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NATIONAL TRANSPORTATION SAFETY COMMITTEE

Aircraft Accident Investigation Report

Sukhoi Civil Aircraft Company
Sukhoi RRJ–95B; 97004
Mount Salak, West Java
Republic of Indonesia
9 May 2012

NATIONAL TRANSPORTATION SAFETY COMMITTEE
MINISTRY OF TRANSPORTATION
REPUBLIC OF INDONESIA
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This Final report was produced by the National Transportation Safety Committee (NTSC), 3rd Floor Ministry of Transportation, Jalan Medan Merdeka Timur No. 5 Jakarta 10110, Indonesia.

The report is based upon the investigation carried out by the NTSC in accordance with Annex 13 to the Convention on International Civil Aviation Organization, the Indonesian Aviation Act (UU No. 1/2009) and Government Regulation (PP No. 3/2001).

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ABBREVIATIONS AND DEFINITIONS

AC	:	Advisory Circular
ADS-B	:	Automatic Dependent Surveillance – Broadcast
AGL	:	Above Ground Level
AIP	:	Aeronautical Information Publication
ALERFA	:	Alert Phase when there is apprehension about the safety of an aircraft and its occupants where communication is not received or the aircraft fails to arrive within 60 minutes of a prescribed time.
AMA	:	Area Minimum Altitude
APP	:	Approach Control
AS		Airspace Alert
ASL	:	Above Sea Level
ATC	:	Air Traffic Control
ATS	:	Air Traffic Services
BASARNAS	:	*Badan SAR Nasional* (National Search and Rescue Agency)
BKN	:	Broken Clouds
BMKG	:	*Badan Meteorologi Klimatologi dan Geofisika* (Meteorological Climatological and Geophysical Agency)
C	:	Celsius
CAS	:	Crew Alerting System
CASR	:	Civil Aviation Safety Regulation
CB	:	Cumulonimbus
CFIT	:	Control Flight Into Terrain
CH	:	Height Cloud
CM	:	Medium Cloud
CPA	:	Collision Prediction Alerts
Cu	:	Cumulus
CVR	:	Cockpit Voice Recorder

Dinas Pengembangan Operasi, *Markas Besar TNI Angkatan Udara*: The Indonesian Air Force Headquarters, Office For Operation Development.

DETRESFA	:	Distress Phase when there is reasonable certainty that the aircraft and its occupants are threatened by grave and imminent danger.
DGCA	:	Directorate General of Civil Aviation
DME	:	Distance Measuring Equipment
ELT	:	Emergency Locator Transmitter
EWD	:	Engine Warning Display
FEW	:	Few Clouds
FDED	:	Flight Data Edit Display

FDO	:	Flight Data Officer
FDR	:	Flight Data Recorder
FIR	:	Flight Information Region
FMS	:	Flight Management System
ft	:	Feet
FTD	:	Flight Training Device
FTI	:	Flight Test Instrumentation
GPS	:	Global Positioning System
GPWS	:	Ground Proximity Warning System
Hg	:	Hectogram
Hr	:	Hour
IAC	:	Interstate Aviation Committee of the Federation of Russia
ICAO	:	International Civil Aviation Organization
IFR	:	Instrument Flight Rules
IMC	:	Instrument Meteorological Condition
INCERFA	:	Uncertainty Phase when there is concern about the safety of an aircraft and its occupants where communication is not received or the aircraft fails to arrive within 30 minutes of a prescribed time.
IRS	:	Inertial Reference System
JAATS	:	Jakarta Automated Air Traffic Services
JSC "SCA"	:	Joint Stock Company Sukhoi Civil Aircraft
Km	:	Kilometre
KNKT (NTSC)	:	*Komite Nasional Keselamatan Transportasi* (National Transportation Safety Committee)
LT	:	Local Time
m	:	Meter
MAC	:	Mean Aerodynamic Chord
Mb	:	Millibars
MCP	:	Main Control Panel
MHz	:	Megahertz
MSA	:	Minimum Sector Altitude
MSAW	:	Minimum Safe Altitude Warning
NDB	:	Non Directional Beacon
PAS	:	Predicted Airspace Alert
PIC	:	Pilot in Command
PTR	:	Predicted Terrain Alert
RCC	:	Rescue Coordinator Centre
Sc	:	Strato Cumulus

SCAC	:	Sukhoi Civil Aircraft Company
SCT	:	Scattered Clouds
SIC	:	Second in Command
SID	:	Standard Instrument Departure
St	:	Stratus
STAR	:	Standard Arrival
T^2CAS	:	Terrain and Traffic Collision Avoidance System
TAFOR	:	Terminal Aerodrome Forecast
TAWS	:	Terrain Awareness and Warning System
TCAS	:	Traffic Collision Avoidance System
TD	:	Dew Point
TMA	:	Terminal Approach
TQA	:	Throttle Quadrant Assembly
TR	:	Terrain Alert
TT	:	Temperature
UTC	:	Universal Time Coordinate
VFR	:	Visual Flight Rules
VMC	:	Visual Meteorological Condition
VOR	:	Very high frequency Omnidirectional Range
QFE	:	Height above airport elevation based on local station pressure
QNH	:	Height above mean sea level based on local station pressure

INTRODUCTION

SYNOPSIS

A Sukhoi RRJ-95B aircraft, registered 97004, with a flight number RA 36801 on 9 May 2012 was conducting a demonstration flight from Halim Perdanakusuma International Airport, Jakarta. The accident flight was the second of two scheduled demonstration flights.

On board the flight were two pilots, one navigator, one test flight engineer, and 41 passengers. The passengers consisted of 4 Sukhoi Civil Aircraft Company (SCAC) personnel, one engine manufacturer (SNECMA) personnel, and 36 invited passengers (including one American, one French and 34 Indonesian nationalities).

The flight was planned under the Instrument Flight Rules (IFR) at an altitude of 10,000 feet and the estimated elapsed time was 30 minutes with total fuel endurance of 4 hours. The area for the demonstration flight was over "Bogor" Area while the pilot might assume that the flight was approved to 20 Nm on radial 200 HLM VOR.

The available charts on board the aircraft did not contain information relating to the "Bogor" Area and the nearby terrain.

The PIC acted as pilot flying while the SIC acted as pilot monitoring during this flight. In this flight, a representative of a potential customer sat on the observer seat (jump seat) in the cockpit.

At 0720 UTC, the flight took off from runway 06 then turned right to intercept radial 200 from HLM VOR and climbed to 10,000 feet.

At 0724 UTC, the pilot contacted Jakarta Approach and informed that the flight was established on radial 200 degrees HLM VOR and reached 10,000 feet.

At 0726 UTC, the pilot contacted Jakarta Approach and requested for descent to 6,000 feet and subsequently requested to make a right orbit and was approved by Jakarta Approach controller.

At 0732:26 UTC, the aircraft impacted a ridge of Mount Salak on 28 Nm HLM VOR on radial 198 at coordinate 06°42'45"S 106°44'05"E, at approximately 6,000 feet ASL.

38 seconds prior to impact, the Terrain Awareness Warning System (TAWS) audio warning "TERRAIN AHEAD, PULL UP" activated once and "AVOID TERRAIN" activated 6 times. The PIC inhibited the TAWS system assuming that the warning was a problem on the database.

Seven seconds prior to impact, the flight warning system audio "LANDING GEAR NOT DOWN" activated.

At 0750 UTC, the Jakarta Approach controller on duty noticed that the flight target disappeared from the radar monitor. There was no alert on the Jakarta Radar system prior to the disappearance of the target.

On 10 May 2012, the location of the aircraft was identified by the Search and Rescue helicopter pilot.

All occupants were fatally injured and aircraft was destroyed.

The Cockpit Voice Recorder (CVR) was found on 15 May 2012. The memory module was in good condition and contained 2 hours of good quality recording.

The Flight Data Recorder (FDR) was found on 31 May 2012. It contained 471 parameters of 150 hours recording time.

Both recorders were downloaded in the NTSC facility by the NTSC experts and were assisted by the Russian experts.

A simulation test suggested that a recovery action might have avoided the collision with terrain up to 24 seconds after the first TAWS warning.

Jakarta Radar services had not established a minimum altitude for vectoring aircraft for certain areas and the Minimum Safe Altitude Warning (MSAW) did not provide warnings to the Jakarta Approach controller before the aircraft impacted.

The investigation concluded that the factors contributing to this accident were:

a. The crew were not aware of the mountainous area surrounding the flight path due to various factors resulting in disregarding the TAWS warning.

b. The Jakarta Radar service had not established the minimum vectoring altitudes and the system was not equipped with functioning MSAW for the particular area surrounding Mount Salak.

c. Distraction to the flight crew from prolonged conversation not related to the progress of the flight resulted in the pilot flying did not continue to change the aircraft heading while in orbit. Consequently, the aircraft unintentionally exited the orbit.

Following this investigation the Indonesia Directorate General of Civil Aviation, PT. Angkasa Pura II and the Sukhoi Civil Aircraft Company have performed several safety actions. The NTSC issued several safety recommendations to the Indonesia Directorate General of Civil Aviation (DGCA), Soekarno-Hatta International Airport International Airport, civil aviation authority of Russia and Sukhoi Civil Aircraft Company of Russian Federation.

1 FACTUAL INFORMATION

1.1 History of the Flight

A Sukhoi RRJ-95B aircraft, registered 97004 and with flight number RA 36801 on 9 May 2012 was on a demonstration flight. The accident flight was the second of two scheduled demonstration flights.

The navigator sent the proposed flight plans for both demonstration flights to the handling agency by means of e-mail.

At 0200 UTC[1], the flight plans for the first and second demonstration flight were filed at the airport briefing office by the manager of the ground handling agency. The flights were planned at an altitude of 10,000 feet and the estimated elapsed time was 30 minutes with total fuel endurance of 4 hours and would be conducted under the Instrument Flight Rules (IFR).

The first demonstration flight was scheduled at 0400 UTC, while the second demonstration flight was scheduled at 0645 UTC.

The first demonstration flight departed from Halim Perdanakusuma International Airport[2] at 0443 UTC using runway 24 for takeoff and landed at Halim runway 24 at 0505 UTC.

At 0705 UTC, the Second In Command (SIC) of the second demonstration flight requested a clearance for start-up and pushback. The Halim Tower controller cleared for push back and engine start, and to expect runway 06.

The Pilot In Command (PIC) acted as pilot flying while the SIC acted as pilot monitoring during this flight.

On board the flight were two pilots, one navigator, one test flight engineer, and 41 passengers. The passengers consisted of 4 Sukhoi Civil Aircraft Company (SCAC) personnel, one from the engine manufacturer (a member of SNECMA, one of the two parent companies of PowerJet manufacturer), and 36 invited passengers (including one American, one French and 34 Indonesian nationalities).

A representative of a potential customer sat on the observer seat (jump seat) in the cockpit.

Based on the number of persons on board and the amount of fuel carried, the aircraft takeoff weight was estimated at 38,500 kg (the aircraft maximum takeoff weight was 45,880 kg), and an estimated centre of gravity of 16.7% MAC-Mean Aerodynamic Chord (allowed range of the centre of gravity for takeoff was 12 up to 32.5% MAC). The load sheet and the passenger manifest documents and all copies were taken on board the aircraft and destroyed.

1 The 24-hours clock in Universal Time Coordinated (UTC) is used in this report to describe the local time as specific events occured. Local time is UTC+7 hours.

2 Halim Perdanakusuma International Airport will be named as Halim for the purpose of this report.

At 0714 UTC, the flight was cleared to taxi to runway 06.

At 0718 UTC, the Halim Tower controller gave a clearance to maintain runway heading after takeoff then turn right to intercept radial 200 from HLM[3] VOR and climb to 10,000 feet.

The SIC acknowledged the clearance from the tower.

The Halim Tower controller emphasised that turn has to be made after passing two thousand. The pilot replied that they acknowledge the message.

At 0719 UTC, the flight was cleared for take-off.

At 0721 UTC, the flight was instructed to contact Jakarta Approach.

At 0724 UTC, the pilot contacted Jakarta Approach and informed that the flight was established on radial 200 degrees HLM VOR and reached 10,000 feet.

The Jakarta Approach controller replied that the flight has been identified on the radar display and instructed the flight to maintain 10,000 feet and continue to the area. The pilot replied “maintain 10,000 feet”.

At 0726 UTC, the pilot contacted Jakarta Approach and requested for descent to 6,000 feet. The Jakarta Approach controller asked the SIC to repeat the request.

The SIC repeated the request for descent to 6,000 feet. Subsequently, Jakarta Approach controller responded and acknowledged the request by replying “6,000 copied”. The pilot replied: “Descending to 6,000 feet”.

At 0728 UTC, the SIC requested to make a right orbit, the Jakarta Approach controller approved the flight to make right orbit at 6,000 feet.

The Jakarta Approach controller on duty stated that the radar display indicated that the aircraft was over WI(R)-4 Atang Sanjaya Training Area when requesting the orbit. The WI(R)-4 airspace area extends from ground to 6,000 feet. The area was at about 17 Nm southwest of HLM VOR.

At 0750 UTC, according to the Daily Report provided by Air Traffic Services Operation, the controller on duty noticed that the flight target disappeared from the radar monitor.

At 0752 UTC, the controller on duty attempted to contact the RA 36801 flight three times. At 0754 UTC, the Jakarta Approach reattempted to contact the RA 36801 flight and there was no reply.

At 0755 UTC, according to the Daily Report provided by Air Traffic Services Operation, the controller on duty reported the situation to the Air Traffic Services Operation Regional Coordinator (ATS Coordinator). The ATS Coordinator made an internal coordination with Halim officer on duty regarding the position of the aircraft.

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3 HLM is the identification code of the Halim Perdanakusuma International Airport VOR/DME.

During a subsequent interview, the ATS Coordinator stated that:

- At 0835 UTC, INCERFA was declared.
- At 0855 UTC, ALERFA was declared and informed the BASARNAS.
- At 1122 UTC, DETRESFA was declared.

On 10 May 2012 at 0135 UTC, the location of the aircraft was identified by the Search and Rescue helicopter pilot. The probable location was determined using Jakarta Approach radar plot calculation and the SAR team used that information to locate the accident aircraft.

The aircraft wreckage was found on a ridge of Mount Salak on 28 Nm HLM VOR on radial 198, at approximately 6,000 feet. According to the Flight Data Recorder (FDR) data, the impact point was recorded at coordinate 06°42'45"S 106°44'05"E. The last recorded radio altimeter data was at 370 feet. The aircraft impacted into an 85 degree slope ridge.

All occupants were fatally injured and aircraft was destroyed.

1.2 Injuries to Persons

Injuries	Flight crew	Passengers	Total in Aircraft	Others
Fatal	4	41	45	-
Serious	-	-	-	-
Minor/None	-	-	-	Not applicable
TOTAL	4	41	45	-

1.3 Damage to Aircraft

The aircraft was destroyed due to the high magnitude of deceleration force and post impact fire.

1.4 Other Damage

There was no other damage reported.

1.5 Personnel Information

1.5.1 Pilot in Command

Gender	:	Male
Age	:	57 years
Nationality	:	The Russian Federation
Date of joining company	:	01 November 2003
License	:	Test Pilot I (First class)
Valid to	:	20 February 2013
Type rating	:	• Let L-29, -39, -410; • Mikoyan MiG-15, -17, -21, -23, -25, -29, -31;

		• Sukhoi Su-7, -9, -17, -22, -24, -25, -80, RRJ-95B; • Antonov AN-26, -30, -72, -124-100; • Ilyushin Il-76; • Boeing 737-200; • Tupolev Tu-134, -154B/M, -204, -214; • Yakovlev Yak-40; • Airbus A-320, -319.
Medical certificate valid to	:	20 February 2013 (without restriction)
Last proficiency check on RRJ-95B	:	12 November 2011
Last line check on RRJ-95B	:	25 August 2011
Flight Time		
Total time	:	10, 347 hours
This make & model	:	1,348 hours 47 minutes
Last 90 days	:	78 hours 22 minutes
Last 30 days	:	21 hours 35 minutes
Last 24 Hours	:	1 hours 41 minutes
This Flight	:	16 minutes
Hours on duty prior to occurrence	:	4 hours 7 minutes
Hours off prior to duty	:	18 hours 23 minutes
Hours awake prior to occurrence	:	7 hours 20 minutes
Duration of last sleep	:	8 hours 30 minutes

During the period between 2010 and 2011, the certification test of Terrain Awareness and Warning System (TAWS) function on the Terrain and Traffic Collision Avoidance System (T^2CAS) including bench and flight tests was performed. The PIC, who was the Lead Test Pilot, supervised and participated on 9 test flights with a total of 23 hours and 39 minutes.

1.5.2 Second in Command

Gender	:	Male
Age	:	44 years
Nationality	:	The Russian Federation
Date of joining company	:	22 January 2010
License	:	Test Pilot II (Second class)
Valid to	:	21 September 2012
Type rating	:	• Let L-29, -39; • Mikoyan MiG-21, -29; • Sukhoi Su-25UB, RRJ-95B; • Antonov AN-26, -30, -72, -124-100; • Ilyushin Il-20, -38, -76, -96; • Tupolev Tu-134; • Yakovlev Yak-18, -40, -42, -52, -54, -58, -112, -130;

- Myasischev M-101.

Medical certificate valid to	:	21 September 2012 (without restriction)
Last proficiency check on RRJ-95B	:	5 April 2012
Last line check on RRJ-95B	:	15 June 2011

Flight Time

Total time	:	3,318 hours
This make & model	:	625 hours
Last 90 days	:	98 hours 43 minutes
Last 30 days	:	34 hours 17 minutes
Last 24 Hours	:	1 hours 41 minutes
This Flight	:	16 minutes
Hours on duty prior to occurrence	:	4 hours 7 minutes
Hours off prior to duty	:	18 hours 23 minutes
Hours awake prior to occurrence	:	6 hours 50 minutes
Duration of last sleep	:	9 hours

1.5.3 Navigator

The Navigator, included as a crewmember to mitigate workload to the pilots during ferry flights and off-route flights.

Gender	:	Male
Age	:	51 years
Nationality	:	The Russian Federation
Date of joining company	:	19 April 2006
License	:	Test Navigator I (First Class)
Valid to	:	17 January 2013
Medical certificate valid to	:	17 January 2013 (without restriction)
Aeronautics check	:	6 July 2011

Flight Time

Total time	:	3,533 hours
This make & model	:	485 hours
Last 90 days	:	64 hours 39 minutes
Last 30 days	:	46 hours 28 minutes
Last 24 Hours	:	1 hours 41 minutes
This Flight	:	16 minutes
Hours on duty prior to occurrence	:	4 hours 7 minutes
Hours off prior to duty	:	18 hours 23 minutes
Hours awake prior to occurrence	:	7 hours 20 minutes
Duration of last sleep	:	8 hours 30 minutes

1.5.4 On-board Operator

An on-board operator was included as an additional crewmember to act as a steward during ferry and demonstration flights.

1.5.5 Rest and Duty Period

The crew performed a demonstration flight in Naypyidaw (Myanmar) on 7 May 2012 for 37 minutes which was concluded at 0717 UTC.

On 8 May 2012, the crew performed a positioning flight from Naypyidaw to Jakarta with the total flight time of 4 hours and 21 minutes arriving in Jakarta at 0850 UTC. The rest period between these duties was 19 hours and 42 minutes.

