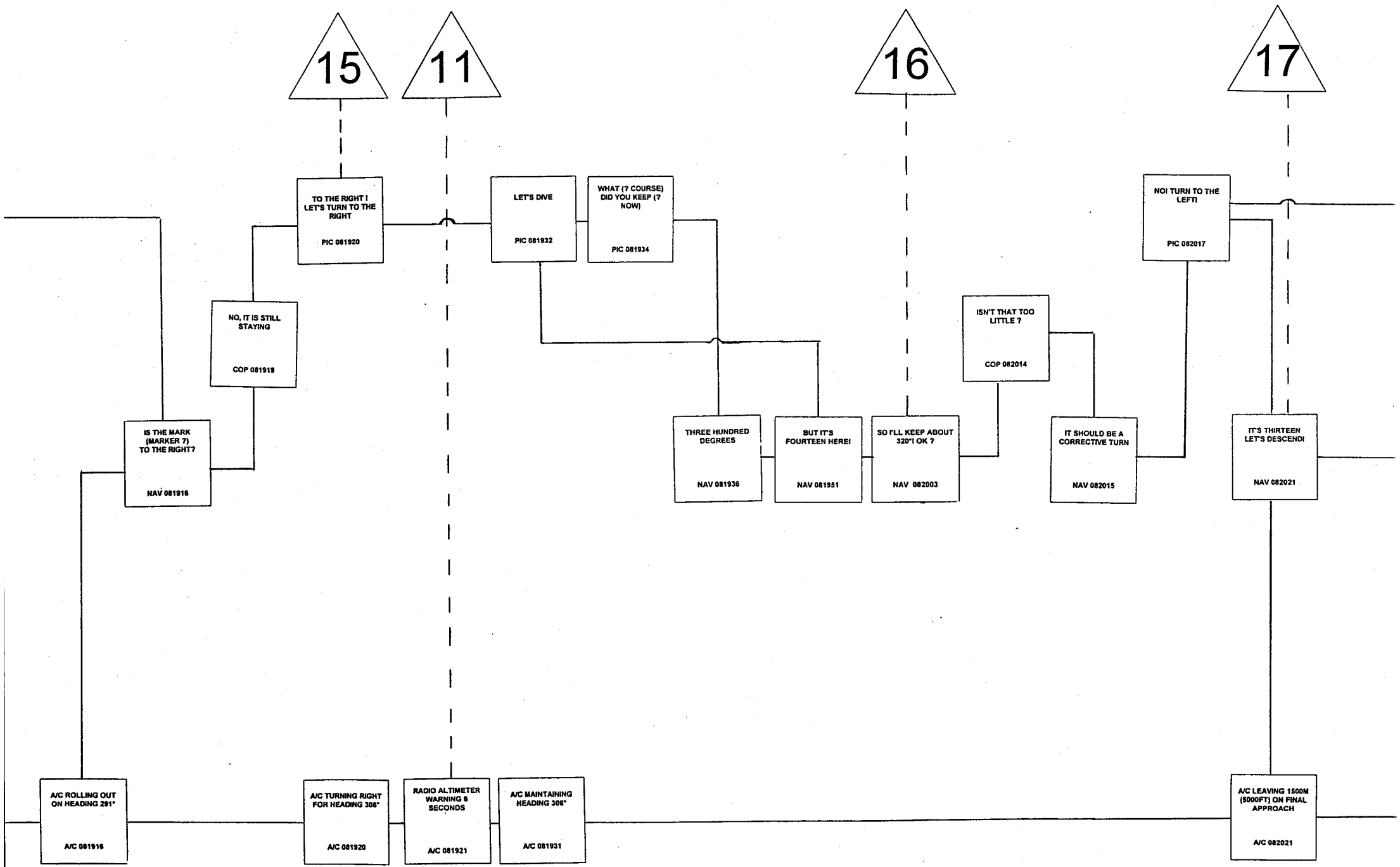
08:22:25	AFIS	**VKO 2801, weather is wind from 231/17, visibility still more than 10 in rain, we have few at 900 feet and broken at 2000.**
22:58	AFIS	**VKO 2801 did you copy latest weather?**