On 9 May 2012, the crew performed the first demonstration flight which was started at 0443 UTC. The rest period before this flight was 18 hours 23 minutes.

During the last 48 hours prior to the accident flight, the duty and rest period of the crew was within the required limits.

1.5.6 ATC Controller at Jakarta APP

Gender	:	Male
Age	:	44 year
Nationality	:	Indonesian
Date of joining company	:	May 1995
License	:	Senior ATC
Date of issue	:	1 April 2000
Last validation check	:	1 March 2012
Valid to	:	1 March 2014
Rating	:	Radar Controller
Date of last medical	:	14 February 2012
Last performance check	:	1 February 2012
Hours on duty prior to occurrence	:	20 minutes
Hours off prior to duty	:	15 hours
Hours awake prior to occurrence	:	8 hours
Duration of last sleep	:	6 hours 30 minutes

During the interview the controller stated that he felt over-loaded.

The Angkasa Pura II as the service provider had no quantitative assessment on the controller workload.

Assessment on the capacity management including controller workload, stated in the Advisory Circular (AC) 170-02 Paragraph 3.1 Capacity Management (see Appendices 6.2).

1.6 Aircraft Information

1.6.1 General

Registration Mark	:	97004
Manufacturer	:	Sukhoi Civil Aircraft Company (SCAC)
Country of Manufacturer	:	The Russian Federation
Type/ Model	:	RRJ-95B
Serial Number	:	95004
Date of manufacture	:	9 August 2009
Certificate of Airworthiness		
Number	:	95/13-415
Issued	:	5 December 2010
Validity	:	24 July 2014
Certificate of Registration		
Issued	:	5 December 2010
Validity	:	24 July 2014
Category	:	Experimental passenger airplane
Crew (Cockpit/Cabin)	:	2/ 2
Time Since New	:	843 hours 58 minutes
Cycles Since New	:	502
Last Major Check	:	None
Last Minor Check	:	73 hours 7 minutes

1.6.2 Engines

Manufacturer	:	PowerJet[4]
Type/Model	:	SaM 146
Serial Number-1 engine	:	SaM-146108
▪ Time Since New	:	482 hours
▪ Cycles Since New	:	508
Serial Number-2 engine	:	SaM-146106
▪ Time Since New	:	1039 hours
▪ Cycles Since New	:	713

4 PowerJet is a joint company of NPO "Saturn", Russia and SNECMA, France

1.6.3 T²CAS

The aircraft RRJ-95B was equipped with Terrain and Traffic Collision Avoidance System (T²CAS) which incorporates independent Traffic Collision Avoidance System function (TCAS) and Terrain Awareness Warning System function (TAWS). However, the TCAS system will not be discussed in this report as this had no link to this accident.

The purpose of the TAWS is to provide terrain situational awareness aiming to prevent Controlled Flight Into Terrain (CFIT) situations. TAWS as a situational awareness system is not to be used as a primary navigation means of the aircraft.

TAWS warnings take into account the current configuration and climb capabilities of aircraft (including gross weight, center of gravity, flaps and gear position, engine status, etc.), flight parameters (including vertical speed, flight path angle, ground speed, track angle, latitude and longitude, air temperature, roll, Global Positioning System (GPS), barometric altitude, and radio altitude), and terrain database.

1.6.3.1 Functional overview

TAWS carries out the following functions:

a) Provide flight crew with basic Ground Proximity Warning System (GPWS) alerts:
   - Mode 1. Excessive descent rate.
   - Mode 2. Excessive terrain closure rate.
   - Mode 3. Loss of altitude after take-off or go around.
   - Mode 4. Unsafe terrain clearance not in landing mode.
   - Mode 5. Excessive descent below glideslope.
   - Mode 6. Excessive bank angle alert.
   - Altitude callouts.

b) Provide flight crew with Collision Prediction Alerts (CPA) mode:
   - Warning and Caution alert for flight into terrain.
   - Premature Descent Alert

c) Terrain Display.

1.6.3.2 Some significant information quoted from the T²CAS manual

TAWS is aimed to prevent Controlled Flight Into Terrain (CFIT) accidents by giving the crew timely alerts based on predicted terrain obstacle clearance profiles, calculated with real time actual aircraft performance.

The TAWS generates both predictive and reactive warnings. The predictive terrain and obstacle warnings are provided by advanced forward looking functions that utilize terrain, obstacle, and airport databases, as well as modeling of the aircraft climb capability. The forward looking functions predict terrain and obstacle hazard situations, and generate aural, visual, and graphical display alerts.

The forward looking function continuously correlates the projected flight path up to two minutes ahead of the aircraft against an internal terrain elevation database. Alerts are generated whenever the forward looking calculations show the projected flight path intersects the correlated terrain elevations underlying that flight path.

In the horizontal plane, the envelope or coverage area for terrain conflict detection during straight flight is a narrow field of view, beginning with a circle of uncertainty based on lateral accuracy, diverging at a 1.5î-angle on either side of the flight path as it extends outward in front of the aircraft (see Figure 1). This narrow view ensures that terrain on either side of the flight path does not initiate unnecessary alerts and warnings. Once the aircraft initiates a turn, the forward looking function uses the aircraft turning rate to extrapolate terrain conflict detection over the full terrain area underlying the projected turn between the present aircraft track and the track that is projected by the turning rate, up to 90î.

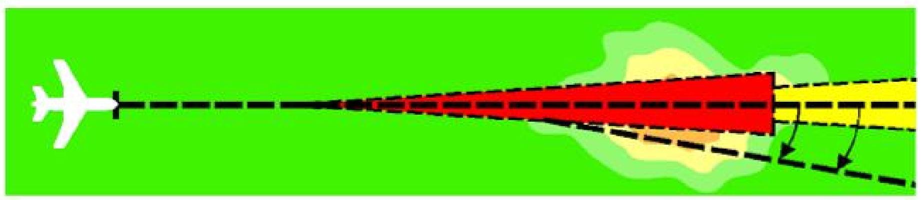


Figure 1: TAWS protective envelope formation for direct horizontal flight

If a pull-up manoeuvre is not sufficient for the aircraft to clear the terrain directly along the flight path, the forward looking software generates a unique "Avoid Terrain" warning to notify the flight crew that, based on the operational status of the aircraft (performance model), an alternate course of action (left or right turn) may be necessary to avoid a CFIT situation.

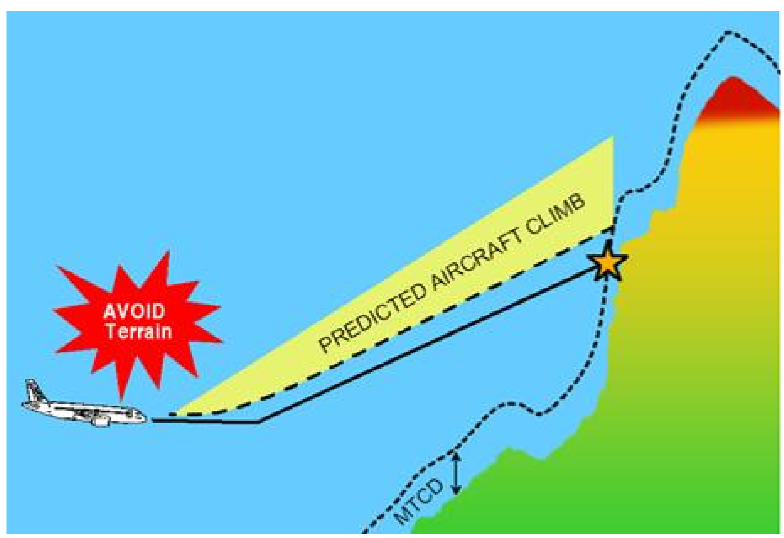


Figure 2: TAWS looking forward function using flight path angle and aircraft climb model: Avoid Terrain Warning

PILOT REACTIONS TO TAWS ALERTS

Pilot reactions to alerts and warnings will differ according to local regulation authorities, weather conditions, type of warning, phase of flight, and aircraft performance.

Pilots should be trained to react to TAWS alerts and warnings according to their company's policy. Training programs will be required for TAWS just as they are required for basic GPWS, aircraft stall warning, windshear, engine failures and other emergencies.

Pilots should react to all TAWS aural alerts, display pop--ups and visual annunciations as required by company policy. The amber CAUTION requires immediate attention if the condition continues. The red WARNING annunciation is a TAWS warning and requires immediate action by the pilot.

The forward looking TAWS function should be inhibited prior to takeoff and/or landing procedures at airports and runways which have previously been identified as producing false terrain or obstacle alerts until corrections have been made.

If concerns about the reliability or appropriateness of TAWS alerts arise, pilots may inhibit the forward looking TAWS function and contact ACSS Customer Technical Support for TAWS Event analysis.

When the forward looking TAWS terrain or obstacle awareness function(s) is inhibited or unavailable, it continues to provide basic GPWS functions (Mode 1 to 5 with Altitude callout, bank angle). Wind shear also remains operational.

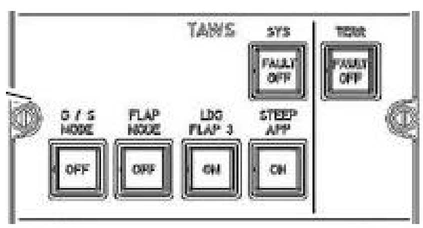


Figure 3: TAWS control panel

Upon TAWS forward looking alerts such as "TERRAIN AHEAD PULL UP" and "AVOID TERRAIN" the Navigation displays ND1 and ND2 are automatically switched to TERR mode.

If the system and terrain (SYS and TERR) buttons are pushed on TAWS function modes control panel (i.e. Off position), the basic Ground Proximity Warning System (GPWS) remain operating, however the Collision Prediction Alert (CPA, i.e. forward looking alerts) are inhibited. In this situation, associated aural and visual alerts are disengaged. The display of dangerous terrain then disappears from both Navigation Displays (ND1 and ND2).

1.6.4 Flight Warning System

The Sukhoi RRJ-95B is equipped with a Flight Warning System that provides to the flight crew textual warnings on the Engine Warning Display (EWD) as part of the Crew Alerting System (CAS) messages such as “LDG FLAPS/SLATS NOT LAND” and “LAND GEAR NOT DOWN”. Associated with the textual EWD warning message “LAND GEAR NOT DOWN” an aural alert “GEAR NOT DOWN” is provided.

Crew acknowledgement of the CAS message can be performed by pressing the “Alert Cancel” button. This action will erase the message from the Engine Warning Display (EWD), extinguish the flashing Master Warning and cancel the aural alerts.

Pressing the Master Warning light will not deactivated the alert.

The CAS messages “LDG GEAR NOT DOWN”, along with repetitive aural alert “GEAR NOT DOWN”, is provided under the following conditions:

- At least one landing gear is not fixed in the down position, and**:**
  - Aircraft is at the flight phase 7, or
  - There is no data from both Radio Altitude (RA) and the Flaps/Slats lever is in position 3 or Full.

The flight phase 7 is provided under the following conditions:

- The aircraft is in flight, and
- Height (Radio Altitude) is lower than 1,500 feet, and
- The aircraft is in flight more than 2 minutes, and
- Right and left engines are not in takeoff mode, and
- Height (Radio Altitude) is lower 800 feet for more than 5 seconds, and
- Vertical speed is lower than 300 feet/minute for more than 3 seconds.

1.6.5 Additional Aircraft Information

The aircraft maintenance was conducted by SCAC. The aircraft was airworthy prior to the flight.

The Aircraft Flight Manual included the following definitions:

Caution : An operating procedure or technique, etc…which may result in damage to equipment if not carefully followed. (Ref RRJ-95B AFM Chapter 01.03)

Warning : An operating procedure, technique etc…which may result in personal injury or loss of life if not carefully followed. (Ref RRJ-95B AFM Chapter 01.03)

1.6.6 Additional Equipment On-board

The aircraft registered 97004 had additional equipment installed for the purpose of certification tests and to record operating parameters of engine and flight controls. To monitor the parameters, the aircraft was equipped with Flight Test Instrumentation (FTI) racks and 2 workstations for FTI operators in the rear part of the cabin.

Two seats for the FTI operators were equipped with survival kit including parachutes. In addition, two portable survival kits including parachutes were located on the luggage shelves.

1.7 Meteorological Information

1.7.1 Halim Terminal Aerodrome Forecast (TAFOR)

This TAFOR was issued by *Dinas Pengembangan Operasi*, *Markas Besar TNI Angkatan Udara*, at Halim Airforce Base on 9 May 2012

	0700 UTC	0800 UTC	0900 UTC
Wind	090 / 6 knot	050 / 8 knot	030 / 8 knot
Visibility	5 km	5 km	5 km
Weather	Haze	Haze	Haze
Cloud	SCT 017	BKN 017	FEW 16 CB
TT/TD	33 / 24	32 / 24	31 / 25
QNH (mb/in Hg)	1010/29.83	1009/29.82	1009/29.82
QFE (mb/in Hg)	1007/29.73	1006/29.72	1006/29.72

1.7.2 Weather Observation from Darmaga Station

The following weather observation was from the Darmaga Badan Meteorological Klimatologi dan Geofisika (BMKG) observation station, which was the nearest meteorology station to the accident site, approximately 7 Nm.

	0700 UTC	0800 UTC	0900 UTC
Wind	Southeast at 5 knots	Calm	Calm
Visibility	4,000 m	4,000 m	4,000 m
Weather	Haze	Haze	Haze
Cloud	6 octas	5 octas Cumulonimbus	5 octas Cumulonimbus
Cloud Base (m)	600	600	600
QNH (mb)	1011	1011	1011

1.7.3 Satellite Image

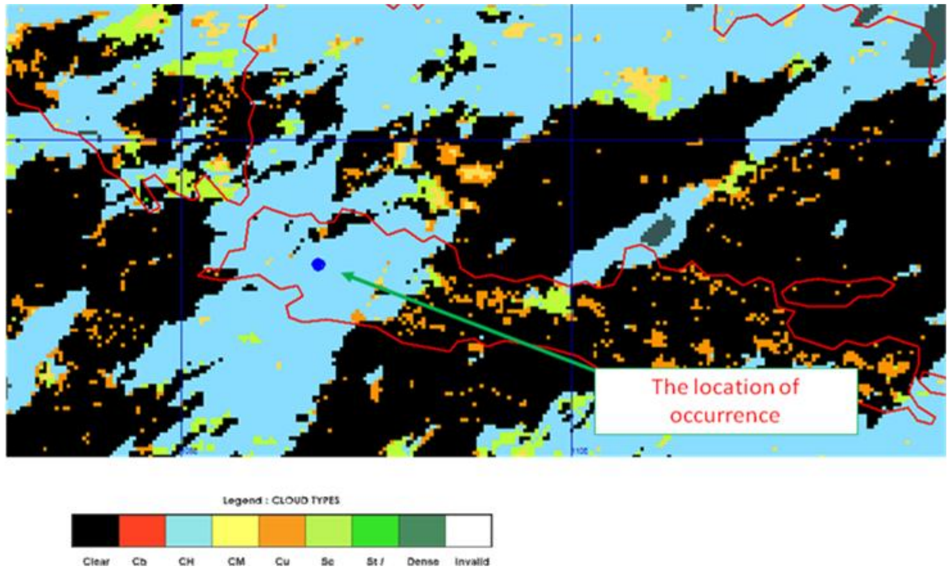


Figure 4: Satellite image at 0700 UTC

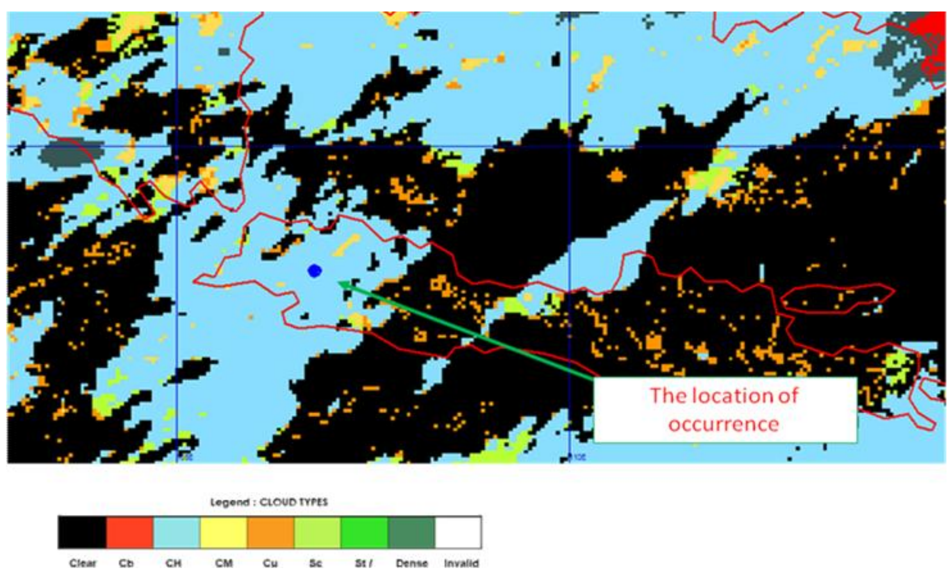


Figure 5: Satellite image at 0800 UTC

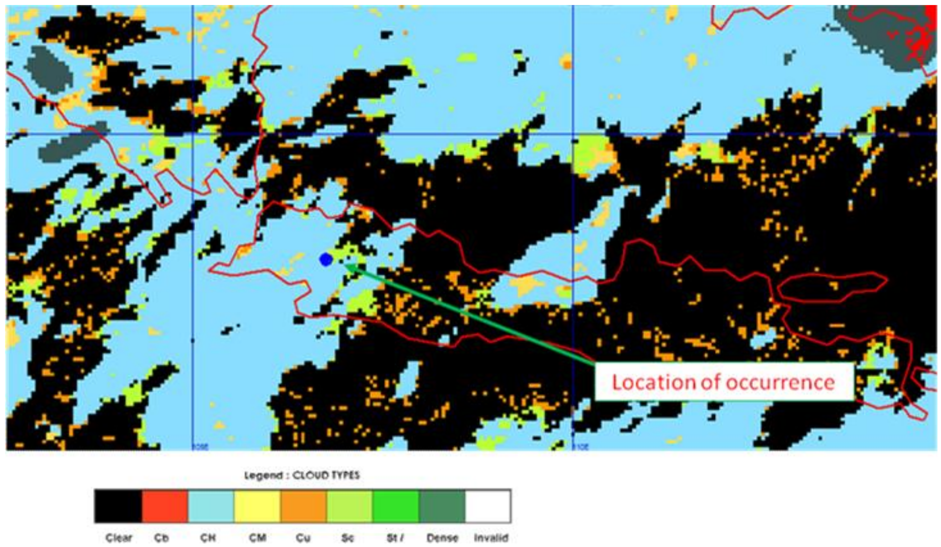


Figure 6: Satellite image at 0900 UTC

1.7.4 Weather Information Excerpt from the Cockpit Voice Recorder (CVR)

The CVR excerpts provided the following information:

At 07:27:52, while the aircraft on descent from 10,000 feet on heading 200 the SIC mentioned “dark cloud ahead”.

At 07:29:18, while the aircraft was making an orbit, the SIC mentioned that sometimes the ground can be seen through the clouds.

1.8 Aids to Navigation

1.8.1 General

The Aeronautical Information Publication (AIP) Indonesia indicated that Minimum Sector Altitude (MSA) within 25 Nm of HLM VOR from 090 degrees clockwise to 270 degrees of HLM VOR was 6,900 feet.

The En-route Chart Indonesia indicated that Area Minimum Altitude (AMA)[6] for the area beyond 25 Nm of HLM VOR was 13,200 feet. The AMA applied to any flight that was flying off the published airways.

There was no information of abnormalities of any ground based navigation aids.

The flight departed from Halim Perdanakusuma International Airport on radial 200 HLM VOR and climbed to 10,000 feet as instructed by ATC. The flight was not on a published airway.

6 Area Minimum Altitude (AMA) provides an obstacle clearance altitude within a latitude and longitude grid block, also known as the Grid MORA (Minimum Off Route Altitude).

The FDR data showed that aircraft navigation equipment such as auto-flight system, Flight Management System (FMS), Inertial Reference System (IRS), Terrain Awareness and Warning System (TAWS) operated normally and the aircraft was flying according to the plan. See appendices 6.1 FDR Data.

1.8.2 Radar Facilities

The Civil Aviation Safety Regulation (CASR) 170.040 Provision of Radar and Automatic Dependent Surveillance – Broadcast (ADS-B) stated:

Radar and ADS-B ground systems should provide for the display of safety-related alerts and warnings, including conflict alert, conflict prediction, minimum safe altitude warning and unintentionally duplicated SSR codes.

Advisory Circular (AC) 170-02, 15.7.4 Minimum Safe Altitude Warning (MSAW) procedures stated:

Note 1.— The generation of minimum safe altitude warnings is a function of an ATC radar data processing system. The objective of the MSAW function is to assist in the prevention of controlled flight into terrain accidents by generating, in a timely manner, a warning of the possible infringement of a minimum safe altitude.

Note 2.— In the MSAW function, the reported levels from transponder-equipped aircraft with Mode C capability are monitored against defined minimum safe altitudes. When the level of an aircraft is detected or predicted to be less than the applicable minimum safe altitude, an acoustic and visual warning will be generated to the radar controller within whose jurisdiction area the aircraft is operating.

According to the Indonesian AIP, the radar services are included as the ATC services.

For the area within Jakarta Terminal Area (TMA), the radar head was located at Soekarno-Hatta Airport.

There was no information of any radar services operation abnormality during the flight.

The radar system at the Jakarta Approach provided several forms of flight alert monitoring, including three conflict alerts (traffic, terrain and airspace) including their predicted alerts. Each alert displayed with a different label and may be accompanied by an aural alarm.

The Airspace Conflict Alert (AS) triggers if any aircraft enters a restricted airspace and the Predicted Airspace Conflict Alert (PAS) triggers when the aircraft is about to enter a restricted area.

For the minimum safe altitude warning function, the Jakarta Approach Radar is equipped with the Terrain Conflict Alert (TR) which triggers if any aircraft altitude is on the same or below the minimum safe altitude, and the Predicted Terrain Conflict Alert (PTR) triggers when the aircraft is close to or approaching the minimum safe altitude.

The Predicted Terrain Conflict and Airspace Conflict alerts are indicated by blinking of the yellow labels of PTR or PAS. The Terrain Conflict and Airspace Conflict alerts are indicated by blinking of the red labels of TR or AS and aural alarm.

The Jakarta Approach radar system was equipped with labels on obstacles such as top of mountains within the area. The terrain information surrounding Mount Salak had not been inserted into the system. The MSAW was not operational although the system had the capability.

The aural warning on the radar was also deactivated, hence all the warnings associated with aural warning only provided a visual warning of the blinking label.

AC 170-02; 8.6.5 Radar vectoring, stated:

8.6.5.3 Whenever possible, minimum vectoring altitudes should be sufficiently high to minimize activation of aircraft ground proximity warning systems.

AC 170-02; 8.6.8 Minimum levels, stated:

A radar controller shall at all times be in possession of full and up-to-date information regarding:

a) established minimum flight altitudes within the area of responsibility;

b) the lowest usable flight level or levels determined in accordance with Chapters 4 and 5; and

c) established minimum altitudes applicable to procedures based on tactical radar vectoring.

The Jakarta Radar service had not established the minimum vectoring altitudes.

Based on the replay of the radar display, it showed that during the flight, the aircraft made an orbit over the WI(R)-4 at an altitude of 6,100 feet and the PAS alert activated. The PTR or TR alerts did not activate when the flight was in the proximity of Mount Salak.

AC 170-02; Chapter 1 General; 2 Scope and purpose, stated:

c. The objectives of the air traffic control service as prescribed in Annex 11 do not include prevention of collision with terrain. The procedures prescribed in this document do not therefore relieve pilots of their responsibility to ensure that any clearances issued by air traffic control units are safe in this respect, except when an IFR flight is vectored by radar.

The following plot was captured from radar replay of the Jakarta Approach which was then superimposed onto Google-earth.

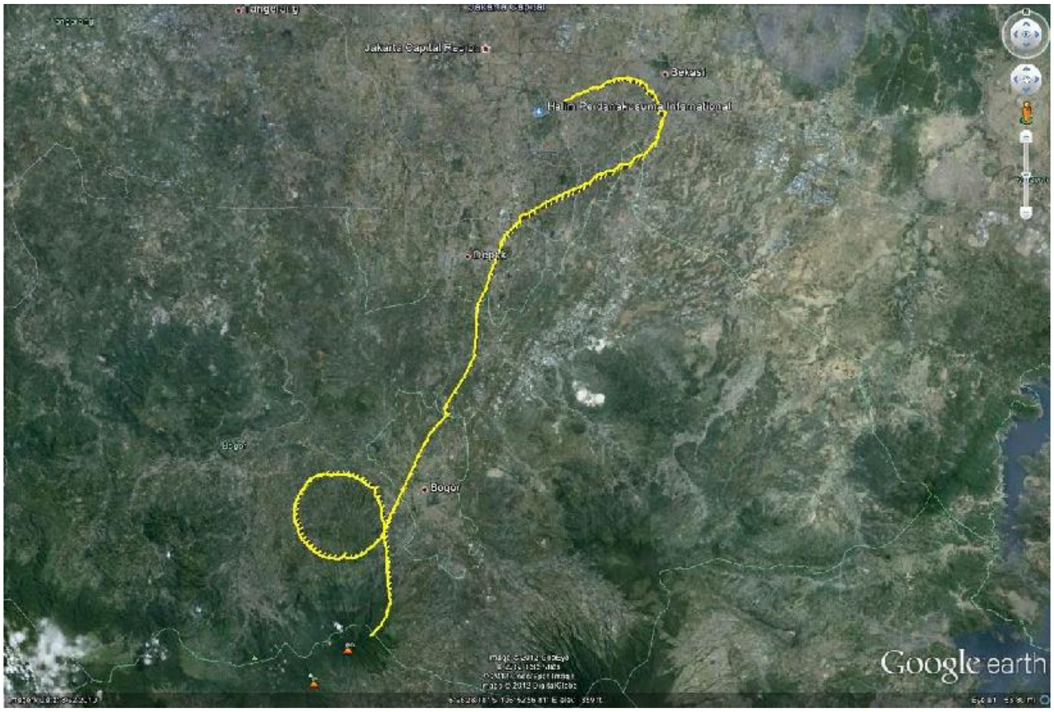


Figure 7: Plot from the radar replay

1.8.3 Relevant Navigation Charts

The navigation chart for the purpose of this flight did not contain information related to the Atang Sanjaya Training Area / WI(R)-4 and the terrain contour.

Figure 8 shows the chart that was available in the aircraft. This chart was typical of an instrument navigation chart that was suitable for en-route flight.

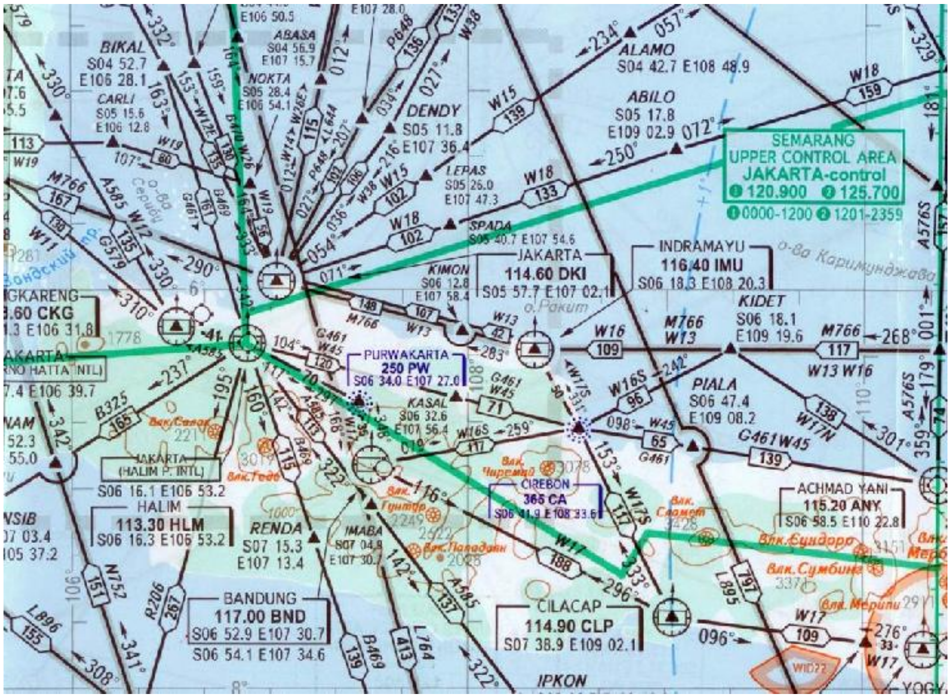


Figure 8: Navigation chart available in the aircraft

Figure 9 shows a sample of instrument navigation chart that provides information includes the Atang Sanjaya Training Area / WI(R)-4 and the terrain contour. This chart was not carried on the aircraft.

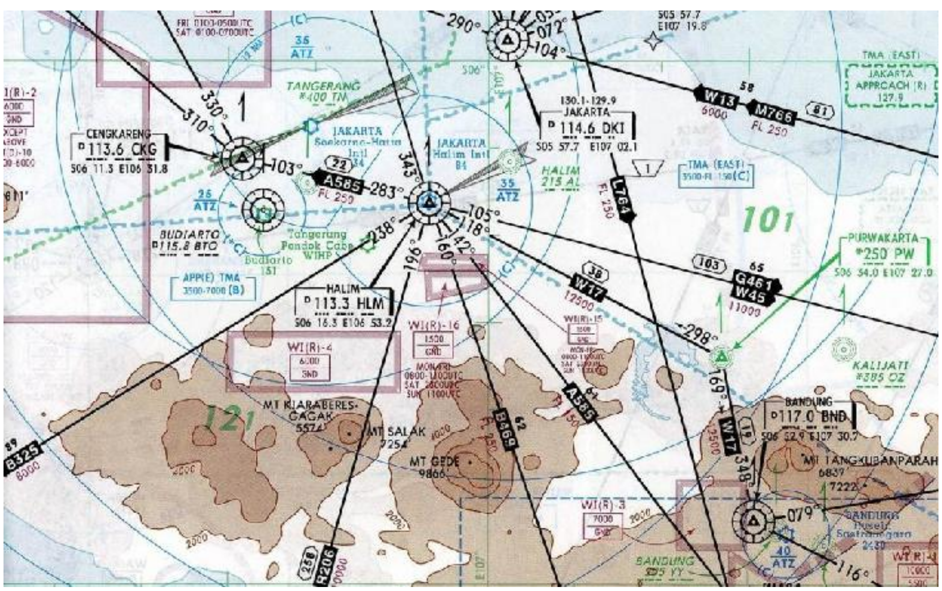


Figure 9: Navigation chart contains information of Atang Sanjaya Training Area and terrain contour

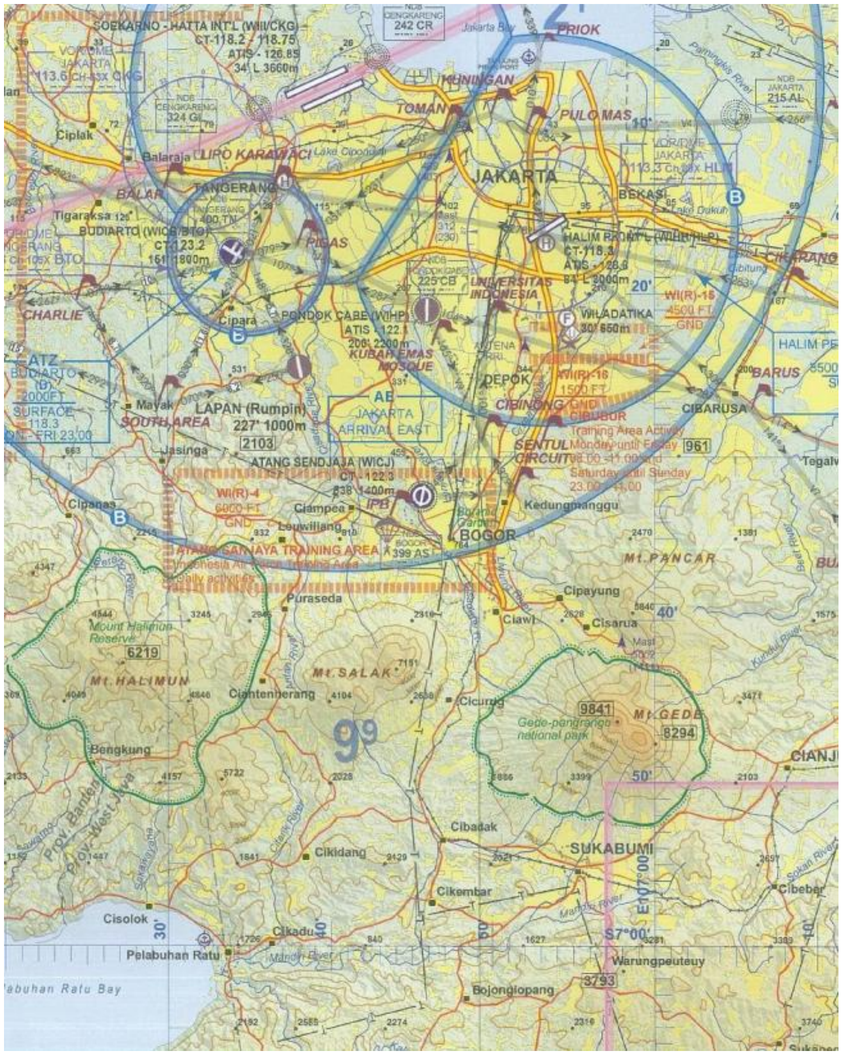


Figure 10: Visual chart

This typical visual chart (figure 10) contains information of the Atang Sanjaya Training Area / WI(R)-4 and the terrain contour which is normally provided by the local government. The investigation was unable to determine if this chart was carried on the aircraft.

1.9 Communications

In the preflight phase, the Halim Tower controller requested a clearance to the Jakarta Approach controller for the flight to the Bogor Area at an altitude of 10,000 feet. This request was approved by the Jakarta Approach controller.

All communication between the aircraft and ATC controllers were established and recorded on the ground based facilities as well as in the CVR.

The communications between ATC and the pilot were as follows:

- 0705 UTC, the pilot requested push back and start;
- 0714 UTC, the pilot requested to taxi. The Halim Tower controller issued a taxi clearance and a squawk number;
- 0718 UTC, the pilot received departure clearance to initially runway heading until passing 2,000 feet then turn right to intercept radial 200 HLM VOR and climb to 10,000 feet;
- 0719 UTC, the pilot received take off clearance;
- 0721 UTC, the Halim Tower controller instructed to the pilot for right turn, continue climb to 10,000 feet and contact Jakarta Approach.
- 0724 UTC, the pilot reported to Jakarta Approach controller that they were established on radial 200 and reaching 10,000 feet. The Jakarta Approach controller instructed the pilot to maintain 10,000 feet and proceed to the area. The pilot replied "maintain 10,000 feet".
- 0726 UTC, the pilot requested descent to 6,000 feet. The Jakarta Approach controller asked the pilot to repeat the request. The pilot repeated the request and the Jakarta Approach controller acknowledged the request by saying "Copied".
- 0728 UTC, the pilot requested to orbit to the right and was approved by Jakarta Approach controller for orbit to the right at 6,000 feet. This communication was the last communication between the pilot and the Jakarta Approach controller.
- 0752 UTC, the Jakarta Approach controller noticed that the target had disappeared from the radar screen, and attempted to contact the pilot but there was no reply.

According to AC 69-01, one set of crew duty for the approach control unit and area control centre consists of one controller, one assistant, one flight data operator and one supervisor.

At that time of the flight, there was no assistant and supervisor, accordingly the controller combined the functions as assistant and supervisor.

During those periods of time, the Jakarta Approach controller was handling about 14 departure and arrival aircrafts.

The voice recorded on the ATC ground based recorder indicated that there were intensive exchanges of communication between the controller and all pilots during that time. The communications were performed continuously one after another.

1.10 Aerodrome Information

Airport Name	:	Halim Perdanakusuma International Airport
Airport Certificate	:	No. 008/SBU-DBU/VII/2010
Airport Identification	:	WIHH / HLP
Coordinate	:	06° 17’ 03” S 106° 53’ 06” E
Elevation	:	84 feet
Airport Operator	:	PT. Angkasa Pura II (Persero)
Runway Direction	:	06 – 24
Runway Length	:	3,000 meters
Runway Width	:	45 meters
Surface	:	Asphalt concrete

The Halim Airport has several instrument approach procedures including ILS Approach procedure for runway 24, VOR Approach procedures for runway 06 and 24, VOR approach procedure runway 24 and NDB Approach procedure for runway 24.

The VOR Approach procedure for runway 06 stated that the turn altitude was 1,600 feet and the Minimum Sector Altitude (MSA) in the area from 090 degrees clockwise to 270 degrees of HLM VOR was 6,900 feet.