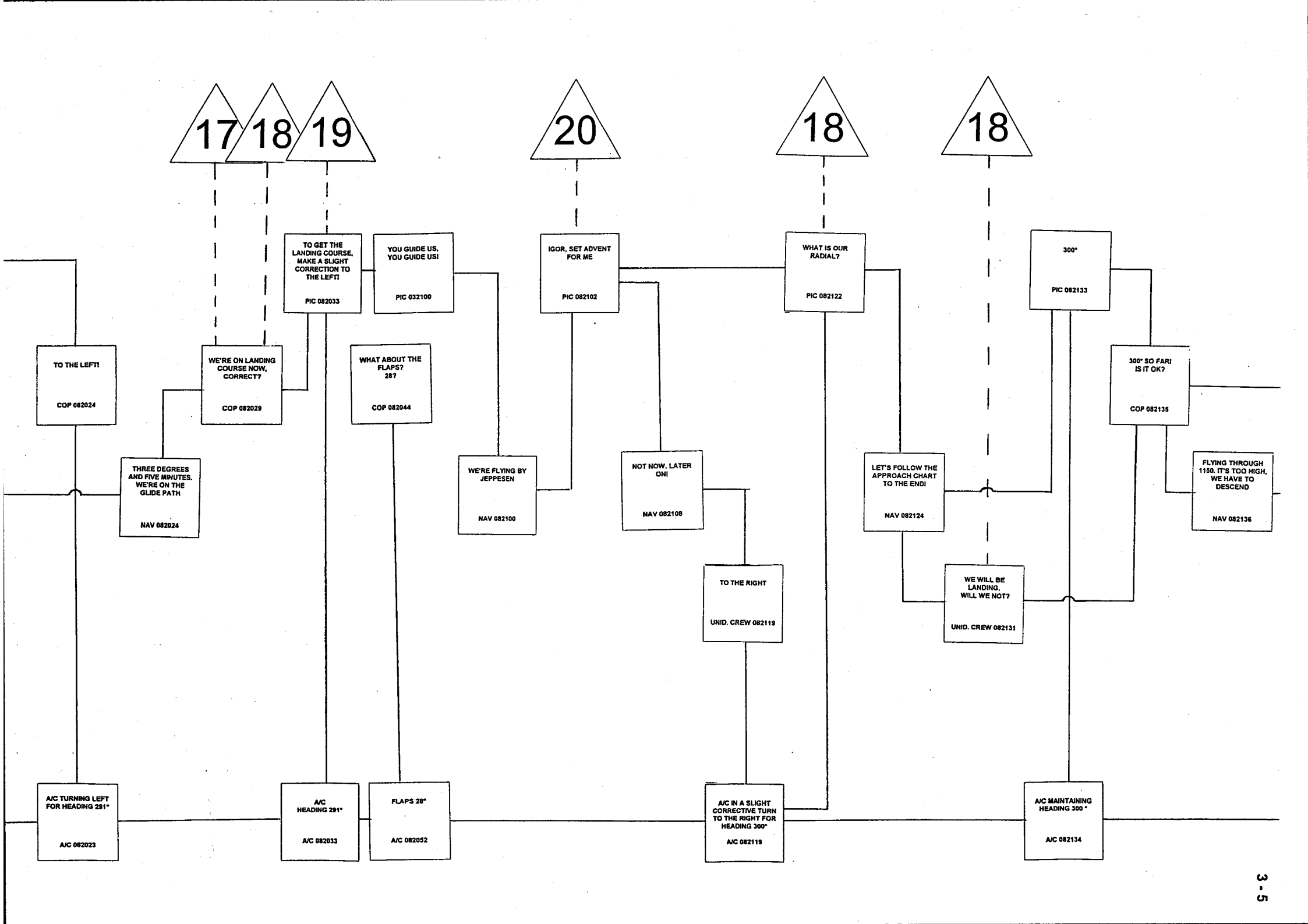

STEP
0
1
2
3
4
PIC
COP
NAV
UNID. CREW
AFIS
A/C
APPROACH BRIEFING RUNWAY 10 LEFT PILOT FLYING COMMUNICATION FROM THE RIGHT
PIC 075150
PRESSURE 751, CHECK AGAINST THE CHECKLIST, REPORT READY
PIC 075249
751, READY! CHECK AGAINST BEFORE DESCENT CHECKLIST
PIC 075328
NO, IT'S SIMPLY..
PIC 080217
I'LL ADJUST THE SPEED FOR YOU, WHILE YOU CARRY OUT THE APPROACH
COP 075249
REQUEST! IT IS TIME TO DESCEND
COP 075328
IS THE 'RADAR' (LOCALIZER) AN UNUSUAL ONE?
COP 080212
NEVER RELIEVED OF COMMUNICATION
NAV
LONGYEAR INFO VKO 2801 ETA ENSB 0815 ESTIMATED DESCENT (FROM FL350 TO FL 60)
NAV 075540
2801,ROGER LEAVING FL 350 FOR FL 60 ESTIMATED APPROACH RUNWAY 10
NAV 075619
FOR RUNWAY 28, 2801 UNDERSTAND YOU?
NAV 075950
EVERYTHING IS CHECKED
UNID CREW 075302
YEAH, THAT'S WHAT I CALL AN APPROACH
UNID CREW 080240
VKO 2801 THAT IS APPROVED
AFIS 075608
VKO 2801 RUNWAY 28 IN USE
WIND FROM 230/18
AFIS 075751
VKO 2801 CONFIRM YOU WILL MAKE AN APPROACH FOR RUNWAY 28 VIA ADV
AFIS 075941
A/C MAINTAINING FL350
A/C
A/C LATERAL NAVIGATION CONTROLLED BY NAV VERTICAL NAVIGATION BY COP
A/C
LEAVING FL350 FOR FL60
A/C 075619
SEGMENT 1
1
2

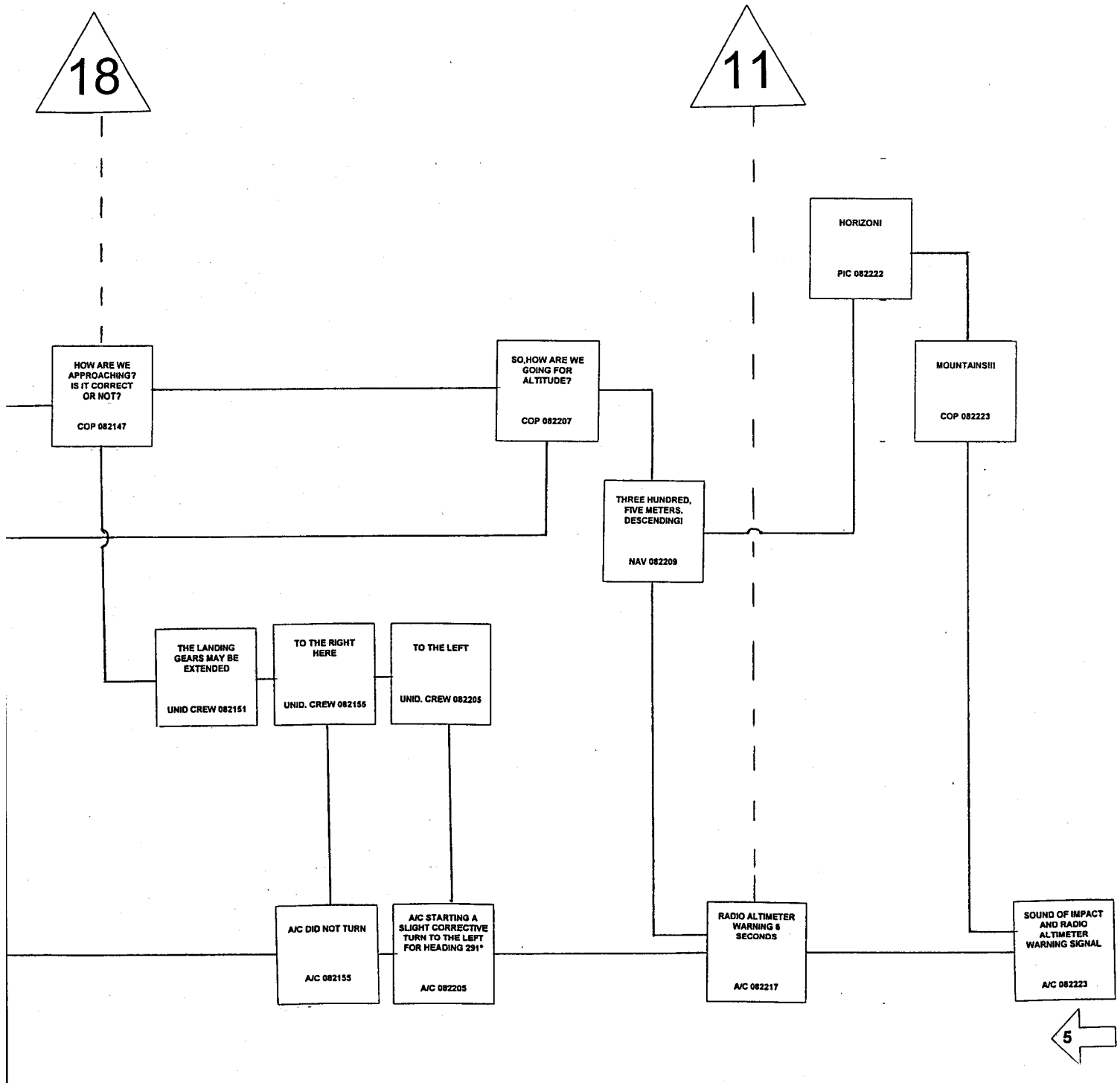
APPENDIX 3


5
6
7
5
8
9
10
11
12
13
13
A CORRECTIVE TURN WILL BE (?NECESSARY)
PIC 081714
WE HAVE REACHED 1500M
COP 081036
WE'LL LAND BY THE STANDARD PROCEDURE
COP 081049
LONGYEAR INFO 2801 REQUEST RUNWAY IN USE FOR LANDING TO RUNWAY 1, 10
NAV 080440
ROGER, 28
NAV 080459
STANDARD
NAV 081053
WE WILL LAND BY JEPPESEN
NAV 081344
2801 PASSING NOW OVER NDB LA 5000 FT ON 1006 TURNING RIGHT HEADING 155
NAV 081532
WE'RE APPROACHING
UNID CREW 081716
IT IS
UNID CREW 080244
VKO 2801 LONGYEAR RUNWAY IN USE IS 28
AFIS 080456
VKO 2801 ROGER, AND GIVE ME A REPORT PASSING ADV OR ABEAM ADV INBOUND
AFIS 081608
A/C MAINTAINING 1500 M (5000 FT)
A/C 081036
RADIO ALTIMETER WARNING 8 SECS
A/C 081346
A/C STARTING RIGHT TURN NEAR ADV
A/C 081521
A/C RIGHT TURN COMPLETED ROLLING OUT ON HEADING 180°
A/C 081628
A/C TURNING FROM 140° FOR LEFT BASE TURN TO FINAL APPROACH
A/C 081718
2
1
3
3
1
4