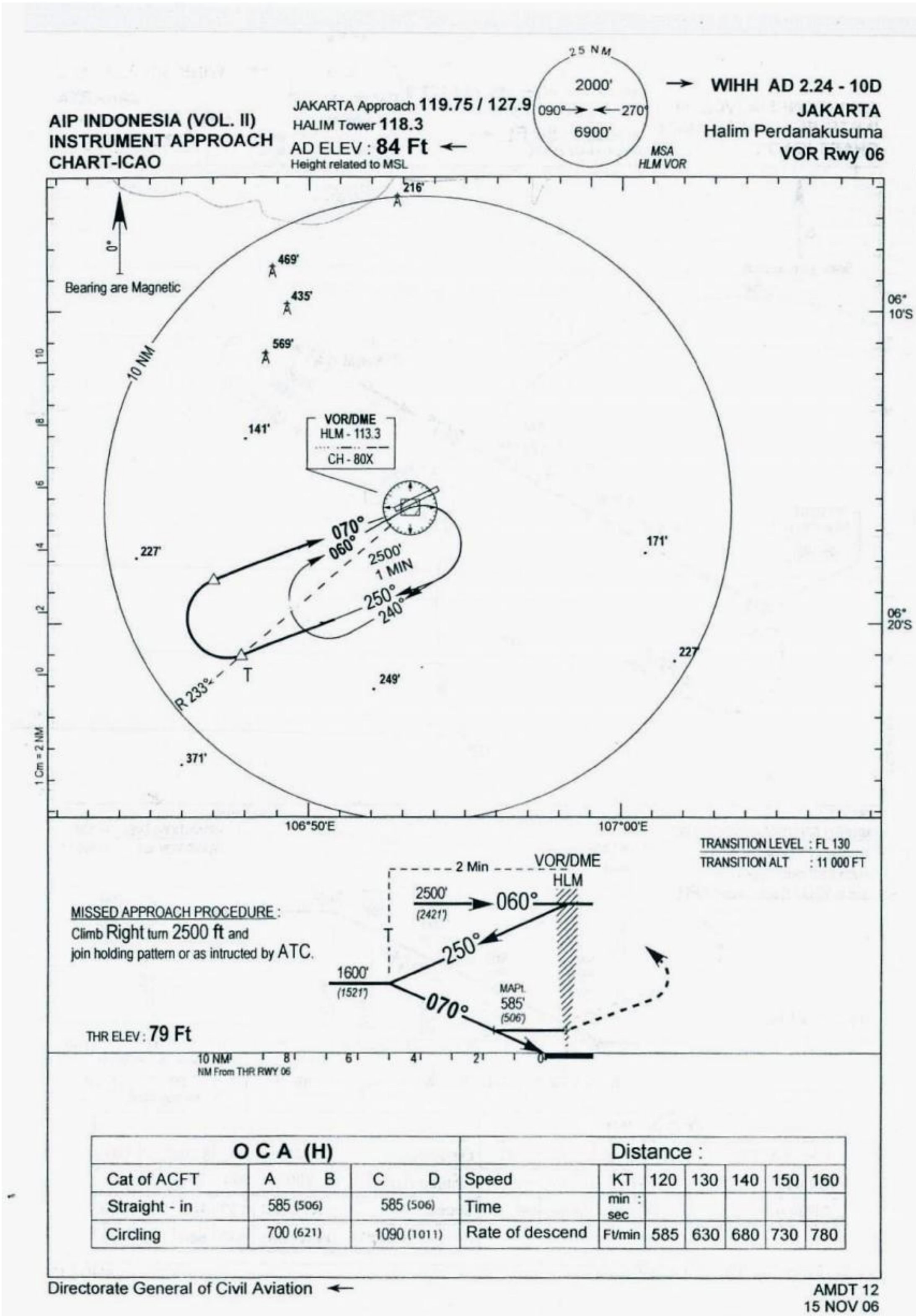


Figure 11: VOR approach procedure for runway 06 Halim

1.11 Flight Recorders

1.11.1 Flight Data Recorder (FDR)

Manufacturer : L3 Communication

Type/Model : FA2100

Part Number : 2100-2043012

Serial Number : 000447319

The Flight Data Recorder (FDR) was recovered from the accident site on 31 May 2012. The FDR was found in relatively good condition. The data was downloaded by the NTSC at its facility and contained 471 parameters for the 150 flight hours, including approximately 22 minutes recording of the accident flight, commencing from engine start.

The Russian experts participated during the download process.

All of the parameters were successfully downloaded and processed. The detailed parameters are attached in the Appendices 6.1 FDR Data.

There was no evidence of aircraft malfunction during the flight.

Several parameters of the FDR are plotted as follows:

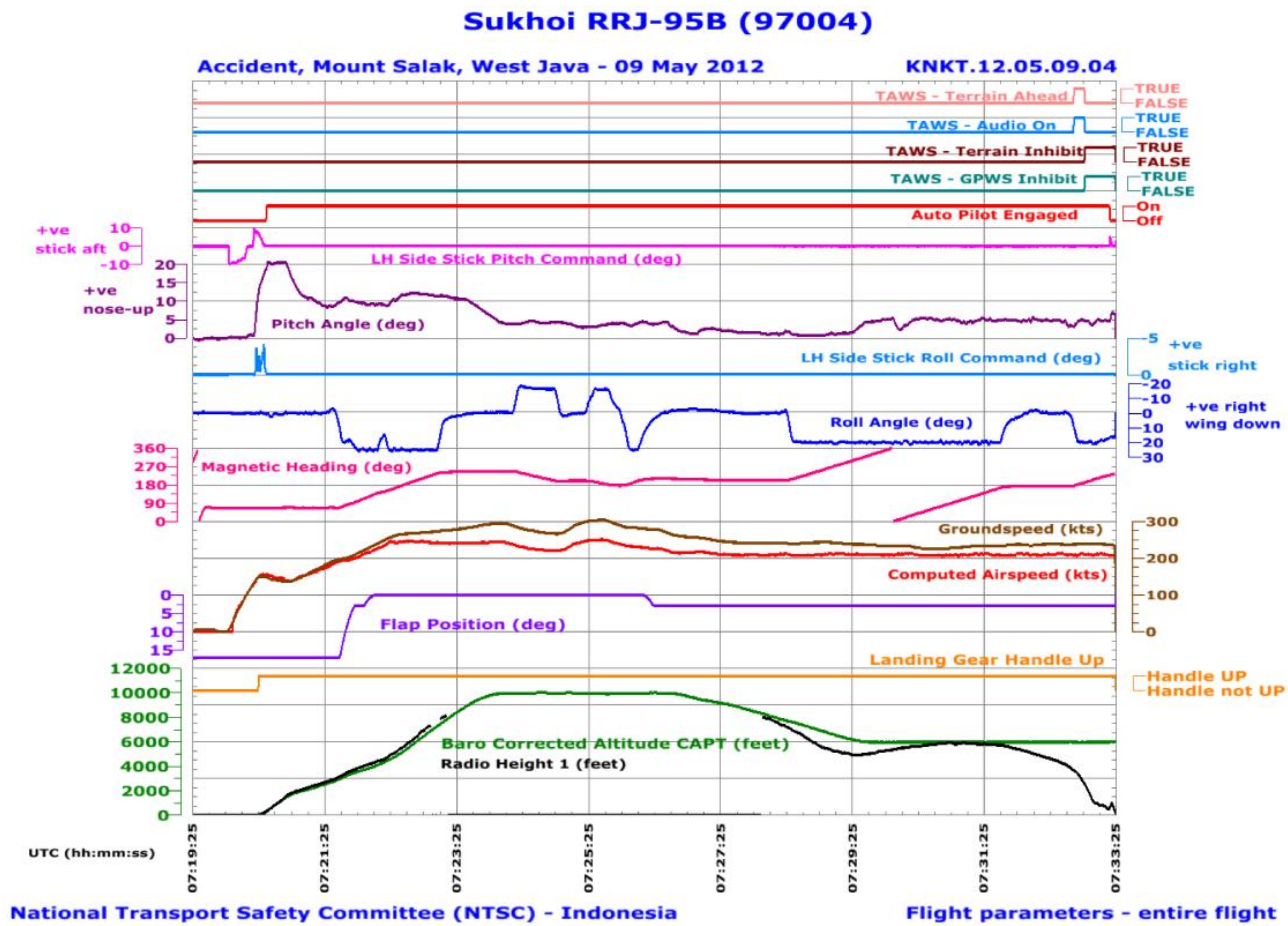


Figure 12: FDR information related to the flight instrument parameters (entire flight)

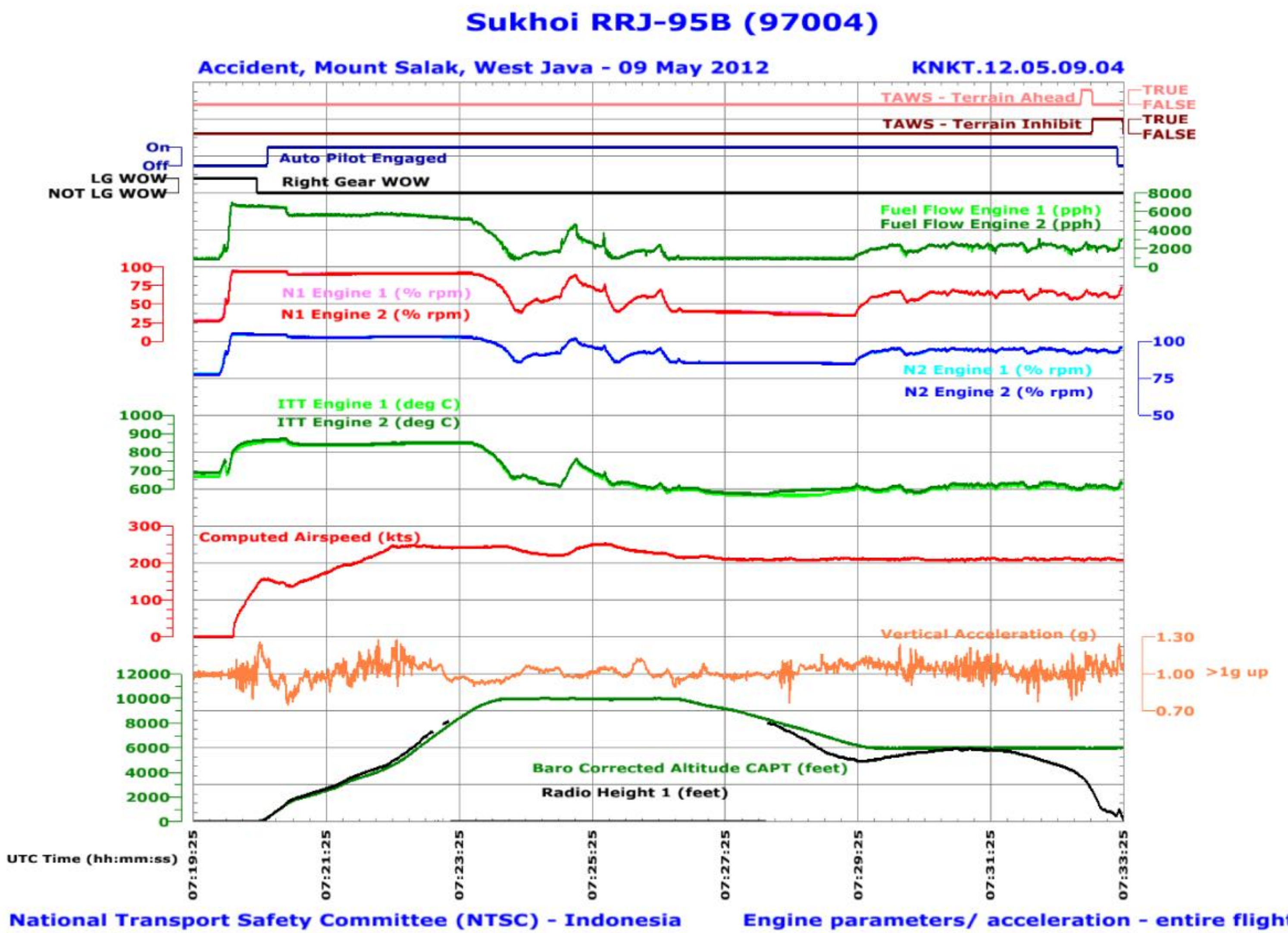


Figure 13: FDR information related to the engine parameters (entire flight)

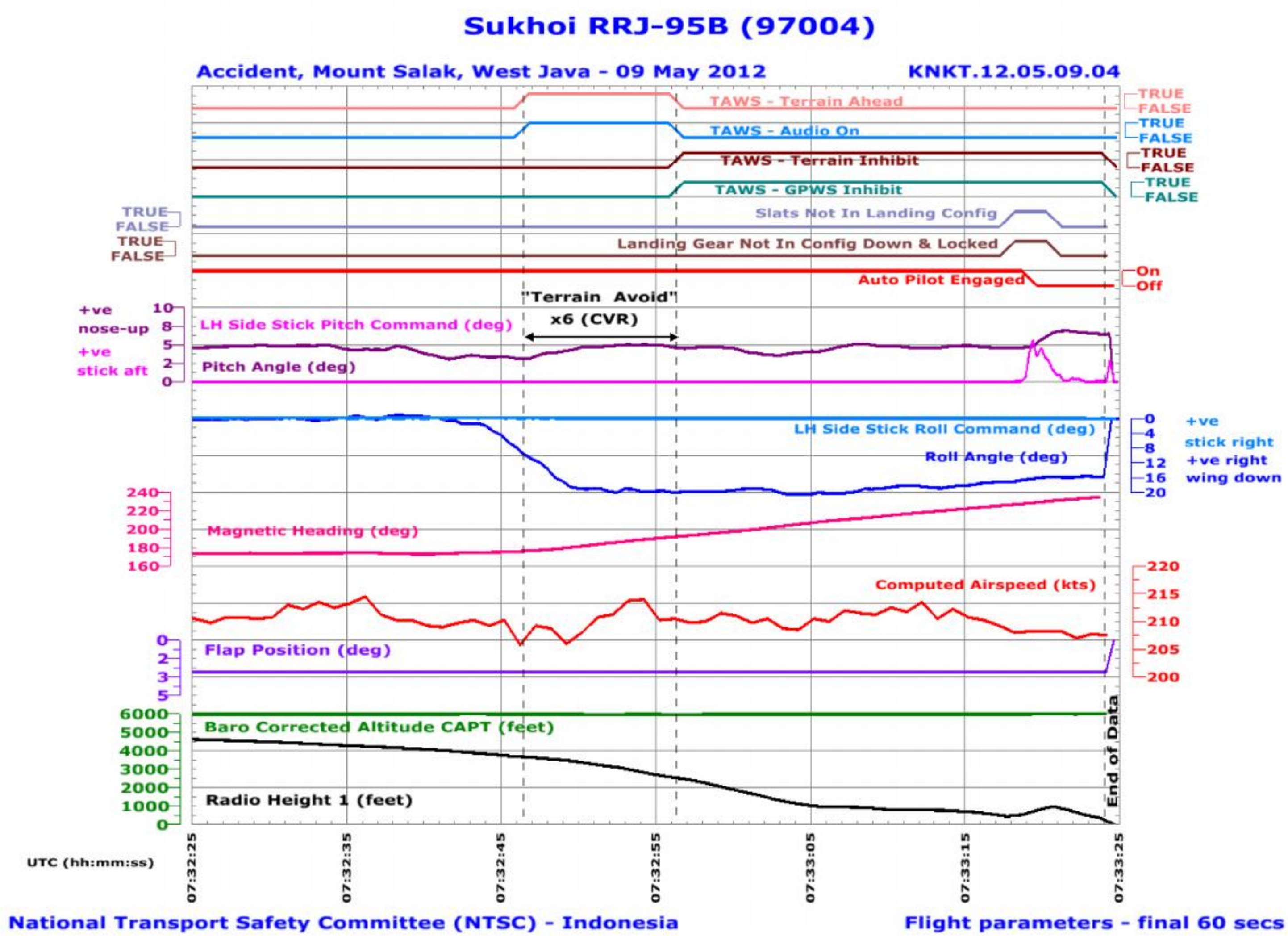


Figure 14: FDR information related to the flight instrument parameters (last 60 seconds)

The flight path of the first (white line) and second demonstration flight (yellow line) based on FDR data (figure 14).

Figure 15: The first and second flight paths

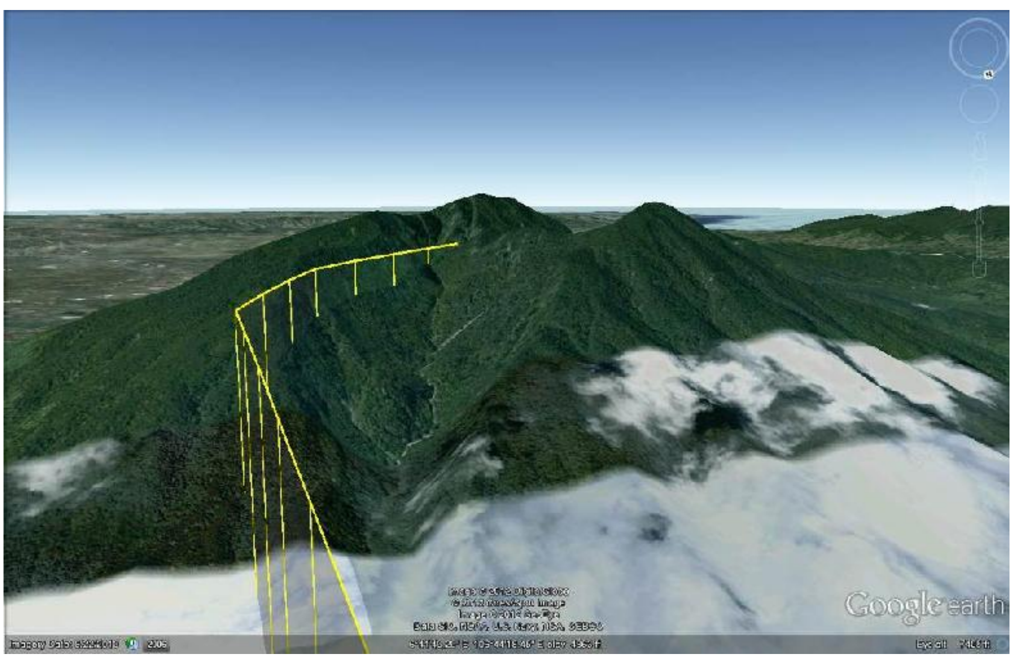


Figure 16: FDR flight path and altitude on the final phase of the flight

1.11.2 Cockpit Voice Recorder (CVR)

Manufacturer	: L3 Communication
Type/Model	: FA2100
Part Number	: 2100-1025-12
Serial Number	: 000501504

The Cockpit Voice Recorder (CVR) was recovered from the accident site on 15 May 2012. The CVR was found partly burnt and bent. However, the memory module was found in good condition. The temperature marking labeled 182°C on the memory module remained intact without any change in color.

The Russian investigation team including representative of the Interstate Aviation Committee (IAC) participated during the opening of the protective shell and setting up the memory module onto a serviceable CVR frame.

The CVR data was successfully downloaded by NTSC at its facility. The CVR contained 124 minutes of good quality recording, including 30 minutes of the accident flight, starting from pilot preparation by reading the checklist.

Several pertinent excerpts from the CVR were superimposed with the flight path derived from the FDR as shown in figure 16.

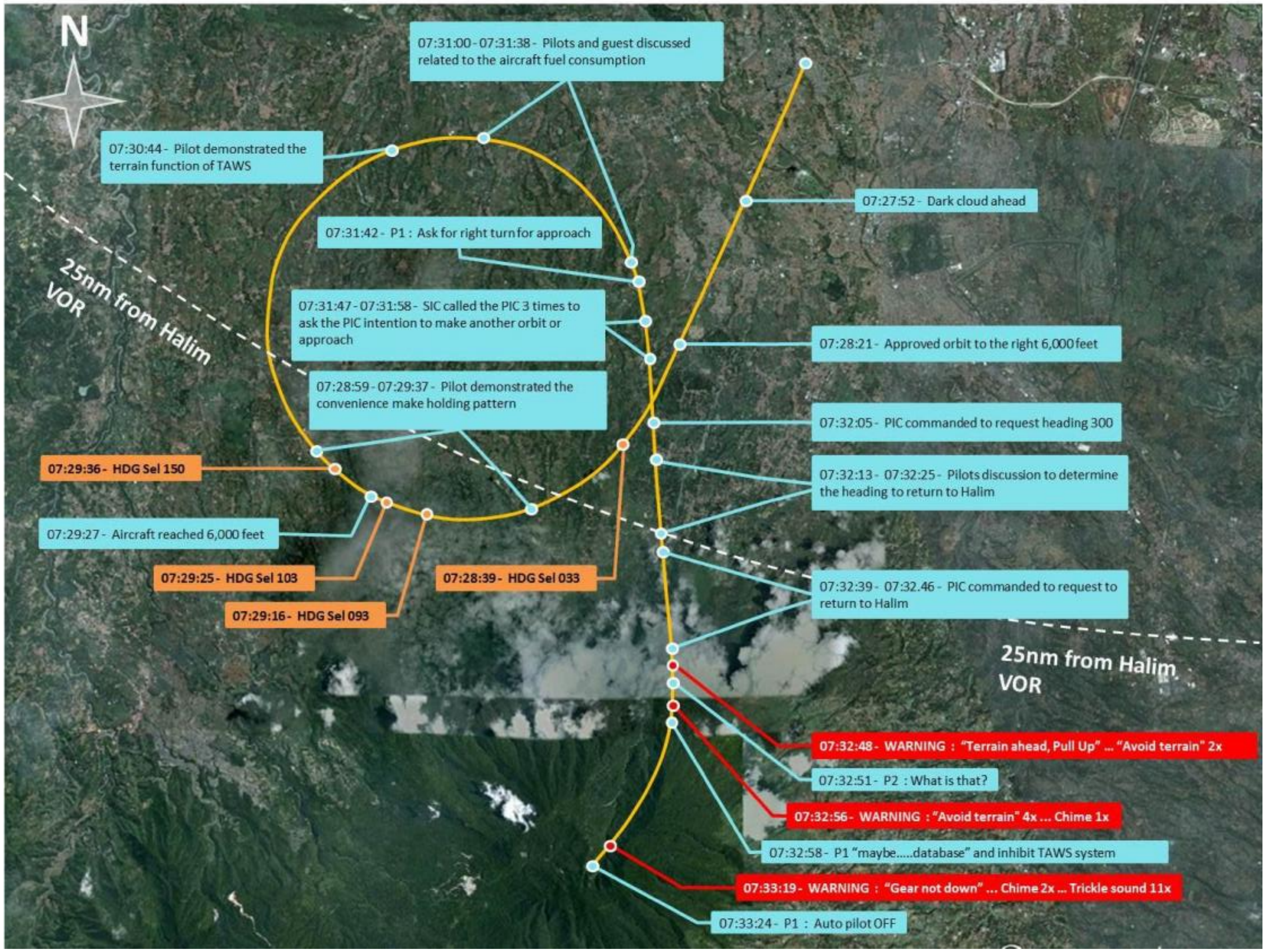


Figure 17: Event link of the final segment of the flight

At the final segment of the recording approximately 38 seconds before the end of recording, there were several alerts and warnings from the TAWS and from the aircraft warning system.

Time	Cockpit Voice Recorder	Flight Data Recorder
07:20:33	(PIC) Autopilot ON	Radio-altitude 343 feet
07:20:34		LNAV mode ON
07:20:49		“Climb “ mode ON Altitude 1500 feet
07:21:08	(PIC) Runway heading	“Heading Stabilization” ON Current heading 67° Altitude = 2065 feet
07:21:19	(TOWER) cleared the flight to right turn, continue climb to 10,000 and contact Jakarta approach.	
07:21:31	(SIC) Acknowledged the ATC instruction.	
07:21:36		Heading set to 116° Flaps retraction command first to FLAP 1 position and after that to FLAP 0 In the process of flaps retraction, heading set to 145° Altitude 2,900 feet IAS 190 knots Right turn initiated with bank angle 20°-24° Flaps retracted.
07:21:46	(PIC) LNAV	LNAV mode ON
07:23:17		The aircraft on heading 244°
07:23:25 – 07:23:40	(PIC) After takeoff checklist reading	
07:24:09		“Altitude Capturing” mode OFF “Altitude stabilization” mode ON Aircraft reached altitude of 9,984 feet IAS 243 knots Heading 245°
07:26:11		Flaps selected to FLAP 1 position Altitude 9,992 feet IAS 230 knots
07:26:22	(SIC) Requested descent to 6,000 feet	

Time	Cockpit Voice Recorder	Flight Data Recorder
07:26:24	(APP) 6,000 feet. Copied.	
07:26:36	(SIC) Descending to 6,000 feet	
07:26:37		Altitude set to 5,984 feet "Descent" and "Thrust stabilization" modes ON Altitude 9,992 feet IAS 220 knots Aircraft started to descend
07:26:41	(PIC) Vertical speed	"Vertical speed stabilization" mode ON Altitude 9,982 feet IAS 216 knots
07:26:47		Vertical speed set to 1,500 feet/min Altitude 9,901 feet IAS 214 knots
07:26:49	(PIC) Check LNAV	
07:27:04		"Descent" and "Thrust stabilization" modes ON Altitude 9,540 feet IAS 218 knots
07:27:24	(PIC) Heading	LNAV mode OFF "Heading Stabilization" mode ON Altitude 9,214 feet IAS 211 knots
07:27:26	The SIC suggested to the PIC to set heading 070 for landing.	
07:27:32	The SIC added that they would land to the opposite runway from the first demonstration flight.	
07:27:52	(SIC) Dark cloud ahead	Aircraft Heading 203°
07:27:53 – 07:28:00	Discussion between a SCAC employee and the PIC regarding to the PIC's decision to descend. The PIC stated that his intention to descend was to prepare for the approach to runway 06, otherwise the altitude would be too high. The PIC stated that another method to lose altitude was to make an orbit.	
07:28:13	(SIC) Requested to Jakarta Approach to make right orbit.	
07:28:21	(APP) Approved orbit to the right, 6,000 feet.	

Time	Cockpit Voice Recorder	Flight Data Recorder
07:28:26		Heading set to: initially 333°, then in sequence 033°, 103°, 150° Altitude = 7,700 feet IAS = 210 knots Aircraft performed a turn with a right bank angle of 19°-20° and descends to 6,000 feet
07:28:37 – 07:28:59	The PIC demonstrated the aircraft ability for making holding pattern on the FMC	
07:29:18	(SIC) Mentioned that sometimes the ground can be seen through the clouds.	
07:29:27	(PIC) Six thousand, ALT STAR.	
07:30:14		Heading selector set to 174°
07:30:44	The PIC demonstrated TAWS feature of "terrain" by displaying the terrain on the EFIS. Furthermore the PIC stated "but no problem with terrain, at this moment".	Aircraft Heading 070°
07:30:48	(Guest) "Ya, it's flat…"	
07:31:00 – 07:31:38	Guest and pilots discussion related to a guest question of aircraft fuel consumption.	
07:31:42	(PIC) commanded SIC to request for right turn for approach.	
07:31:43		Roll angle decreasing
07:31:47	(SIC) Asked the PIC intention whether to make another orbit or return to Halim.	
07:31:52	(SIC) Repeated the previous question.	
07:31:53	(PIC) "What?"	Aircraft reached heading 174°
07:31:54	(SIC) repeated the previous question.	
07:31:55	(PIC) "We will make approach"	
07:31:58	(SIC) mentioned that he will make the request after the turn is completed.	
07:32:05	(PIC) commanded SIC to request now. The PIC then humming tried to determine the heading for return to Halim.	
07:32:13	(SIC) I can check in this LEGs (FMC pages)	

Time	Cockpit Voice Recorder	Flight Data Recorder
07:32:15	(PIC) "Look at LEGs (page) which one?"	
07:32:17	The SIC could not find heading reference for return to Halim on the LEG page. The SIC then calculated the heading by referring to the out bound heading.	
07:32:22	The PIC questioning the SIC's calculation.	
07:32:23	The SIC still could not determine the heading for return to Halim.	
07:32:24	The PIC stated the heading to Halim was 020	
07:32:25	(SIC) OK	
07:32:26	(PIC) On heading 020 for VOR DME approach	
07:32:29	(PIC) Commanded the SIC to request to Jakarta Approach heading 020 and descent to 1,600 feet for VOR DME approach	Aircraft heading 174°
07:32:44		Heading selector set to 325° Aircraft initiated right turn with a bank angle of 20°. Then the bank angle smoothly decreases.
07:32:46	(PIC) "Just request quickly"	
07:32:47	(SIC) Ok.	
07:32:48	TAWS Aural warning: "Terrain Ahead Pull Up"	
07:32:50	TAWS Aural warning: "Avoid Terrain"	
07:32:51	TAWS Aural warning: "Avoid Terrain" (SIC) "What is that?"	
07:32:52	TAWS Aural warning: "Avoid Terrain"	
07:32:54	TAWS Aural warning: "Avoid Terrain"	
07:32:55	TAWS Aural warning: "Avoid Terrain"	
07:32:56	TAWS Aural warning: "Avoid Terrain"	
07:32:58	Chime sound	TAWS inhibited
07:32:58	(PIC) "may be ... data base"	

Time	Cockpit Voice Recorder	Flight Data Recorder
07:33:19	FWS Aural warning: “Gear not down”	Pulse Side Stick (SS) movement to pitch at 5° with duration of 2 seconds resulting in autopilot disengage. The SS movement and FWS aural warning "GEAR NOT DOWN" occurred simultaneously.
07:33:20	Chime sound twice	Pressing SYS and TERR buttons
07:33:21	Trickle sound 11times	Autopilot OFF
07:33:23	(SIC) “What is that?”	
07:33:24	(PIC) Autopilot OFF	
07:33:26	End of recording	

1.12 Wreckage and Impact Information

The aircraft impacted terrain at 6,000 feet ASL on an approximately 85 degree slope ridge. The wreckage was spread over a wide area. Most of the wreckage such as landing gear, engines and vertical stabilizer were found at the bottom of the valley at approximately 500 meters below the impact point.

The area surrounding the impact point was burnt. Some wreckage in that area was found partially burnt.

The aircraft was destroyed by impact forces and post-impact fire.

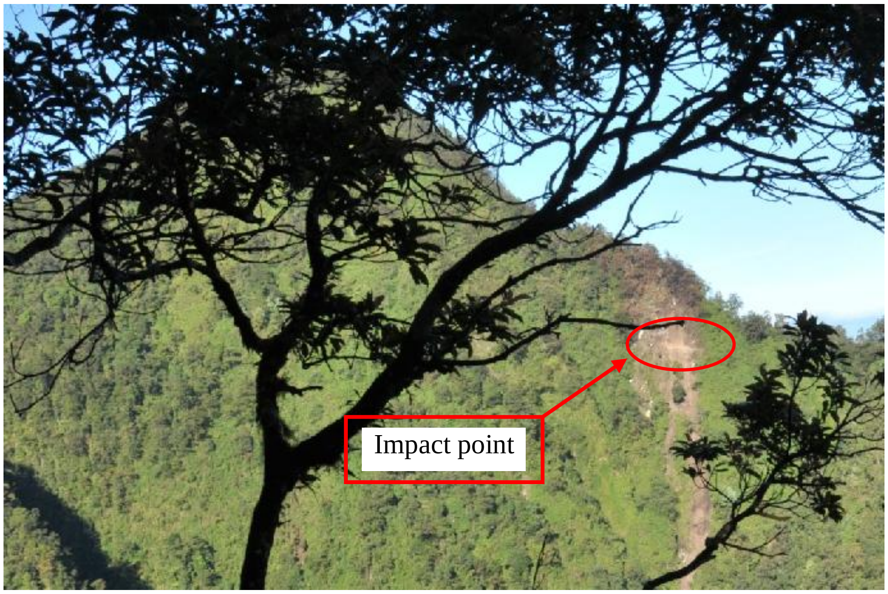


Figure 18: The ridge facing to the east

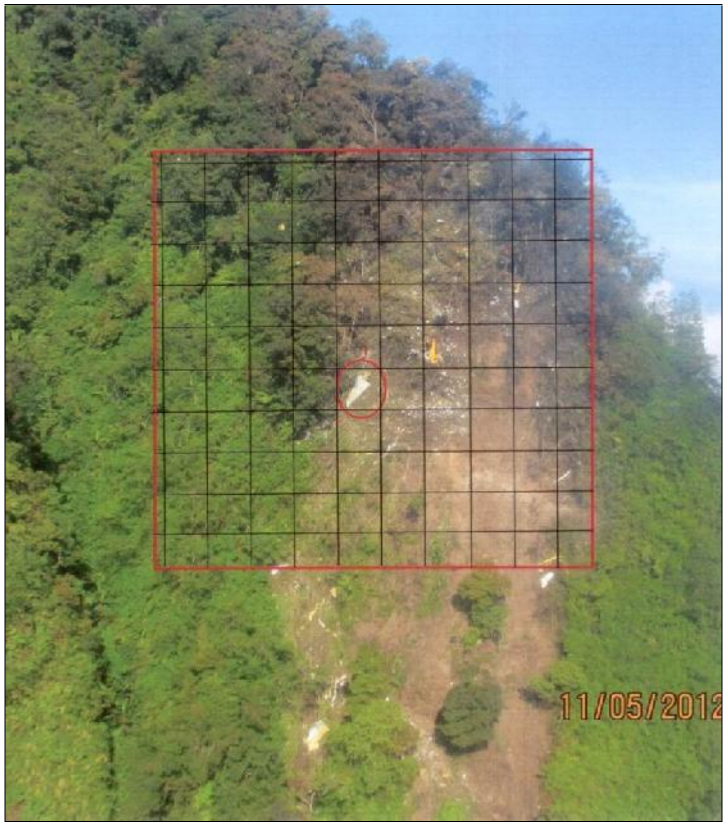
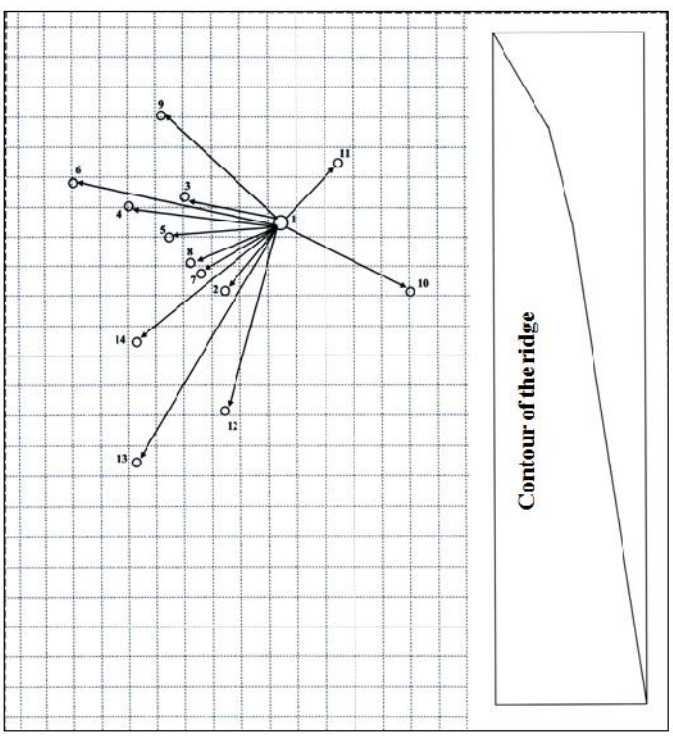


Figure 19: The accident site



Description:

1. Left horizontal stabilizer (as "reference point");
2. Left landing gear and its strut;
3. Pilot seat;
4. TQA (Throttle Quadrant Assembly);
5. Passenger seat;
6. Part of fuselage skin;
7. Aft service door with slide container;
8. Parachute;
9. Wiring;
10. Predicted impact point;
11. Life Raft;
12. Passenger seat;
13. Part of fuselage skin including CVR and FDR unit;
14. Passenger seat.

Figure 20: Wreckage distribution

1.13 Medical and Pathological Information

Identification of the remains of the victims in the accident was carried out by the Department of Forensic Medical Examination of the National Police with participation of specialists from the Russian Centre for Forensic Medicine of the Health Ministry of Russia (Minzdravsotsrazvitie of Russia).

Identification was carried out by means of molecular genetic analysis of the remains.

The report of the pathological and toxicological examinations for both pilots showed that no alcohol or drugs were detected.

1.14 Fire

There was no evidence of in-flight fire.

Evidence of fire was found surrounding the impact point, especially above the impact point. Some wreckage and vegetation in that area were burnt. Wreckage in the valley below was found without any indication of fire. This situation indicated a post-impact fire.

1.15 Survival Aspects

The aircraft was equipped with an Emergency Locator Transmitter (ELT 406 MHz), which was capable of transmitting on 3 different frequencies: 406 MHz, 121.5 MHz, and 243 MHz.

No distress signal was received by BASARNAS, the Australian RCC (Rescue Coordinator Centre), Singapore RCC or Malaysia RCC.

The ELT was found with the antenna detached due to the high magnitude of impact force. The separation of the antenna from the ELT unit explained the reason why no distress signal was transmitted.

Figure 21: Emergency Locator Transmitter with antenna detached

The Jakarta Radar data was used during the search and rescue operation to locate the position of the aircraft.

On 12 May 2012, team of Ministry of Emergency Situations of the Russian Federation arrived in Jakarta to assist the BASARNAS search and rescue operation. The nature of surrounding terrain and weather hampered the search and rescue operation.

On 18 May 2012, the search and rescue operation was terminated.

The accident was not survivable due to the magnitude of the deceleration forces.

1.16 Tests and Research

For the purposes to evaluate the aircraft system and pilot actions on the accident flight, a simulator test was performed using the simulator Flight Training Devices (FTD) at the SCAC facility in Russia. The simulation was performed by the SCAC and the Gromov Flight Research Institute (Russia) test pilots.

The simulation was performed by using FDR recording data. The route of the accident flight was up-loaded in the simulator FMS. The simulator TAWS was up-loaded with a digital map of Indonesia terrain database, the same that was installed in the accident aircraft.

The flight simulations were performed in automatic mode with reproduction of crew actions in-flight, both under clear Visual Meteorological Conditions (VMC) and Instrument Meteorological Conditions (IMC).

The objectives of the simulation were:

- To assess the TAWS operation particularly on the final segment of the accident flight;
- To assess the possibility to prevent collision with the terrain by pilot action in responding of the TAWS warning.

The results of the simulation test were as follows:

- The TAWS was functioning properly and provided correct information to the crew when the aircraft was in proximity to the terrain;
- The collision could be avoided if the crew performed the appropriate actions in response to the TAWS warning.

Conclusion of the simulator test:

The collision with the terrain could be avoided if the crew performed the appropriate actions in responding the TAWS warning within 24 seconds after the first TAWS warning activated.