11
11
11
14
15
BUT HERE IT'S ALREADY THREE
PIC 081808
I'AM TURNING JUST A LITTLE BIT TO THE LEFT
PIC 081828
WHAT SHOULD I HOLD ?
PIC 081852
NO, (? IT SHOULD BE) TO THE RIGHT
PIC 081914
THE FLAG DISAPPEARED ON MY INSTRUMENT
COP 081819
MAY BE WE TOOK THE FOURTH (FINAL TURN) TOO EARLY ?
COP 081906
CALL YOU BACK TEN MILES INBOUND, 2801
NAV 081744
AH - ABEAM EIGHT MILES 2801 INBOUND...
NAV 081757
FOUR MARKS (IND.)
UNID CREW 081805
VKO 2801 GIVE ME A CALL EIGHT MILES INBOUND
AFIS 081740
VKO 2801, GIVE ME A CALL 8 MILES INBOUND
AFIS 081755
RADIO ALTIMETER WARNING 6 SECONDS
A/C 081743
RADIO ALTIMETER WARNING 2 SECONDS
A/C 081816
RADIO ALITIMETER WARNING 6 SECONDS
A/C 081821
FLAPS 15°
A/C 081937
4
5


15
11
16
17
TO THE RIGHT ! LET'S TURN TO THE RIGHT
PIC 081920
LET'S DIVE
PIC 081932
WHAT (? COURSE) DID YOU KEEP (? NOW)
PIC 081934
NO! TURN TO THE LEFT!
PIC 082017
NO, IT IS STILL STAYING
COP 081919
ISN'T THAT TOO LITTLE ?
COP 082014
IS THE MARK (MARKER ?) TO THE RIGHT?
NAV 081918
THREE HUNDRED DEGREES
NAV 081936
BUT IT'S FOURTEEN HERE!
NAV 081951
SO I'LL KEEP ABOUT 320°! OK ?
NAV 082003
IT SHOULD BE A CORRECTIVE TURN
NAV 082015
IT'S THIRTEEN LET'S DESCEND!
NAV 082021
A/C ROLLING OUT ON HEADING 291°
A/C 081916
A/C TURNING RIGHT FOR HEADING 306°
A/C 081920
RADIO ALTIMETER WARNING 6 SECONDS
A/C 081921
A/C MAINTAINING HEADING 306°
A/C 081931
A/C LEAVING 1500M (5000FT) ON FINAL APPROACH
A/C 082021


17
18
19
20
18
18
TO THE LEFT!
COP 082024
WE'RE ON LANDING COURSE NOW, CORRECT?
COP 082029
TO GET THE LANDING COURSE, MAKE A SLIGHT CORRECTION TO THE LEFT!
PIC 082033
YOU GUIDE US, YOU GUIDE US!
PIC 032100
WHAT ABOUT THE FLAPS? 28?
COP 082044
IGOR, SET ADVENT FOR ME
PIC 082102
WHAT IS OUR RADIAL?
PIC 082122
300°
PIC 082133
300° SO FAR! IS IT OK?
COP 082135
THREE DEGREES AND FIVE MINUTES. WE'RE ON THE GLIDE PATH
NAV 082024
WE'RE FLYING BY JEPPESEN
NAV 082100
NOT NOW. LATER ON!
NAV 082108
LET'S FOLLOW THE APPROACH CHART TO THE END!
NAV 082124
FLYING THROUGH 1150, IT'S TOO HIGH, WE HAVE TO DESCEND
NAV 082136
TO THE RIGHT
UNID. CREW 082119
WE WILL BE LANDING, WILL WE NOT?
UNID. CREW 082131
A/C TURNING LEFT FOR HEADING 291°
A/C 082023
A/C HEADING 291°
A/C 082033
FLAPS 28°
A/C 082052
A/C IN A SLIGHT CORRECTIVE TURN TO THE RIGHT FOR HEADING 300°
A/C 082119
A/C MAINTAINING HEADING 300 °
A/C 082134


18
11
HORIZONI
PIC 082222
HOW ARE WE APPROACHING? IS IT CORRECT OR NOT?
COP 082147
SO,HOW ARE WE GOING FOR ALTITUDE?
COP 082207
MOUNTAINS!!!
COP 082223
THREE HUNDRED, FIVE METERS. DESCENDING!
NAV 082209
THE LANDING GEARS MAY BE EXTENDED
UNID CREW 082151
TO THE RIGHT HERE
UNID. CREW 082155
TO THE LEFT
UNID. CREW 082205
A/C DID NOT TURN
A/C 082155
A/C STARTING A SLIGHT CORRECTIVE TURN TO THE LEFT FOR HEADING 291°
A/C 082205
RADIO ALTIMETER WARNING 6 SECONDS
A/C 082217
SOUND OF IMPACT AND RADIO ALTIMETER WARNING SIGNAL
A/C 082223
5