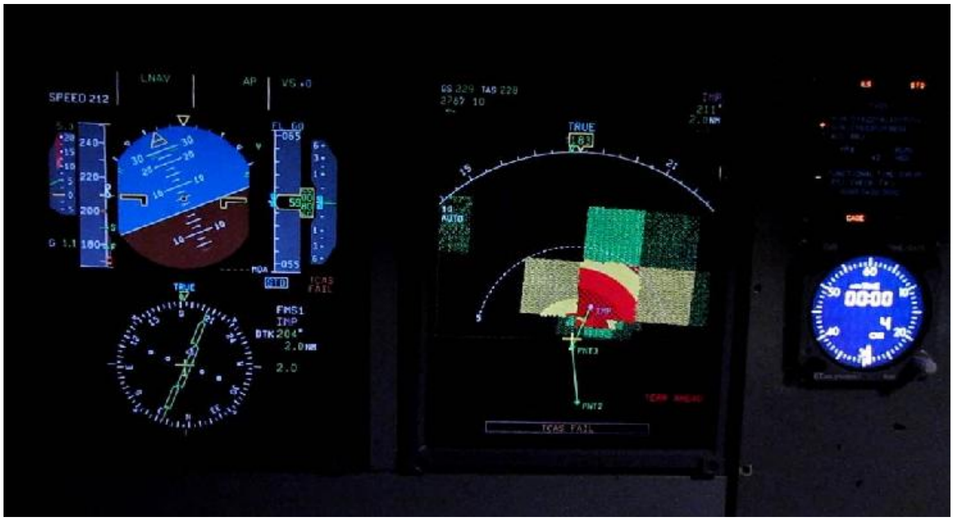


Figure 22: The cockpit instrument displayed in the simulation of the last segment of the flight

1.17 Organizational and Management Information

1.17.1 Aircraft Manufacturer

Aircraft Manufacturer	:	Sukhoi Civil Aircraft Company (SCAC)
Aircraft Manufacturer full name in Russian	:	Закрытое акционерное общество "Гражданские самолеты Сухого"
Address	:	23B, Building 2, Polikarpov Street,
		Moscow, 125284, Russian Federation

SCAC performed the following activities based on the following approvals:

- Development of AE, license No. 10266-AT-R, issued by the Ministry of Industry and Trade of the Russian Federation on 12.05.2009, valid until 12.05.2014;
- Manufacturing of aircraft, license No.10267-AT-P, issued by the Ministry of Industry and Trade of the Russian Federation on 12.05.2009, valid until 12.05.2014;

Activities in the field of experimental aviation, including experimental aircraft operations, are not a subject to licensing in accordance with the legislation of the Russian Federation.

Prior to the accident, SCAC had four RRJ-95/SSJ100 aircraft, including the RRJ-95B serial number 95004, registration 97004, which were operated for the purpose of test, certification, and demonstration.

The SCAC activities related to manufacturing and development are supervised by the Ministry of Industry and Trade of the Russian Federation.

1.17.2 Ground Handling Agency

Sub-contracted Ground handling Agency	:	PT. Indoasia Ground Utama
Address	:	Airside area Flops Centre 05 GL Halim Perdanakusuma International Airport, PO BOX 4161 JKTJ Jakarta 13041, INDONESIA

PT. Indoasia Ground Utama was the sub-contracted ground handling agency used by Sukhoi Civil Aircraft Company to provide services during the promotion/demonstration flights in Jakarta.

The services provided by the ground handling agent was to arrange the ATC flight plan, handling of passengers (customers) and compiled the passenger manifest.

The investigation was not able to obtain a copy of the actual crew and passenger manifest. The investigation was informed by the ground handling agency that the original manifest and its copies were carried on board the aircraft.

1.17.3 Air Traffic Services Provider

PT. Angkasa Pura II is the State-Owned Enterprises engaging in airport and Air Traffic Services in Western Indonesia. Angkasa Pura II managed 12 Airports, including the Soekarno-Hatta International Airport, Jakarta and Halim Perdanakusuma International Airport, Jakarta.

Halim Tower control zone covers an area within a radius of 12 Nm from the HLM VOR with altitude below 3,500 feet. This airspace is classified as Class C.

Jakarta Terminal Area (TMA) was divided into:

- The Jakarta Arrival control zone covers an area within a radius of 30 Nm from the centre of Soekarno-Hatta Airport. The airspace limits are between 3,500 feet up to 7,000 feet. This control zone is classified as Class B.
- Jakarta Approach zone covers an area within 75 Nm from the centre of Soekarno-Hatta Airport. The altitude airspace covers up to an altitude of 15,000 feet. The Jakarta Approach control is divided into two sectors, Jakarta West Control and Jakarta East Control. The airspace is classified as Class C.

The Atang Sanjaya Training Area is within the Jakarta East Control jurisdiction.

1.18 Additional Information

1.18.1 Flight Planning and Coordination

On 9 May 2012, the ground handling agent staff member submitted the flight plans to the briefing office for both demonstration flights. The proposed flights were prepared by the Navigator with the intention to fly within a radius of 20 Nm from Halim airport. The ground handling agent staff member carried 3 copies of the flight plan for each flight, one copy for the flight crew and two copies for the briefing office.

The briefing office staff did not approve the proposed flight plans as the planned route would interfere with the air traffic of Soekarno-Hatta International Airport. The briefing office staff suggested that the flight route be revised to “Pelabuhan Ratu” which was on the 200 radial and 50 Nm from the HLM VOR. The suggestion was accepted by the ground handling staff. The flight was planned to fly at 10,000 feet under the IFR.

The briefing office staff made a correction to the flight plan by adding “HLM-P.Ratu-HLM”, “radial 200” and crossed out the proposed route of “radius 20 Nm”. Meanwhile, the ground handling staff made a correction on his copy of the flight plan by adding “radial 200” in the column “route”.

Prior to the second flight, the PIC stated that he wanted to change the route to radial 160 of HLM VOR then a right turn onto the 200 radial. The ground handling staff reported that he called the briefing office and told them of the PIC’s request. The briefing office staff could not recall that he received such a phone call.

The Halim Tower controller on duty heard a conversation among the briefing office staff that the first flight was performed over the “Bogor Area”, and assumed that the second flight would be conducted in the same way.

The Halim Tower controller informed the Jakarta Approach controller, about the intended route to the “Bogor Area” at an altitude of 10,000 feet and this was approved by Jakarta Approach.

The area chart was given to the crew that was obtained from the briefing office. The area chart did not contain any terrain information.

The flight training area is airspace with the limit of boundaries with minimum and maximum allowed altitude. Atang Sanjaya Training area / WI(R)-4 is a restricted area/military training area located near Bogor city. This area is commonly named as “Bogor area”. The Atang Sanjaya Training Area is located at 17 Nm from HLM VOR and has a rectangular area of 7 x 20 Nm. The altitude limit of the area is from ground level to 6,000 feet. The airspace over the Atang Sanjaya Training Area at altitudes above 6,000 feet is not a military training area.

The Jakarta Flight Data Officer (FDO) received the flight plan from the briefing office and entered the data into the Flight Data Edit Display (FDED). He selected the aircraft type as Sukhoi 30 (Su-30) as the database on the FDED did not include the Sukhoi RRJ-95B.

After accepting the flight under his jurisdiction, the Jakarta Approach controller on duty wanted to know the particular information of the flight by checking on the FDED in his radar display. The FDED showed that the flight was a Su-30 (Sukhoi military aircraft). After checking this information, the controller believed the flight was a military Sukhoi aircraft that was flying to the Bogor Area for a test flight. The controller realized that the missing aircraft was a civil aircraft Sukhoi RRJ-95B only after he called the Halim Tower controller.

1.19 Useful or Effective Investigation Techniques

The investigation was conducted in accordance with the NTSC approved policies and procedures, and in accordance with the standards and recommended practices of Annex 13 to the Chicago Convention.

2 ANALYSIS

This analysis will discuss the factors associated with the collision with terrain involving the Sukhoi RRJ-95B that occurred on 9 May 2012. The analysis will discuss the sequence of events, flight preparation, ATC workload and pilot situational awareness.

Information obtained from the CVR and FDR recorded data showed that the aircraft, engines and systems were not factors in the accident.

2.1 Sequence of Events

07:26:37 Altitude set to 5,984 feet; "Descent" and "Thrust stabilization" modes ON; Altitude 9,992 feet; IAS 220 knots; Aircraft initiated the descent.

The aircraft started to descend from 10,000 feet to selected altitude of 6,000 feet at a speed of 220 knots.

07:26:37 “We are going to land to the opposite runway” (of the first demonstration flight).

This indicated that the aircraft would land on the runway 06, while the first demonstration flight landed on runway 24.

07:27:55 There was a discussion between the PIC and a SCAC employee who asked the intention of the descent.

The PIC stated that the intention of the descent was for preparation to land on runway 06 at Halim, otherwise they would be too high for the approach.

The PIC explained further that another method if they were too high was to make an orbit.

The pilot intention to descend to 6,000 feet and subsequently make an orbit was to lose altitude. The intended landing runway was runway 06. The aircraft position at that time was too high to make an approach. This situation differed to the first demonstration flight that landed on runway 24.

The decision to orbit might be due to the fact that the flight had reached the point as approved on the flight plan as assumed by the pilot, which was on the 200 radial and 20 Nm from the HLM VOR.

07:27:52 (SIC) “Dark cloud ahead.” Aircraft heading was 203°.

The SIC mentioned that there was dark cloud ahead while the aircraft was heading towards the Mount Salak area. This indicated that the area around Mount Salak was cloudy.

07:28:37 - 07:28:59 The PIC demonstrated the aircraft ability for holding using Flight Management Computer (FMC) entry data.

07:29:18 The SIC stated that sometimes the ground can be seen through the cloud.

This statement indicated that the area around the aircraft was partially cloudy. According to the FDR data, the area of the orbit was over the Atang Sanjaya Training Area.

07:30:44 The PIC demonstrated the aircraft TAWS system feature of "TERRAIN". Furthermore the PIC stated that kind of information was not necessary at that moment. The guest who sat in the cockpit commented "Ya, it's flat…". At that time, the FDR data showed that the aircraft was on a heading of 070°.

The PIC demonstrated the TAWS feature by activating the terrain display on the EFIS. At that moment, the aircraft was heading to the north east toward the Java Sea, so that the terrain display might not indicate any terrain information due to the flat area ahead.

The PIC mentioned that the terrain function was not necessary and it was confirmed by the guest that it was flat. The flat area as stated by the guest may be the area in front of the aircraft which was covered by TAWS on that aircraft heading.

The guest statement could have affected the PIC's perception that the whole area surrounding the flight path was flat.

During the period of 07:30:44 - 07:31:38 (54 seconds) there was discussion in the cockpit which was not related to the progress of the flight.

07:31:42 The PIC asked the SIC to request a right turn for return and approach. The SIC did not respond.

07:31:47 The SIC asked the PIC's intention to continue the orbit or return to Halim.

This question was not responded to by the PIC and the SIC repeated the question 3 times. The PIC replied that he intended to return.

07:31:43 The FDR data revealed that the roll angle was decreasing.

07:31:53 Aircraft reached a heading of 174 degrees.

07:31:58 The SIC then mentioned that he would make the request to Jakarta Approach controller after the orbit was completed. The PIC commanded the SIC to make the request immediately.

The orbit was performed by selecting the 'heading selector' on the Main Control Panel (MCP) initially to 333° and subsequently to 033°, 103°, 150° and 174° at 07:30:14.

The reducing roll angle indicated that the aircraft heading was close to the intended heading. The aircraft then stopped the turn and flew on a heading of 174° as selected on the 'heading selector'. At this point, the aircraft had exited the orbit. The orbit was initiated while the aircraft was on heading of 200° and stopped on a heading of 174° instead of returning to a heading of 200°. The complete 360° orbit had not been completed.

The PIC set the heading to 174° at 07:30:14 and subsequently his attention was distracted with conversation not related to the progress of the flight. The pilots may not have noticed that the aircraft had exited the orbit and assumed that it was still continuing to turn. This was evident as at 07:31:58, the SIC mentioned that he would make the request to Jakarta Approach controller after the orbit was completed, however the aircraft had stopped turning at 07:31:53.

The PIC action of turning the ‘heading selector’ indicated that the PIC was familiar with the autopilot basic mode. This skill is stored in the motoric program and can be executed without requiring the central decision process. The typical skill base error may occur during any distraction or degradation of situational awareness. This type of error can be characterized as either a slip or lapse.

07:32:13 - 07:32:25 There was a discussion between the pilots to determine the heading to return to Halim.

It took several seconds for the SIC to determine the direction to return to Halim. The investigation could not determine the reason for this. The SIC exclamations of determining the direction to return to Halim may have distracted the PIC.

07:32:29 The PIC commanded the SIC to request a right turn to a heading of 020° and descent to 1,600 feet.

The intention to descend to 1,600 feet was to descend to the Turning Altitude for the VOR Approach to runway 06 at Halim.

At this time, the aircraft was flying on a heading of 174° for approximately 4 Nm. The PIC’s intention to descend indicated that he was not aware of the mountainous area surrounding the flight path.

07:32:44 The FDR recorded that the ‘heading selector’ has changed to 325° and the aircraft commenced a right turn with a roll angle of 20°.

07:32:48 TAWS aural warning: “Terrain Ahead Pull Up”.

07:32:50 – 07:32:56 TAWS aural warning: “Avoid Terrain (6x)”.

07:32:51 (SIC) What is that?

The aural warning from the TAWS activated as the aircraft started to roll to the right. Once the aircraft initiates a turn, the forward looking function of the TAWS uses the aircraft turning rate to extrapolate terrain conflict detection over the full terrain area underlying the projected turn between the present aircraft track and the track that is projected by the turning rate, up to 90°.

The TAWS warning “Terrain Ahead Pull Up” means that the predicted flight path will collide with the terrain contained within the internal database within 120 seconds and a pull up (immediate climb) action is required to avoid a collision.

The TAWS warning changed to “Avoid Terrain” 6 times. This warning means that the predicted flight path collided with the internal terrain database within 120 seconds and a pull up and an alternate course of action (left or right turn) may be required to avoid a collision.

During the simulator exercise, at the activation of the TAWS warning “Avoid Terrain”, the Navigation Display both on the PIC and SIC (ND1 and ND2) automatically switched to Terrain Mode (TERR) with a scale of 10 Nm. A solid red cell with black cross hatches was displayed between the headings of 190° and 230° at a distance of 1 up to 3 Nm. ND1 and ND2 displayed on the upper right corners accompanied by “TERR AHEAD” message flashing in red.

In the middle of these warning activations, the SIC asked “What is that?” This expression could be interpreted as “Why is that”. This expression indicated that the SIC was surprised with the warning and he did not expect that the warning would activate. This indicated that the SIC was not aware of the mountainous area surrounding the flight path.

07:32:58 Chime (1x). FDR revealed that the TAWS system was inhibited.

07:32:59 (PIC) “may be ... data base”.

The FDR data revealed that the SYS and TERR button of the TAWS were switched off. This indicated that the PIC inhibited the TAWS system. The chime indicated the deactivation of the TAWS. The PIC inhibited the TAWS assuming that the warning might be triggered by a problem with the TAWS terrain database.

The PIC did not react appropriately to the TAWS warnings, this indicated that he did not appreciate the significant of the warnings.

The simulator test showed that, after the TAWS was inhibited, the display of dangerous terrain (solid red cell with black cross hatches) disappeared from ND1 and ND2, also the aural and visual alerts (TAWS function) were off.

For 20 seconds after the PIC statement relating to the database (07:32:59) until the activation of the aural aircraft warning system (07:33:19), there was no conversation between the pilots. Meanwhile, the PIC command at 07:32:29 to request return to Halim has not been executed. There was no further discussion related to the progress of the flight. This may have occurred due to excessive task demands or information within a short period.

07:33:19 Aural aircraft warning system “Gear Not Down”. The FDR revealed a pulse on Side Stick (SS) movement of pitch to 5° up with a duration of 2 seconds.

07:33:20 Chime (2x)

07:33:21 Trickle sound (11x)

07:33:23 (SIC) “What is that?”

07:33:24 (PIC) “Autopilot OFF”

The aural warning of “Gear Not Down” was from the aircraft warning system. This warning activated whenever the aircraft height was below 800 feet above ground level (AGL) and the landing gear was not down. The TAWS (GPWS) mode 04 has a similar warning of “Too Low Gear”.

The PIC manually activated the side stick to 5° pitch up, this action resulted in the autopilot disengaging. The disengagement of the autopilot was indicated by the trickle sound warning. It was also stated by the PIC that the autopilot was turned off.

The action of the PIC to manually fly by operating the side stick to pitch up at 5° could not be an indication of an attempted escape action. Normally an escape action requires flight control pull up, advance engine power to go around power (TOGA) and speed brake retract. The investigation could not determine the reason of the PIC’s action.

The simulator test showed that a successful recovery action had to be initiated within

24 seconds after the first TAWS warning (07:32:48). After this time, any pilot action would not successfully avoid collision with terrain.

2.2 Flight Preparation

The proposed flight plan had been revised and was agreed by the ground handling and Halim briefing office staff. The agreed flight plan was to fly to "Bogor Area". The proposed flight plan did not contain information of the area and only contained the 200 radial and 20 Nm.

The briefing office staff informed the Halim Tower controller that the flight would be performed in the "Bogor Area". Furthermore, the Halim Tower controller informed Jakarta Approach controller of that information.

There was a different understanding between the pilots and the ATC relating to the intended flight plan. Both Halim Tower controller and the Jakarta Approach controller understood that the flight would be performed in the "Bogor Area". However, given that the previous demonstration flight reached the point on the 200 radial at 20 Nm from HLM VOR it is likely that the pilot believed that the second demonstration flight was approved to the same point.

The chart available on board the aircraft (see figure 8) did not contain the information of the Atang Sanjaya Training area. Without this map the pilot may not have been aware of the location of the Atang Sanjaya Training area and the surrounding mountainous area.

The incomplete briefing and inadequate information on the flight plan suggested that the pilot would not have been aware of the "Bogor" area including the area boundaries and altitude limitations.

2.3 Flight Altitude

The flight was planned to the "Bogor" Area at 10,000 feet under the IFR. The "Bogor" area is located at 17 Nm from HLM VOR within the MSA of HLM VOR which was 6,900 feet. Beyond 25 Nm from HLM VOR, the minimum altitude would be the Area Minimum Altitude (AMA) which was 13,200 feet.

The Jakarta Approach controller checked the FDED and found information that the flight was a Su-30 (Sukhoi military aircraft). After checking this information, the controller's understanding of the aircraft type was that it was a Sukhoi military aircraft and that it was flying to the "Bogor" Area for a test flight.

The Jakarta Approach controller was not concerned about the limits of the Atang Sanjaya Training (Bogor) area which are from ground level up to 6,000 feet. The Jakarta Approach controller assumed that a military aircraft was eligible to fly in this area. As a result, the Jakarta Approach controller approved the aircraft to descend to 6,000 feet.

2.4 Minimum Safe Altitude Warning (MSAW)

The objective of the MSAW function is to assist in the prevention of Controlled Flight Into Terrain (CFIT) accidents by generating, in a timely manner, a warning of the possible infringement of a minimum safe altitude.

Based on the replay of the radar display, the evidence showed that the flight made an orbit over the "Bogor" area (WI(R)-4) at an altitude of 6,100 feet and the Predicted Airspace (PAS) alert activated.

The Predicted Terrain (PTR) or Terrain (TR) alerts were not active while the flight was in the proximity of Mount Salak. There was no warning to the Jakarta Approach controller relating to the aircraft's position, relative to Mount Salak.

2.5 ATC Workload

The voice recorded on the ATC ground based recorder indicated that, in the period prior to the accident, there was an intensive exchange of communication between the controller and all pilots within the ATC area of responsibility. The communications were performed continuously one after another, practically without pause.

During that period, the controller was handling 13 other aircraft. The intensive exchange of communications required the controller to transfer his attention quickly from one aircraft to another. The quick transfer of attention might have led the controller to concentrate only on the aircraft being communicated with. Consequently, the aircraft under his area of control which were not directly in radio communication might not have been closely monitored. This situation was one of the factors that may have contributed to the Jakarta Approach controller not noticing that the Sukhoi aircraft had disappeared from the radar screen for a period of about 24 minutes.