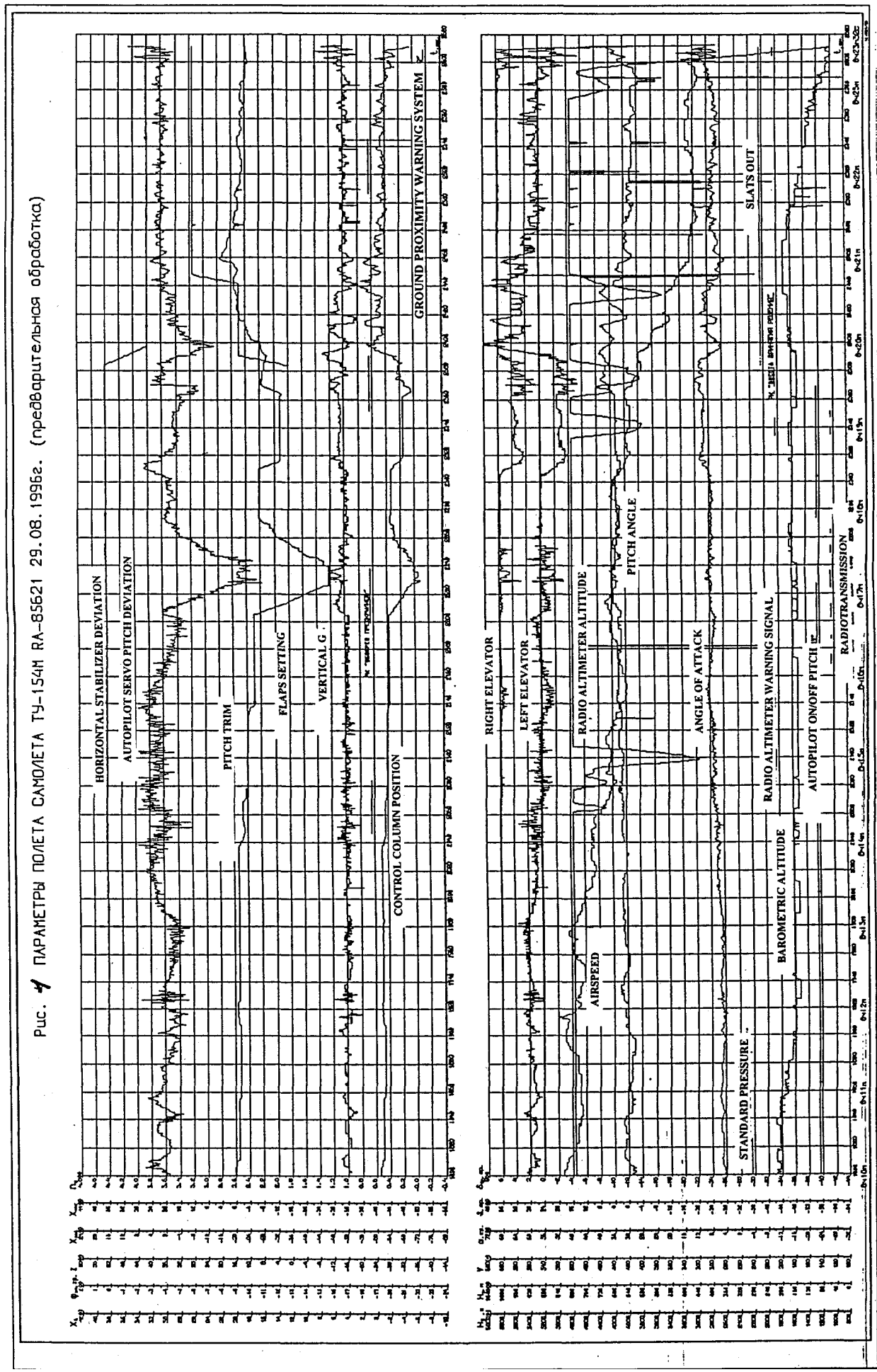


Рис. 4 ПАРАМЕТРЫ ПОЛЕТА САМОЛЕТА ТУ-154М RA-85621 29.08.1996г. (предварительная обработка)

Рис. 2 ПАРАМЕТРЫ ПОЛЕТА САМОЛЕТА ТУ-154М RA-85621 29.08.1996г. (предварительная обработка)

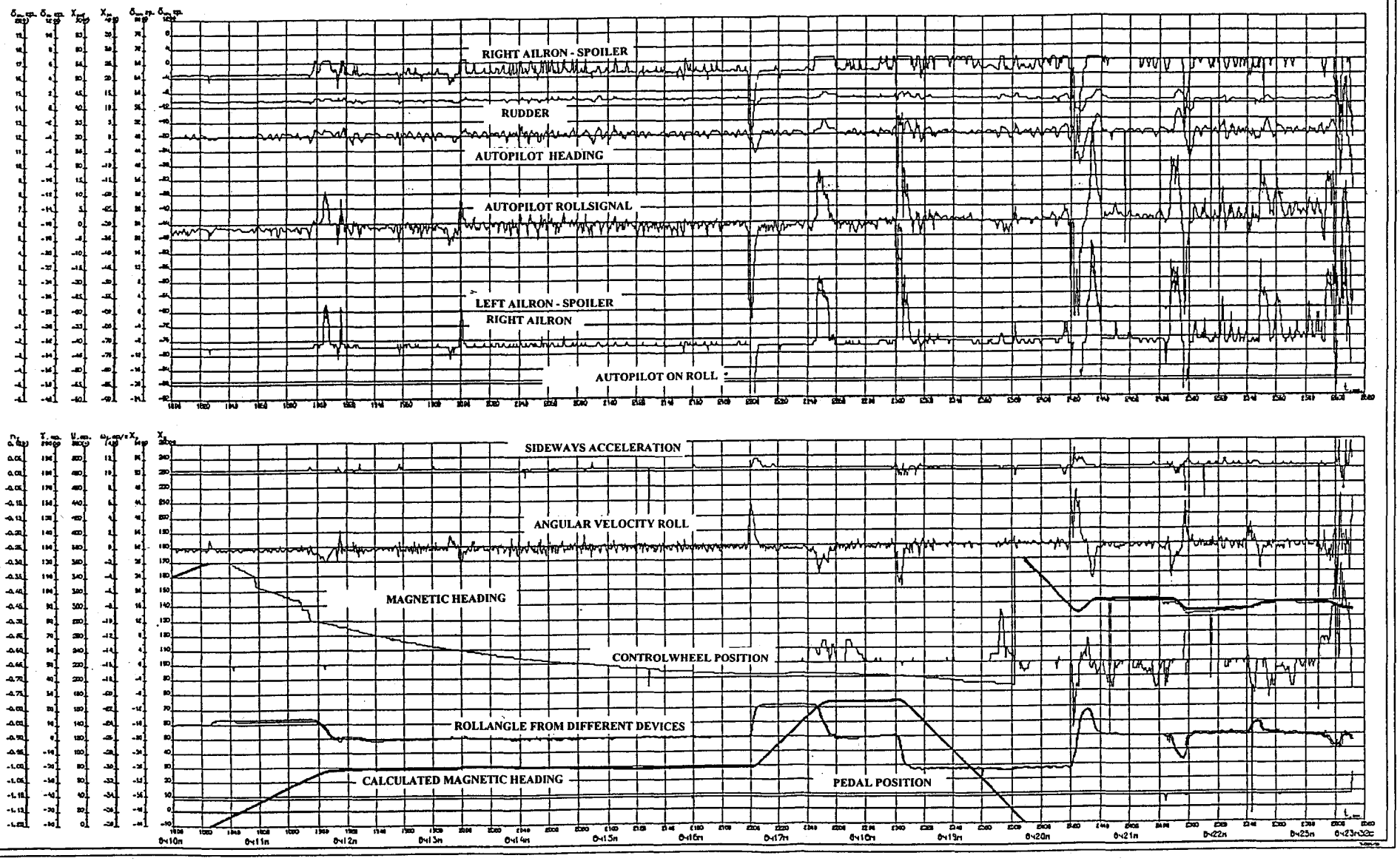
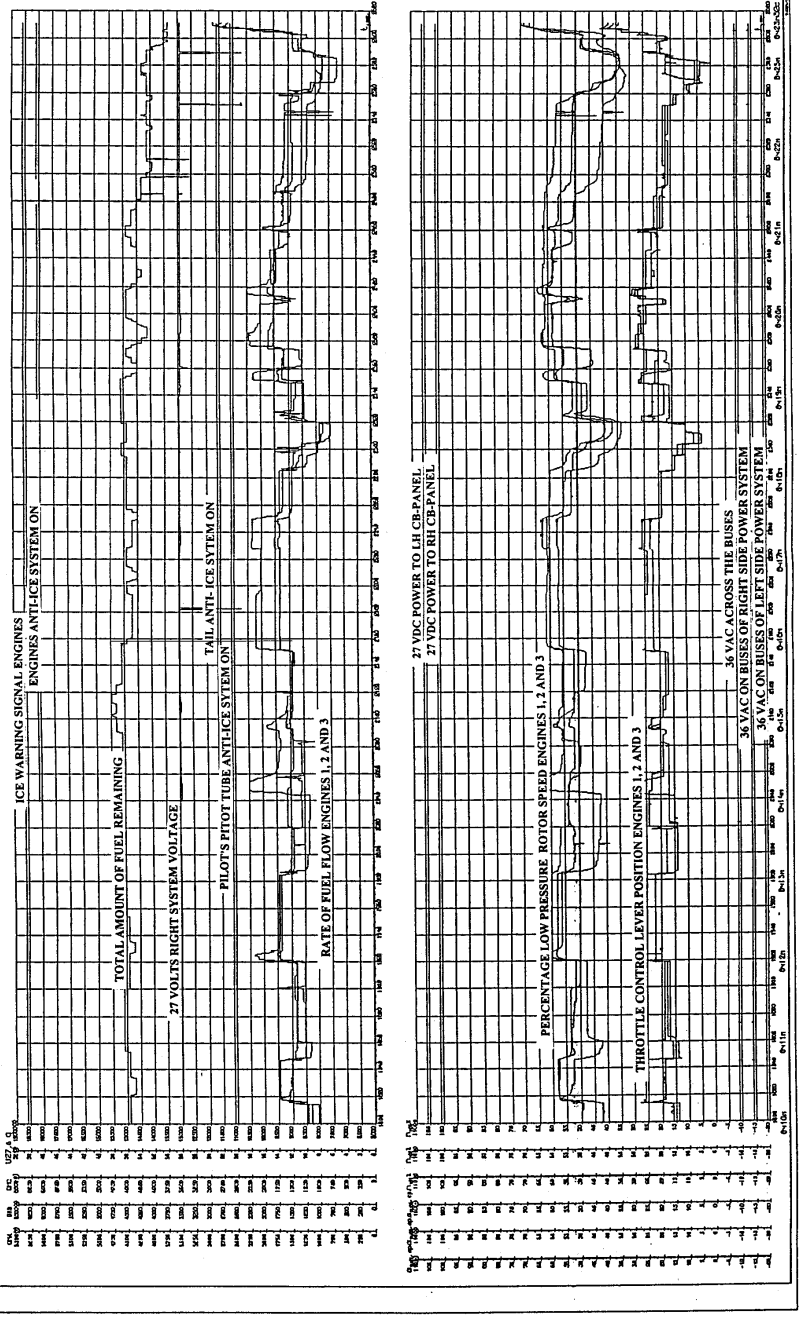
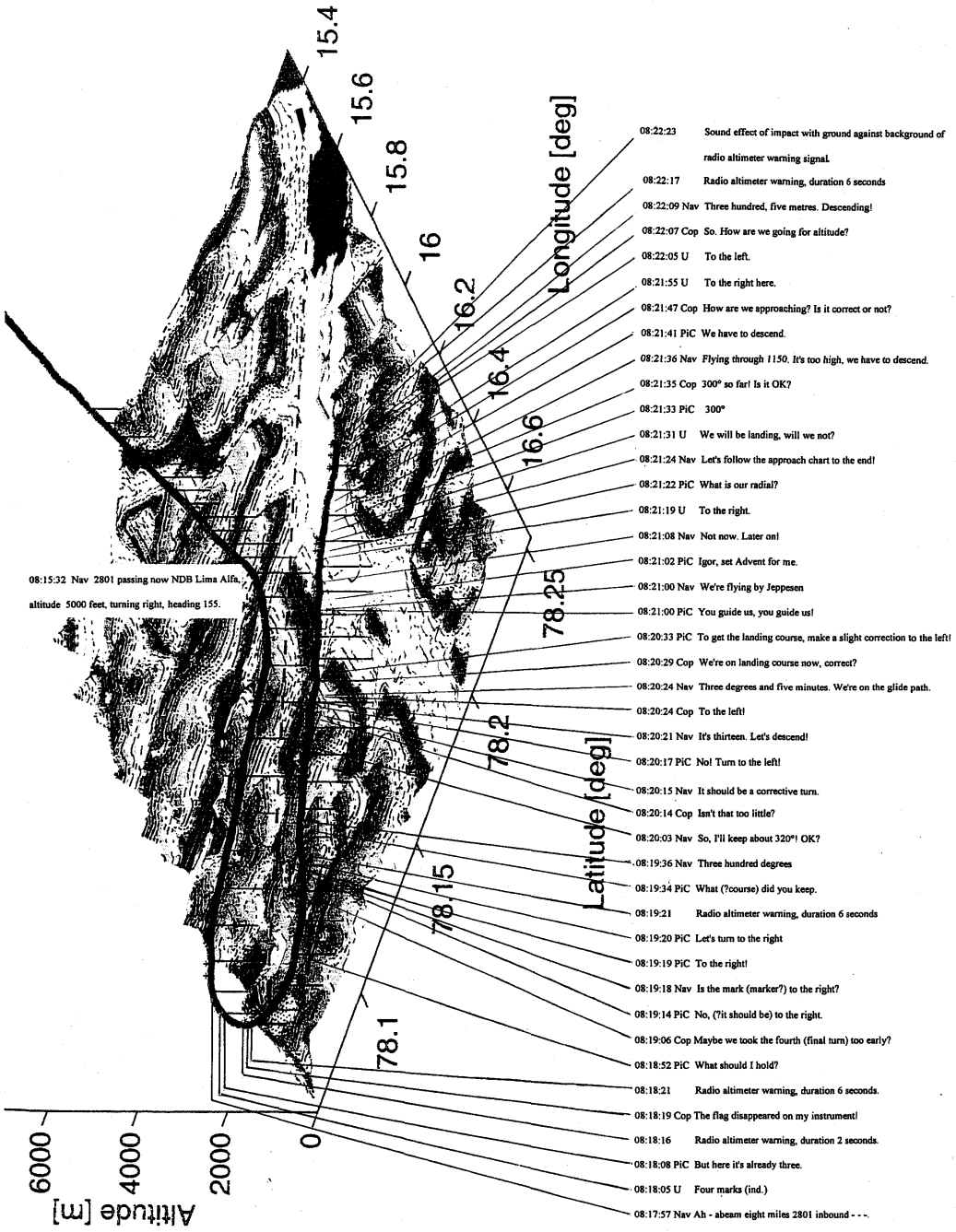


Рис. 3 ПАРАМЕТРЫ ПОЛЕТА САМОЛЕТА ТУ-154М RA-85621 29.08.1996г. (предварительная обработка)



APPENDIX 5



08:15:32 Nav 2801 passing now NDB Lima Alfa, altitude 5000 feet, turning right, heading 155.

08:22:23 Sound effect of impact with ground against background of radio altimeter warning signal.
08:22:17 Radio altimeter warning, duration 6 seconds
08:22:09 Nav Three hundred, five metres. Descending!
08:22:07 Cop So. How are we going for altitude?
08:22:05 U To the left.
08:21:55 U To the right here.
08:21:47 Cop How are we approaching? Is it correct or not?
08:21:41 PiC We have to descend.
08:21:36 Nav Flying through 1150. It's too high, we have to descend.
08:21:35 Cop 300° so far! Is it OK?
08:21:33 PiC 300°
08:21:31 U We will be landing, will we not?
08:21:24 Nav Let's follow the approach chart to the end!
08:21:22 PiC What is our radial?
08:21:19 U To the right.
08:21:08 Nav Not now. Later on!
08:21:02 PiC Igor, set Advent for me.
08:21:00 Nav We're flying by Jeppesen
08:21:00 PiC You guide us, you guide us!
08:20:33 PiC To get the landing course, make a slight correction to the left!
08:20:29 Cop We're on landing course now, correct?
08:20:24 Nav Three degrees and five minutes. We're on the glide path.
08:20:24 Cop To the left!
08:20:21 Nav It's thirteen. Let's descend!
08:20:17 PiC No! Turn to the left!
08:20:15 Nav It should be a corrective turn.
08:20:14 Cop Isn't that too little?
08:20:03 Nav So, I'll keep about 320°! OK?
08:19:36 Nav Three hundred degrees
08:19:34 PiC What (?course) did you keep.
08:19:21 Radio altimeter warning, duration 6 seconds
08:19:20 PiC Let's turn to the right
08:19:19 PiC To the right!
08:19:18 Nav Is the mark (marker?) to the right?
08:19:14 PiC No, (?it should be) to the right.
08:19:06 Cop Maybe we took the fourth (final turn) too early?
08:18:52 PiC What should I hold?
08:18:21 Radio altimeter warning, duration 6 seconds.
08:18:19 Cop The flag disappeared on my instrument!
08:18:16 Radio altimeter warning, duration 2 seconds.
08:18:08 PiC But here it's already three.
08:18:05 U Four marks (ind.)
08:17:57 Nav Ah - abeam eight miles 2801 inbound - - -.