It was stated during interview that the Jakarta Approach controller felt over-loaded. At that time there were no assistants or supervisor as stated in Advisory Circular (AC) 69-01, so that the controller covered the jobs of assistant, controller and supervisor. As an Air Traffic Service provider, the Angkasa Pura II is required to conduct an assessment on the capacity management including controller workload. In order to perform such an assessment, there are several criteria to be employed as stated in AC 170-02 Paragraph 3.1 Capacity Management (see Appendices 6.2).

It has been broadly accepted that adult human working memory capacity average is seven plus or minus two unrelated items[7]. The term 'working memory' refers to a brain system that provides temporary storage and manipulation of the information necessary for such complex cognitive tasks as language comprehension, learning, and listening. Once the limit is exceeded, one or more items are likely to be lost or transposed.

The Jakarta Approach controller was controlling 14 aircraft and performing additional tasks as assistant and supervisor. These additional tasks, added to the controller workload.

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7 Source taken from "Engineering Psychology & Human Performance" author Christopher D. Wickens & Justin G. Hollands, Prentice Hall, 2000.

2.6 Pilot Situational Awareness

During the pre-flight briefing, the ground handling agent briefed the navigator concerning information on the flight plan which had been agreed by the ground handling agent and the briefing office staff. The flight plan contained a statement advising of the 200 radial at 20 Nm from HLM VOR. There was no information given by the ground handling agent related to the agreed area of Atang Sanjaya Training area (Bogor Area) to perform the flight.

This limited information may have given the pilot the understanding that the approved route was toward the point on the 200 radial at 20 Nm from HLM VOR and return to Halim. Evidence from the FDR data as shown on figure 14, showed that the first and the second demonstration flights reached this point. Understanding that the approved route was to a point instead of an area, may have contributed to the pilot's lack of awareness of the "Bogor" area.

The area chart obtained from the briefing office that was handed to the crew did not contain any terrain information.

The chart available to the pilot is shown on figure 8. This chart contains information of the height of the mountain, but did not depict the "Bogor Area" and had limited terrain information.

The instrument chart, shown as figure 9, contained terrain contour and "Bogor Area", and the visual chart, shown as figure 10, may have provided a better understanding to the pilot that the point they intended to fly to was close to a mountainous area. These charts were not carried on board the aircraft.

At 07:30:45 when the aircraft was turning at 6,000 feet and was passing through a heading of 070°, there was a discussion between the pilot and a potential customer who was sitting on the observer seat. The pilot demonstrated the ability of the aircraft with the TAWS system by putting the terrain information on the Navigation Display. In the direction of the flight there was no mountain visible on the display. The pilot stated that, at that moment, the terrain display was not necessary. The potential customer confirmed by stating "yes, its flat". This information may have built an assumption for the pilot that the area surrounding the flight manoeuvre was flat, since the information was given by the TAWS and by an Indonesian who understood the area well.

At 07:27:52 while the aircraft was descending from 10,000 feet on a heading of 200° the SIC stated "dark cloud ahead". At that time, the aircraft was heading toward the Mount Salak area. This statement indicated that the area of Mount Salak was covered by dark cloud.

At 07:29:18 while the aircraft was in the orbit area, the SIC mentioned that the ground sometimes could be seen through the clouds. This statement indicated that the area where the aircraft was orbiting was partially cloudy.

This cloud situation was confirmed by the weather report from Darmaga BMKG station in which the cloud base was reported at 600 meters.

It is reasonable to conclude that the cloud cover prevented the pilot's being able to see the mountainous terrain.

Due to the factors stated above, it is likely that the pilot's were not aware of the mountainous terrain in the vicinity of the flight route.

The pilot's lack of situational awareness may have been affected by the following facts:

- At 07:32:51 and 07:32:59, the SIC was surprised by the TAWS warnings AVOID TERRAIN;
- At 07:32:29 and 07:32:46, the PIC commanded the SIC to request heading 020 and descent to 1,600 feet twice even though the flight was above the mountainous area;
- At 07:32:58, the PIC disengaged the TAWS SYST while the AVOID TERRAIN warning activated assuming that the warning may have been triggered by a problem with the TAWS terrain database.

3 CONCLUSIONS

3.1 Findings

a. The flight was planned under the IFR and was not on a published airway.

b. The aircraft was airworthy prior to the flight. There was no evidence that the aircraft had any system malfunction during the flight.

c. The flight crew had valid flight license and medical certificates. There was no evidence of crew incapacitation. Pathological examination did not find any alcohol or drug influencing the pilots.

d. The duty and rest period for the crew within 48 hours prior to the flight were within limits.

e. The ATC assumed that the flight would be performed at Bogor Area while the pilots assumed that the flight was approved to 200 radial, 20 NM HLM VOR, the evidence showed that the first and second demonstration flights reached that point.

f. The chart available on board the aircraft did not contain information of the Atang Sanjaya Training Area and only limited information of the surrounding mountainous area.

g. The PIC acted as Pilot Flying.

h. The Jakarta Flight Data Officer (FDO) entered the data of the flight into the Flight Data Edit Display (FDED) as Sukhoi 30 (Su-30) since the database on the FDED did not contain the Sukhoi RRJ-95B.

i. The FDED showed that the flight was a Su-30 (Sukhoi military aircraft), resulting in the controller believing that the flight was a Sukhoi military aircraft.

j. The crew requested descent to 6,000 feet and an orbit that was approved by ATC while the Minimum Sector Altitude was 6,900 feet.

k. The recorded radar data indicated that the aircraft orbited over the Atang Sanjaya Training Area.

l. The pilot demonstrated the aircraft feature of terrain display while turning and heading north-east and stated that it was not required at that time. A potential customer, who was sitting in the cockpit, replied ”ya, its flat”.

m. There were prolonged discussions between the pilots and the potential customer relating to aircraft fuel consumption, which may have distracted the pilots and delayed the flight crew determining the direction to return to Halim and the aircraft unintentionally exited the orbit.

n. The Jakarta Approach controller’s attention focused on controlling other aircraft with intensive communication exchange without pause.

o. There was 1 TAWS aural warning of “Terrain – Pull up” and 6 “Avoid Terrain” aural and visual warnings.

p. The PIC inhibited the TAWS system function, assuming that there was problem with the TAWS database.

q. The simulation test concluded that the TAWS was functioning properly and the impact could be avoided by appropriate reaction of the pilot up to 24 seconds after the first TAWS warning.

r. The Flight Warning System of "Landing Gear Not Down" provided additional information that the aircraft was in proximity to terrain.

s. The Jakarta Radar service had not established minimum vectoring altitude for certain areas.

t. The terrain information surrounding Mount Salak had not been inserted into the Jakarta Radar system, hence the MSAW did not provide any warning to the controller.

u. The aural warning on the Jakarta Radar system had been deactivated.

v. The aircraft impacted into an 85 degree slope ridge terrain, on the 198 radial and 28 Nm HLM VOR at approximately 6,000 feet.

w. The Jakarta Approach controller noticed that the aircraft had disappeared from the radar screen 24 minutes after impact.

x. The Jakarta Approach controller realized that the missing aircraft was a civil aircraft Sukhoi RRJ-95B only after he called the Halim Tower controller.

y. The original crew and passenger manifest and all copies were carried on board the aircraft. No copy was available from the ground handling agency.

3.2 Factors[8]

a. The flight crew was not aware of the mountainous area in the vicinity of the flight path due to various factors such as available charts, insufficient briefing and statements of the potential customer that resulted in inappropriate response to the TAWS warning. The impact could have been avoided by appropriate action of the pilot up to 24 seconds after the first TAWS warning.

b. The Jakarta Radar service had not established the minimum vectoring altitudes and the Jakarta Radar system was not equipped with functioning MSAW for the particular area around Mount Salak.

c. Distraction of the flight crew from prolonged conversation not related to the progress of the flight, resulted in the pilot flying not constantly changing the aircraft heading while in orbit. Consequently, the aircraft unintentionally exited the orbit.

8 "Factors" is defined as events that might cause the occurrence. In the case that the event did not occur then the accident might not happen or result in a less severe occurrence.

4 SAFETY ACTION

At the time of issuing this Final Accident Investigation Report, the National Transportation Safety Committee had been informed of safety actions resulting from this accident from the parties.

4.1 Indonesia Directorate General of Civil Aviation

a. Audited and evaluated the air traffic services of the Halim Perdanakusuma Airport;

b. Evaluating and assessing the proposal of minimum vectoring altitude/ surveillance minimum altitude chart of several ATS units provides radar services.

c. Technical evaluation, assessment and publishing the implementation of RNAV 1 Standard Instrument Departure at Soekarno-Hatta International airport.

4.2 PT. Angkasa Pura II (Air Traffic Services Provider)

a. Implemented the RNAV 1 Standard Instrument Departure (SID) and Standard Arrival (STAR) on the Jakarta Flight Information Region (FIR);

b. Recruited additional Air Traffic Controllers;

c. Proposed the Minimum Vector Altitude to the Directorate General of Civil Aviation for each airspace which provides radar service;

d. Conducted ATC refresher training for all controllers, the training syllabus include standard phraseology;

e. Inserted the Mount Salak data to the Jakarta Radar System.

4.3 Sukhoi Civil Aviation Company of Russian Federation

a. Conducted pilot refresher training for all SCAC test pilots with stressing on flight crew actions to respond properly the TAWS warning.

b. Conducted additional training for all SCAC test pilots on IFR operations and minimum safe altitude.

c. Conducted additional demonstration flight training for all SCAC test pilots, the training syllabus included features of demonstration flight in mountainous regions.

d. Emphasized the requirements to keep the copies of crew and passenger manifest on the departure station.

5 SAFETY RECOMMENDATIONS

As a result of this accident investigation, the National Transportation Safety Committee issued safety recommendations to address safety issues identified in this report.

5.1 Indonesia Directorate General of Civil Aviation

a. To review its oversight and to ensure flight crew actions to respond properly the aircraft system warning through adequate training;

b. To ensure that all aircraft operated under IFR should be conducted with respect to a published minimum safe flight altitude;

c. To review its oversight and to ensure that all ATS provider comply with the requirement of MSAW and the minimum vectoring altitude being integral part of radar service;

d. To review its oversight and to ensure that all ATS provider follow with the requirement of Advisory Circular (AC) 170-02 regarding Capacity Management;

e. To review its oversight and to ensure that all approved Ground Handling comply with regulatory documentation keeping in regard to crew and passenger manifest.

5.2 Soekarno–Hatta International Airport

a. To ensure that the ATC units and airspace structure provide acceptable workload for the ATC as on Advisory Circular (AC) 170-02 regarding Capacity Management;

b. To ensure its radar warning system functions properly and to review that all radar controllers are fully conversant with the system and comply with procedures that they operate;

c. To ensure that the correct aircraft type data to be entered to the Flight Data Edit Display (FDED).

5.3 Department of Avition Industry - Ministry of Trade and Industry of Russia

a. To review its oversight and to ensure flight crew actions to respond properly the aircraft system warning through adequate training;

b. To ensure that all aircraft operated under IFR should be conducted with respect to a published minimum safe flight altitude;

c. To review the current procedures for the preparation and conduct of a demonstration flight and, if needed, introduce appropriate amendments;

d. To provide the crews with sufficient aeronautical information.

5.4 Sukhoi Civil Aircraft Company of Russian Federation

a. To provide the crews with sufficient aeronautical and other necessary information to the crewmember prior to perform flight outside published airway including obstacle and terrain information;

b. To review its current demonstration flight practices and ensures the compliance to the flight procedures during demonstration flight.