FLIGHT SAFETY FOUNDATION
Airport Operations
Vol. 23 No. 5 *For Everyone Concerned with the Safety of Flight* September–October 1997

English-language Training For Air Traffic Controllers Must Go Beyond Basic ATC Vocabulary

Because miscommunication can have serious consequences, air traffic controllers responsible for international flights must have the skills in English to communicate more broadly than just to repeat learned phrases. The training and testing of controllers in English should require that controllers be able to respond to unusual, as well as routine, situations.

Shannon Uplinger
Uplinger Translation Services

In ordinary speech situations, we interpret spoken content by processing visual cues, such as gestures, and use these cues to supplement verbal information. As a last resort, we ask questions and obtain further information needed to make the meaning clear.

Context also plays an important role in understanding a speaker's message. Even if we miss a word or two of a speaker's presentation, we can still construct what the speaker said based on the usual context of the situation. Large amounts of spoken communication can be processed while we think about other things nearly simultaneously because context often makes much of the semantic content predictable.

Visual cues and contexts help make ordinary speech adequate for most of the things we do. Because pilots and air traffic controllers are invisible to one another they cannot depend on visual cues to facilitate communication. Furthermore, while communicating with each other, both pilots and controllers also process large amounts of visual information and perform other linguistic tasks — pilots communicating with other crew members, controllers communicating with other flights and both groups monitoring their instruments.

Context can be misinterpreted. In pilot–air traffic control (ATC) radio communication, the term "two five zero" can be an altitude, an airspeed or a heading. Expecting, for example, to receive heading instructions from a controller, and perhaps hearing only the words "two five zero," a pilot might mistake an altitude clearance for a heading.

To compensate for distractions and the ambiguity of context, pilots and controllers use highly formatted exchanges and rely on readback to ensure that the intended meaning of their messages has been understood. Despite using readback, miscommunication can occur, especially when the listener's expectations influence what is heard.

In high-risk situations, such as those that can arise during ATC communication, the result of a miscommunication can be serious.

Steven Cushing presents examples of miscommunication that have caused or contributed to aviation accidents. In these accidents, visual, contextual and other redundant cues were unavailable, and the speakers failed to recognize or resolve the ambiguities in their exchanges.[1]

Cushing cites the March 27, 1977, KLM Royal Dutch Airlines Boeing 747 collision with a Pan American World Airways B-747 in the Canary Islands, which resulted in 583 deaths; 61 survived. A pilot of the KLM aircraft said that he was "at takeoff," which the controller assumed to mean that the pilot was ready for takeoff and was awaiting further instructions. Actually, the KLM aircraft was taking off and was about to collide with the Pan American aircraft, which was taxiing on the runway toward the KLM aircraft.

Dealing with ambiguity in ATC communications is even more complex when flight crews, controllers or both are communicating in non-native English, that is, English that has been acquired as a second language.

The International Civil Aviation Organization (ICAO) does not mandate the use of English internationally for ATC communications, but recommends communication in the language "normally used by the station on the ground." Somewhat equivocally, ICAO recommends the use of English "pending the development and adoption of a more suitable form of speech for universal use in aeronautical radiotelephony communications."[2]

ICAO further recommends that English-language support should be available from ATC facilities serving designated routes and airports that are used by international flights. This ambiguous situation has resulted in *de facto* use of English as the international language of ATC without a requirement that it serve as such, and without the development of standards for training and testing controller use of English.

Given the challenges of ATC communication and the lack of regulatory specifications for English as the international language of aviation, it is not surprising that a number of aviation accidents have involved non-native English in pilot-controller communications. As Cushing noted concerning the accident in which the KLM pilot informed the controller that the B-747 was "at takeoff," the grammar of the pilot's native language, Dutch, interfered with his ability to construct the English statement "I am taking off," which would have had a different meaning to the controller.[1]

Other accidents involving misinterpretation of meaning have occurred more recently. On Jan. 25, 1990, the first officer of an Avianca airliner failed to translate to the air traffic controller the captain's statement that the aircraft was in an emergency situation, instead saying, "We're running out of fuel." The controller responded to a low-fuel situation, but not to a low-fuel emergency. The plane impacted terrain at Cove Neck, New York, U.S., killing 73 persons aboard the flight; 85 survived.

In December 1995, the American Airlines Flight 965 accident near Cali, Colombia, might have been prevented if the Colombian controller had been fluent in English.[3] The Colombian government has officially determined flight crew error as the probable cause of the accident. Nevertheless, the Cali controller said that he did not have adequate English skills to ask questions when the crew made illogical statements about the plane's location. The Boeing 757 aircraft flew into a mountain and 160 were killed; four survived.

Problems arising from lack of fluency in English received considerable attention at a three-day Communicating for Safety Conference, sponsored by a number of major aviation professional groups, held May 15–17, 1997, near Phoenix, Arizona, U.S.

Dealing with ambiguity in ATC communications is even more complex when flight crews, controllers or both are communicating in English that has been acquired as a second language.

Speaking at the conference, Capt. John Cox of US Airways said, "Ours is a lexicon of abbreviations, acronyms and jargon, and just consider how many different versions of English we have. Often our language can be confusing — we have problems with oxymorons. slang, homonyms (to, too, two) and so forth."[4]

At the same conference, Frank Price, manager of Air Traffic International Staff of the U.S. Federal Aviation Administration (FAA), said, "Unlike [in] the past, international traffic is now flying into the [U.S.] heartland. Every [FAA Air Route Traffic Control] Center now works international traffic."[4] Outside the United States, air routes — such as those over Russia and China — that were severely restricted or prohibited from use by western air carriers during the Cold War have been opened, increasing the potential for pilot-ATC language problems.

At the special aviation safety conference convened by the U.S. Secretary of Transportation in early 1995 following several highly publicized accidents in the last five months of 1994, proposals were made to require all airline transport pilots to pass a test of English-speaking proficiency. This led to the drafting of a standardized test, which included three parts: written, listening and speaking, and using model airplanes to demonstrate understanding of flight-maneuver terminology. The FAA has reportedly not taken action to require such testing of non-U.S. pilots who fly to the United States, although one private company that teaches "aviation English" uses testing in its own proficiency assessments of non-U.S. pilots that it trains.[5]

At the recommendation of the U.S. National Transportation Safety Board (NTSB), the FAA in April 1997 sent ICAO a letter proposing the establishment of English standards, and ICAO is expected to respond before the end of 1997. The U.S. Congress has also expressed concern about the issue. In connection with appropriations for the FAA, the House of Representatives Transportation Appropriations Subcommittee urged the FAA to work with the NTSB and ICAO to standardize training and evaluation procedures for English proficiency in the worldwide aviation system and approved funding for such a program. A House-Senate conference committee has recently approved a US$500,000 set-aside as part of the FAA budget for fiscal year 1998.

Several U.S.-based air carriers took the initiative to foster training of controllers, despite the absence of an international standard addressing skill levels. United Airlines, Northwest Airlines, Delta Air Lines, Alaska Airlines and FedEx supported English-proficiency programs for Russian and Chinese controllers at U.S. universities.[5]

Training programs to improve controller English skills face a variety of challenges. Because skill-level requirements have never been defined, training has emphasized mastery of standardized terminology. Nevertheless, the acquisition and use of language skill is complex and involves learning grammar, pronunciation, intonation and usage. Developing functionality in a foreign language is a difficult task.

Effective pilot-controller communication depends on the ability of the speakers to avoid ambiguity, at best, or at least to resolve ambiguous situations when they occur. If controllers lack adequate English skills, they cannot resolve ambiguous situations by requesting clarification or verification of details, as happened at Cali. Therefore, English proficiency needs to exceed the level required to reproduce memorized phrases and terms. The mastery of specialized terminology is insufficient.

If controllers lack adequate English skills, they cannot resolve ambiguous situations by requesting clarification or verification of details.

Contrary to the method used in many countries, ATC terminology should be taught not to beginners, but only to students who have at least a relatively advanced knowledge of English. Jack C. Richards suggests that special terminology is best learned in the context of the general language in which it is used.[6]

ATC terminology is highly specialized and occurs infrequently in the general language, so mastery of ATC terminology alone does not produce functional proficiency in English. A fairly high level of functional proficiency is needed to master ATC terminology, because as Richards says, knowing a word includes:

- Knowing the probability of encountering that word in speech or print;
- For many words, knowing the type of words most likely to be associated with the word;
- Knowing the limitations imposed on the use of the word according to variations in function and situation; and,
- Knowing the syntax associated with the word.[6]

Knowledge of specialized terms is also easier to acquire when aspects of the language have been mastered first, such as principles of word formation and sentence structure. Teaching and testing knowledge of ATC terminology with lists of terms turns controllers into parrots, who are handicapped in unusual or stressful ATC situations, rather than skilled users of English who can apply the language in a range of contexts.

One solution to English-proficiency and other communication problems suggested by Cushing is an "intelligent voice interface," which would provide some callouts automatically; monitor voice transmissions for accuracy, completeness, plausibility and similar factors; and question the speaker as needed before transmitting communications. But, as Cushing acknowledges, we lack the technology and a complete understanding of how language is interpreted by the brain. For the present, he recommends development of other visual back-up systems to voice.

Although many advocate the use of datalink to avoid the complexities of voice communication, datalink might be a questionable replacement of voice communication for controlled approaches and other nonroutine situations. Reading and typing English language exchanges in free text, if required for datalink systems, will be a time-consuming and challenging linguistic task for non-native speakers. Moreover, datalink and voice interface systems might discourage active monitoring of other flight crews' and controllers' voice communication, which often provides additional information. The resulting atrophy of verbal skills may impede the ability of controllers and pilots to respond to verbal information, especially when they are communicating in non-native English.

Although technical solutions have their appeal, the solution for the moment should be training that will give every pilot and controller the skills to serve as his or her own "intelligent voice interface." Technical systems should be used for back-up and augmentation, and should replace voice communication only for routine ATC exchanges.

For air traffic controllers, international English performance requirements need to be more clearly defined, and then re-evaluated as new technology is introduced that will change the use of natural language for communication between pilots and controllers. Because international standards have not been

developed, countries presently train and certify controllers according to their own standards, so different kinds of programs produce varying results.

For example, Russia and China, two countries training large numbers of controllers in English, face development of their own national standards for training and proficiency certification. In some Latin American countries, standards exist but should be reviewed. Without international policy and guidance, however, there is nothing to direct that various national standards should be similar.

Despite the lack of an international standard, Russian aviation authorities are working to develop the necessary standardization, testing and training programs to improve and maintain the English skill levels of Russian controllers. The same process may be used by other countries to establish local and eventually regional standardization, and these standards could ultimately provide the basis for a unified international standard for controllers' general English skills.

One of the first questions that Russian authorities have had to address is how much English air traffic controllers need to know. Here the Cali accident is instructive, because the controller's technical language proficiency was not adequate to meet the requirements of his job, although he was apparently fully trained. A controller who knows 200 or 300 English ATC terms may have very little functional ability to communicate in English, and therefore the requirement for general language skills must be defined clearly.

Communication broke down most often when Russian controllers moved from strictly formatted exchanges to discuss weather, airport conditions and other topics that require skill in generating sentences.

Results of surveys of U.S. flight crews who fly in Russia indicated that communication broke down most often when Russian controllers moved from strictly formatted exchanges to discuss weather, airport conditions and other topics that require skill in generating sentences. Some Russian textbooks introduce ATC language to controllers with only the most rudimentary English skills, or none at all,[7] so it is not surprising that a Russian controller would know terminology in English but not have a wider command of the language.

As part of an initiative to measure Russian controller English proficiency and to design training to raise skill levels, Russian authorities have used standardized English testing to determine controllers' baseline scores. This process involves testing large numbers of controllers in different regions and observing controller performance to establish a minimum proficiency standard that can be applied to all controllers or selected groups of controllers based on job requirements.

This testing program, the first step toward development of a national standard, will enable the Russian authorities to identify weaknesses in training, select and prioritize personnel for training, measure the impact of training in terms of cost, and guarantee the capabilities of personnel to perform job duties using English.

This process will ensure that controllers can respond to a variety of nonroutine and emergency scenarios using English — for instance, to respond to questionable transmissions from the cockpit, to identify ambiguous situations and causes of ambiguity, and to provide the flight crews with appropriate instructions when these situations occur. In other words, job proficiency should provide a basis for the standard, and testing should be accomplished with respect to operational scenarios that a controller might encounter.

English courses that the Russian controllers attended in the past were primarily oriented toward development of conversational skills, because of the importance of speaking skills for job performance. Not surprisingly, Russian controller test scores have been higher for listening skills than reading skills.

Nevertheless, although speaking and listening skills might be used most by air traffic controllers, reading and writing skills must also be developed in training, even if to a lesser degree. For language learning, all these skills reinforce each other. Some controllers, for example, learn general and technical vocabularies best with visual reinforcement from reading and writing. To acquire general English proficiency as well as a knowledge of ATC applications, controllers must also acquire and use the full range of language skills.

Another language-training problem of special importance to Russia is attrition caused by lack of practice, which has its greatest influence on listening and speaking skills. Most people who have studied a foreign language are aware of how quickly skills are lost if not used regularly. For Russian controllers in particularly remote locations such as the Far East, the rarity of occasions to use English on the job may not be adequate to maintain their skills, and soon proficiency becomes reduced.

The English training program in these parts of Russia, like programs in other countries where English use is limited, will need to include mechanisms such as regular testing to identify skill attrition, with maintenance and refresher programs to counteract attrition. The value of costly training for controllers is lost when language skills atrophy and the training system does not respond by restoring proficiencies.

Examples from Russia show that the English problem is not easy to solve, but that the problem is solvable. Large-scale baseline testing is planned, as is the development of standards, training and testing to produce, measure, maintain and certify language skills. Such a comprehensive and systematic approach will provide the basis for a program that can be easily managed and evaluated for cost-effectiveness.

Even the best-managed English training will not eliminate inherent ambiguities in language, and such training will not compensate for poor discipline, fatigue and other problems in the workplace. But training will improve the ability of air traffic controllers to perform their jobs and greatly reduce the risk that controllers and pilots will communicate with, but not understand, one another.

Like the controllers and pilots who use English language for ATC communications, the aviation industry needs to be more aware of language issues so that it can design training systems to produce and maintain the necessary language skills.

This will ensure that English training will be provided to controllers as thoroughly and systematically as the other training that they receive, and that continued international use of English for pilot-controller communications will support, rather than undermine, the safety of flight.♦

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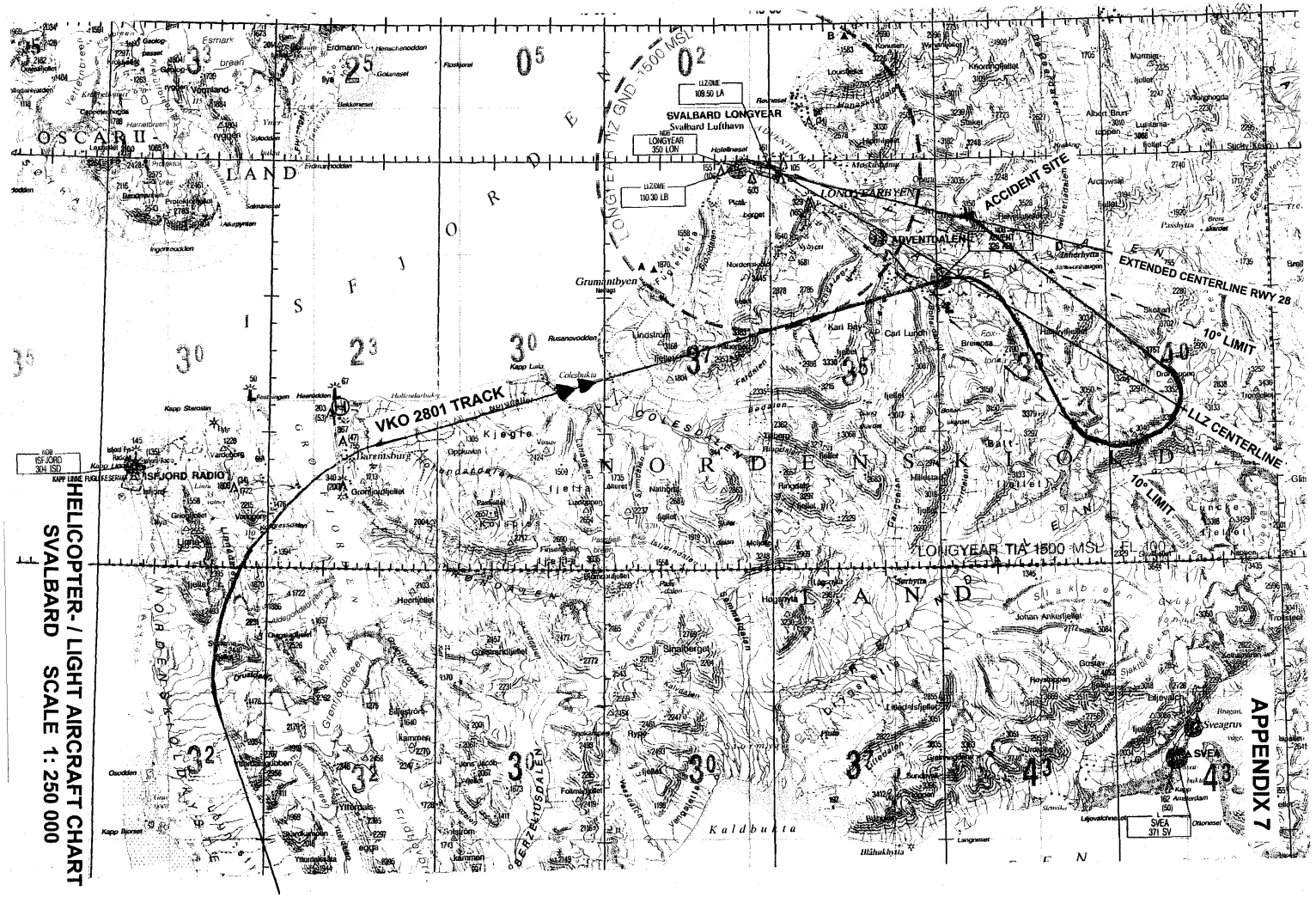
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7. For example, *Uchebnik anglijskogo yazyka dlya letnogo I dispetcherskogo sostava mezhdunarodnykh avialinij,* Moskva, Voennoe izdatel'stvo Ministerstva oborony SSSR, 1972. This textbook for Russian air traffic controllers introduces English pronunciation in the same initial chapters that contain aviation vocabulary such as "airplane," "map," "flight plan," "apron" and "to taxi." It is intended for use in a 300-hour course to prepare controllers to be certified to provide air traffic control in English.

About the Author

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LONGYEAR TIA 1500 MSL
FL 100
SVALBARD LONGYEAR
Svalbard Lufthavn
LONGYEARBYEN
ADVENTDALEN
ACCIDENT SITE
EXTENDED CENTERLINE RWY 28
10° LIMIT
LLZ CENTERLINE
VKO 2801 TRACK
ISFJORD RADIO
HELICOPTER- / LIGHT AIRCRAFT CHART
SVALBARD SCALE 1: 250 000
APPENDIX 7

APPENDIX 8

ABBEVIATIONS

AAIB/N	Aircraft Accident Investigation Board/ Norway
ACC	Area Control Centre
ADF	Automatic Direction Finding
ADV	Advent
AFCS	Automatic Flight Control System
AFIS	Aerodrome Flight Information Service
AIP	Aerodrome Information Publication
ASGAA	Allied Signal General Aviation Avionics
ATC	Air Traffic Control
ATCC	Air Traffic Control Centre
ATS	Air Traffic Service
AUTO	Automatic
BJO	Bjørnøya
BKN	Broken
CAT	Category
CDI	Course Deviation Indicator
COM	Communication
CVR	Cockpit Voice Recorder
DME	Distance Measuring Equipment
E	East
FDR	Flight Data Recorder
FIR	Flight Information Region
FIS	Flight Inspection Section
FM	Flight Manual
ft	feet
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
hPa	hecto Pascal
hrs	hours
HSI	Horizontal Situation Indicator
IAC	Interstate Aviation Committee
IAP	Instrument Approach Procedure
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
ISD	Isfjord
JAN	January
km	kilometer
kN	kilo Newton
kt	knot
LLZ	Localizer

LON	Longyear
LP	Low Pressure
MAN	Manual
MHz	Mega Hertz
N	North
NAV	Navigation
NCAA	Norwegian Civil Aviation Administration
NDB	Non-Directional Beacon
NM	Nautical Miles
NOSIG	No significant change
nT	nano Tessla
OBS	Omni Bearing Selector
OCA	Oceanic Control Area
PAPI	Precision Approach Path Indicator
PiC	Pilot-in-Command
Prob	Probability
QDM	Magnetic heading ('to the station')
QFE	Atmospheric pressure at airport elevation
QNH	Altimeter sub-scale setting to obtain elevation when on the ground
RAC	Rules of the air and air traffic services
RADZ	Rain and Drizzle
RESH	Recent Shower
RFCAA	Russian Federation Civil Aviation Administration
RMI	Radio Magnetic Indicator
SCT	Scattered
SHRA	Rain shower
STEP	Sequentially Timed Events Plotting
SV	Svea
TEMPO	Temporary
TIA	Traffic Information Area
TIZ	Traffic Information Zone
TU	Tupolev
UTC	Universal Time Coordinated
V	Volt
VHF	Very High Frequency
VDF	VHF Direction Finding
VKO	Vnukovo
VOR	VHF Omnidirectional Receiver
VRB	Variable