6 APPENDICES

6.1 FDR Data

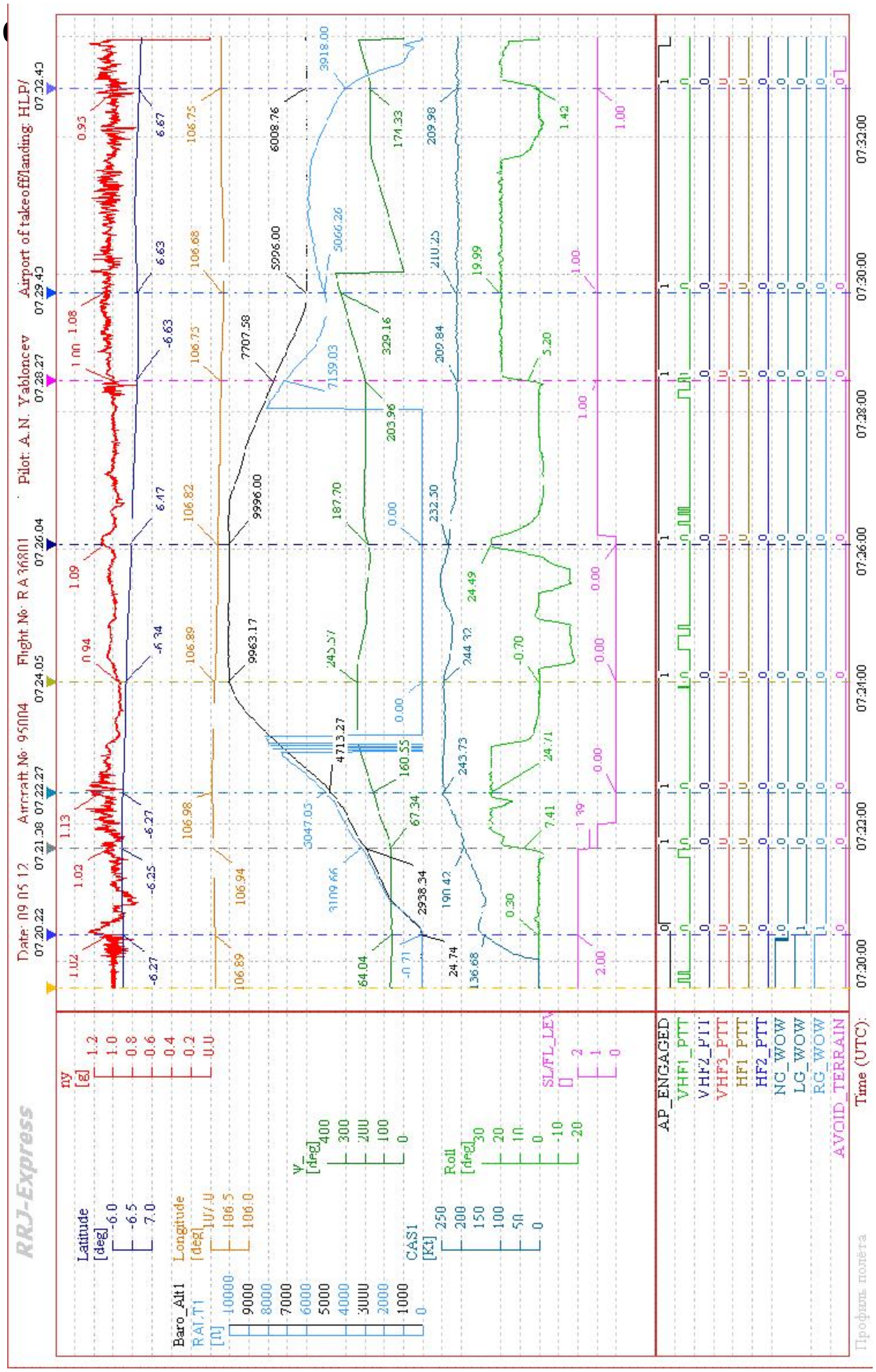


Figure A1 - Flight profile

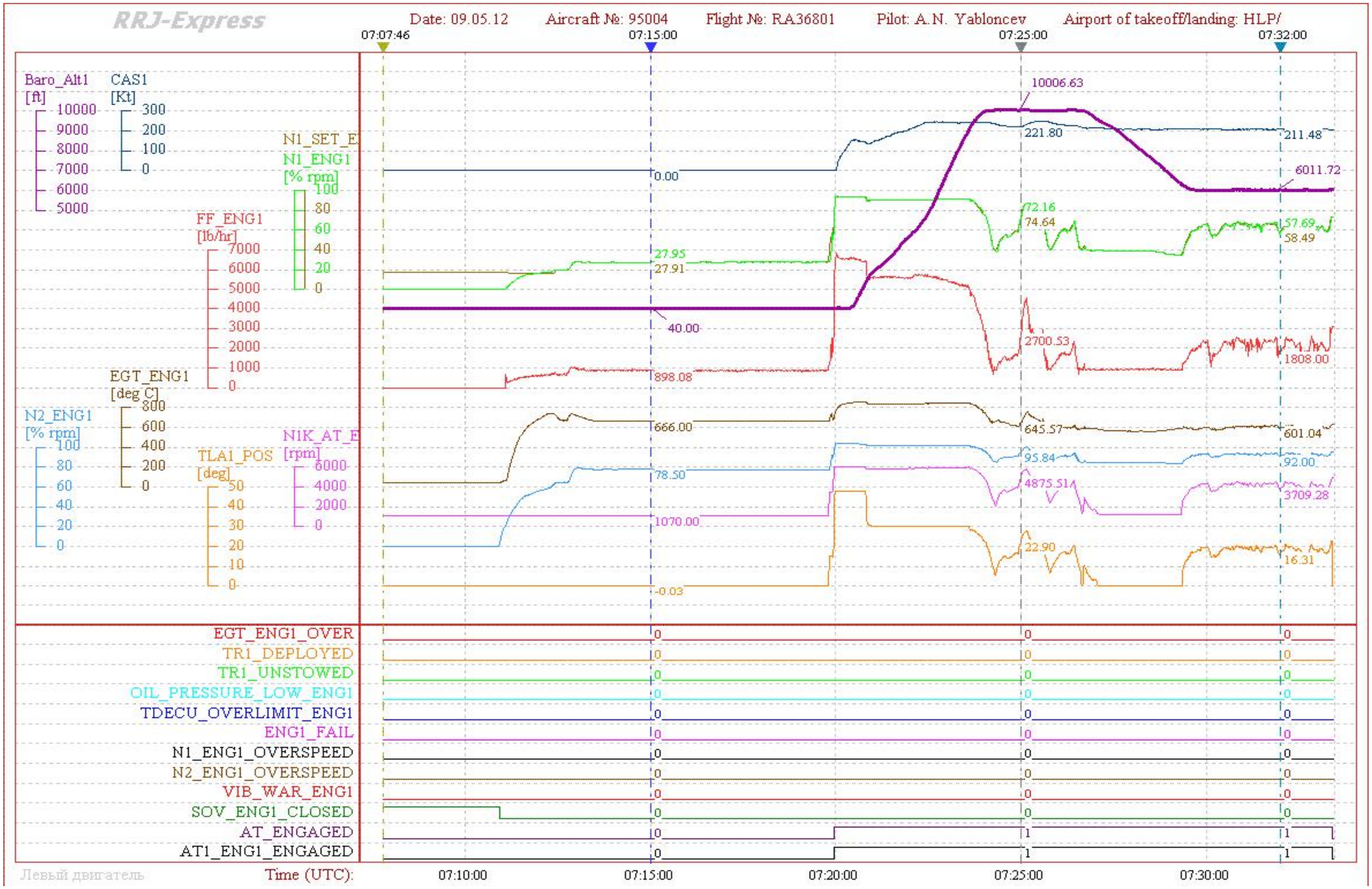


Figure A2 - Left engine parameters

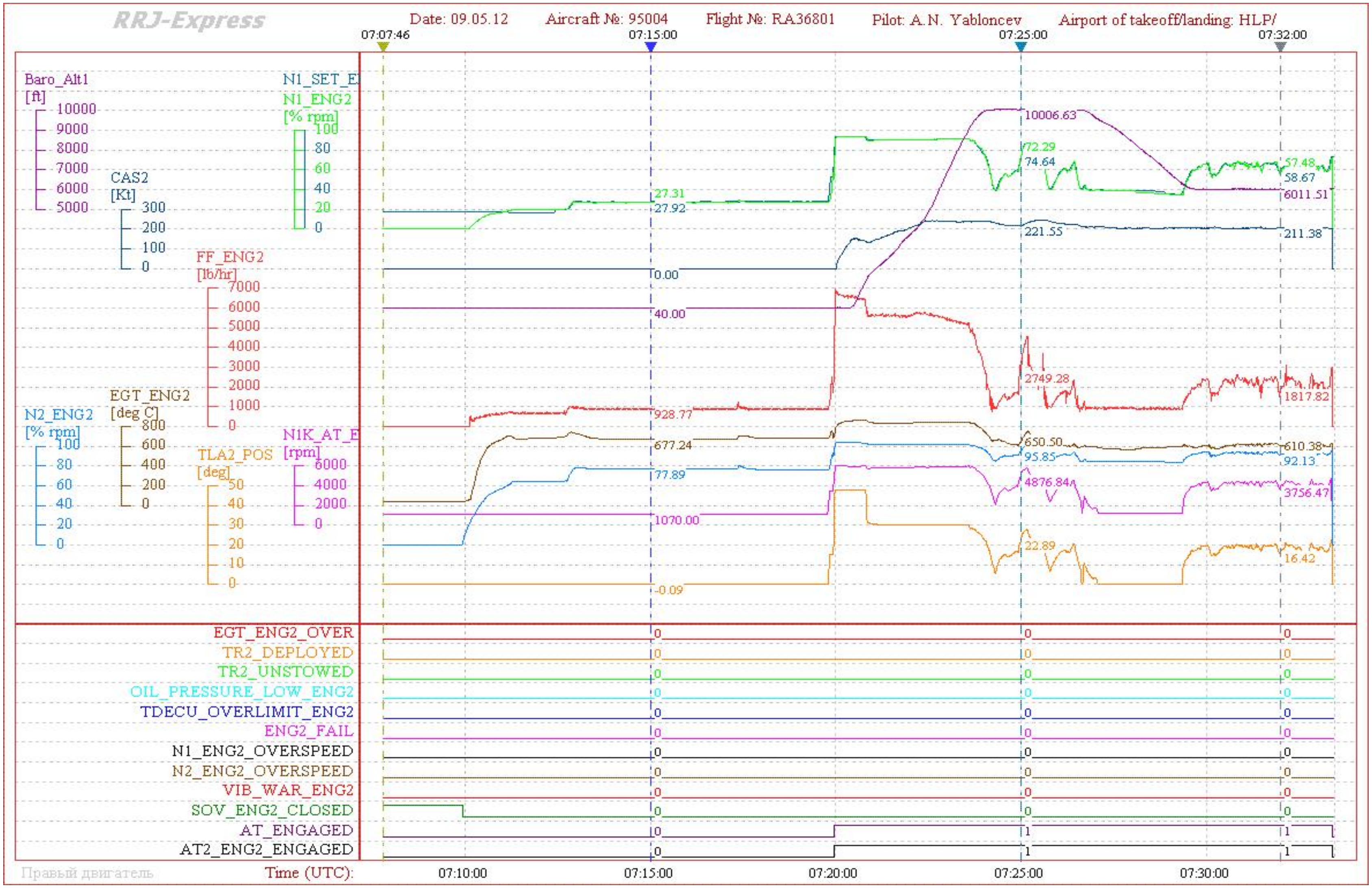


Figure A3 - Right engine parameters

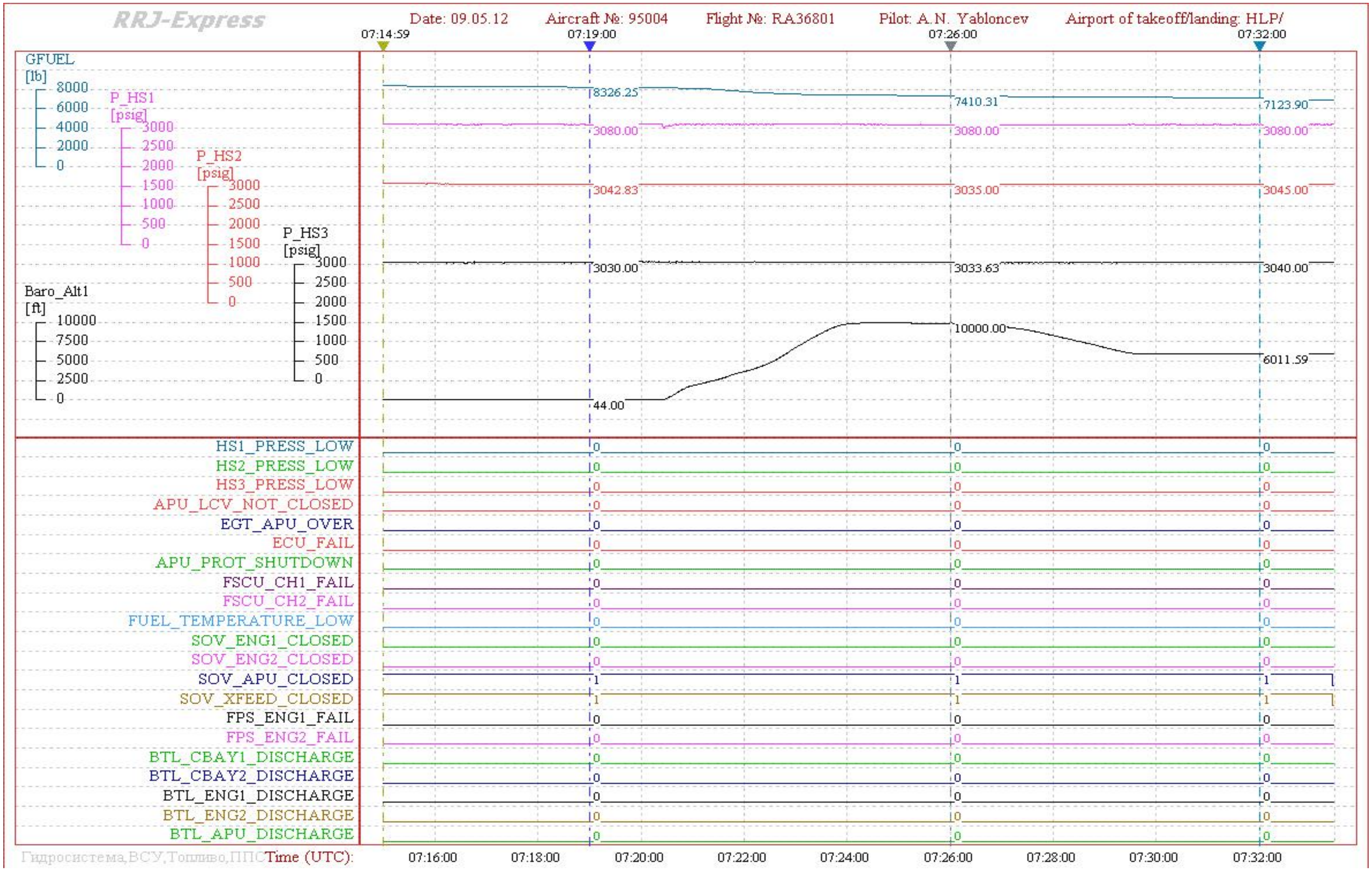


Figure A4 - Hydraulic, APU, fuel and fire protection systems parameters

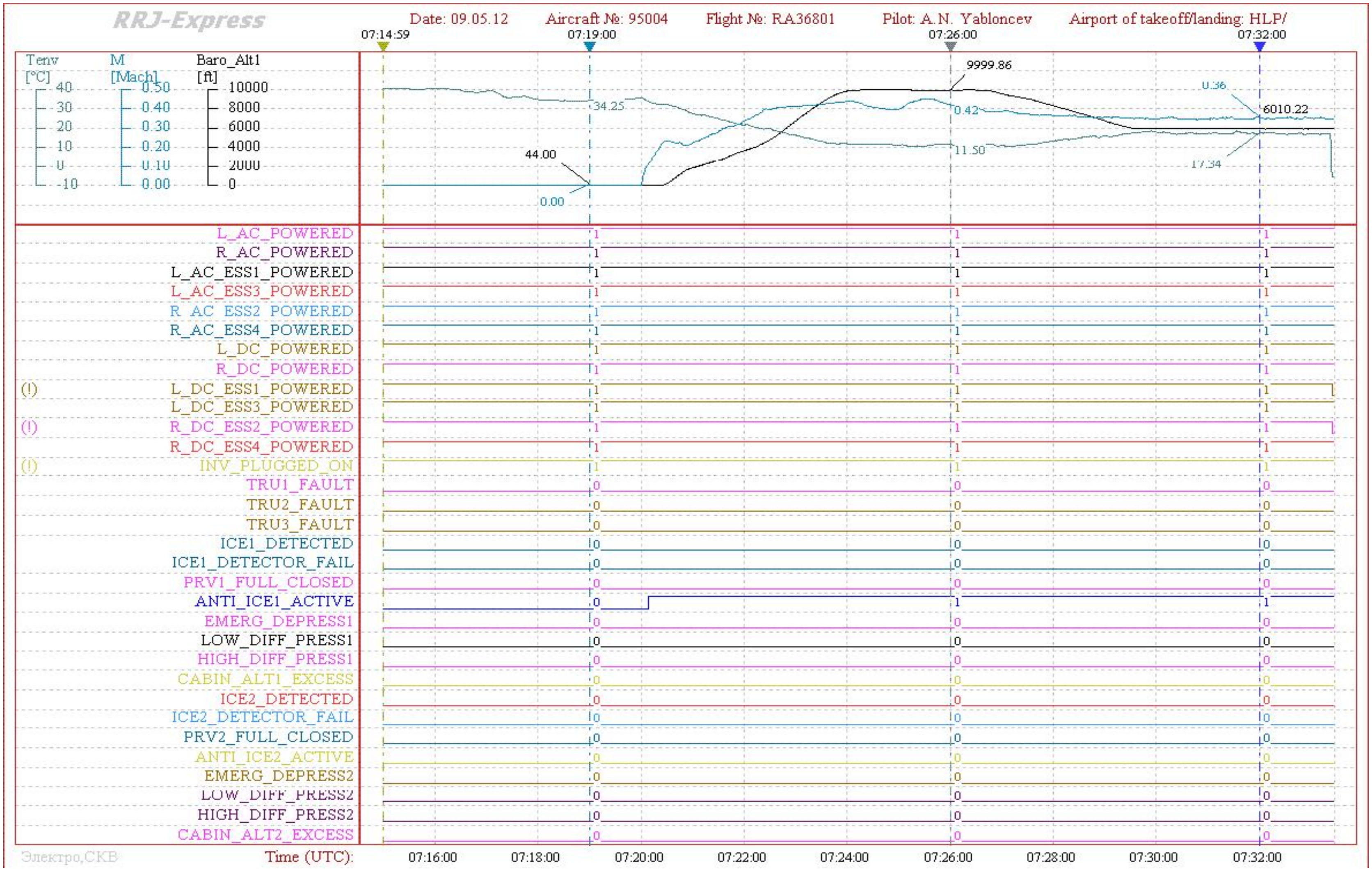


Figure A5 - Operational status commands for the electrical power and air conditioning systems

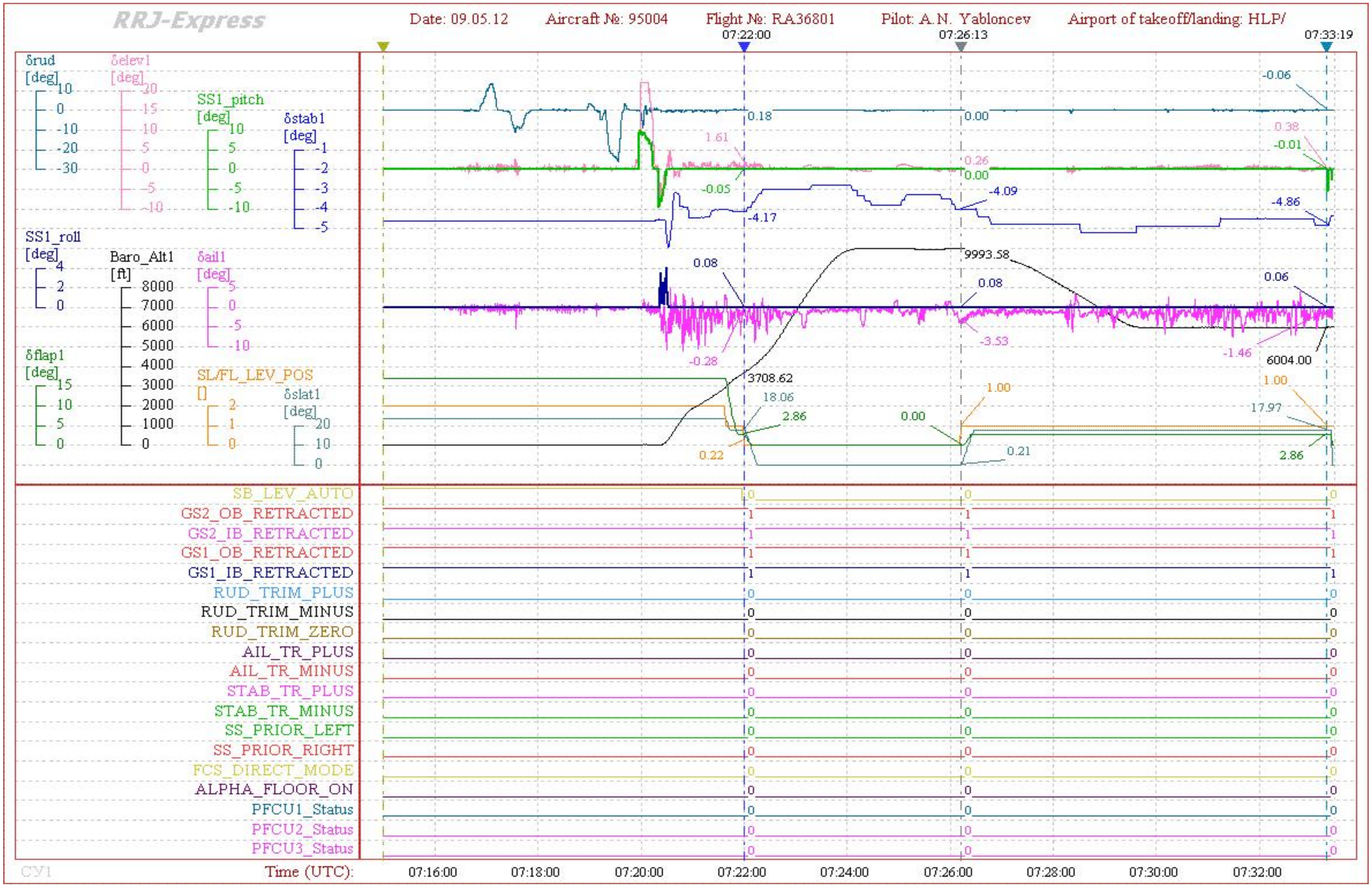


Figure A6-1 - Flight control system parameters (1 of 2)

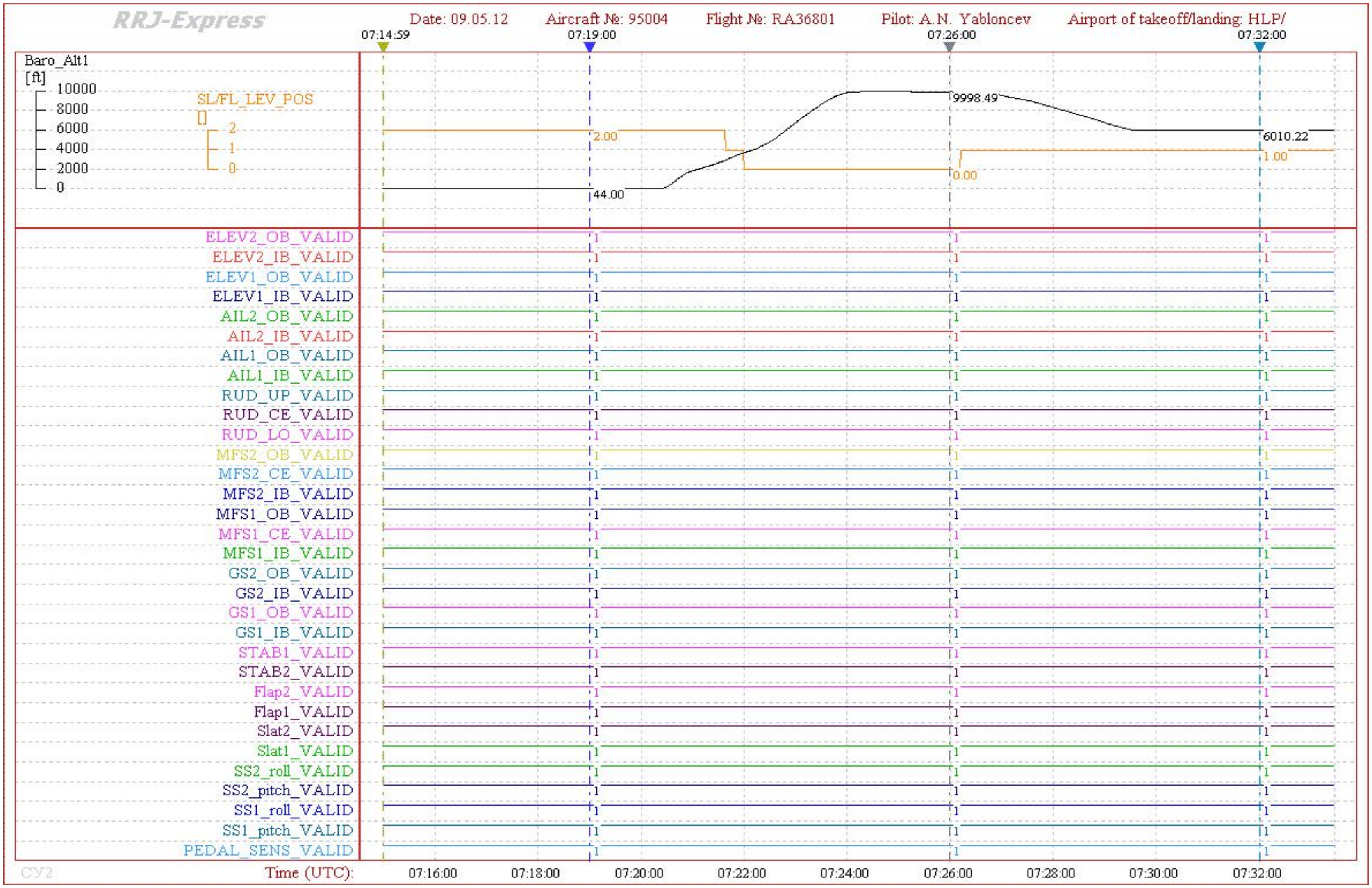


Figure A6-2 - Flight control system parameters (2 of 2)

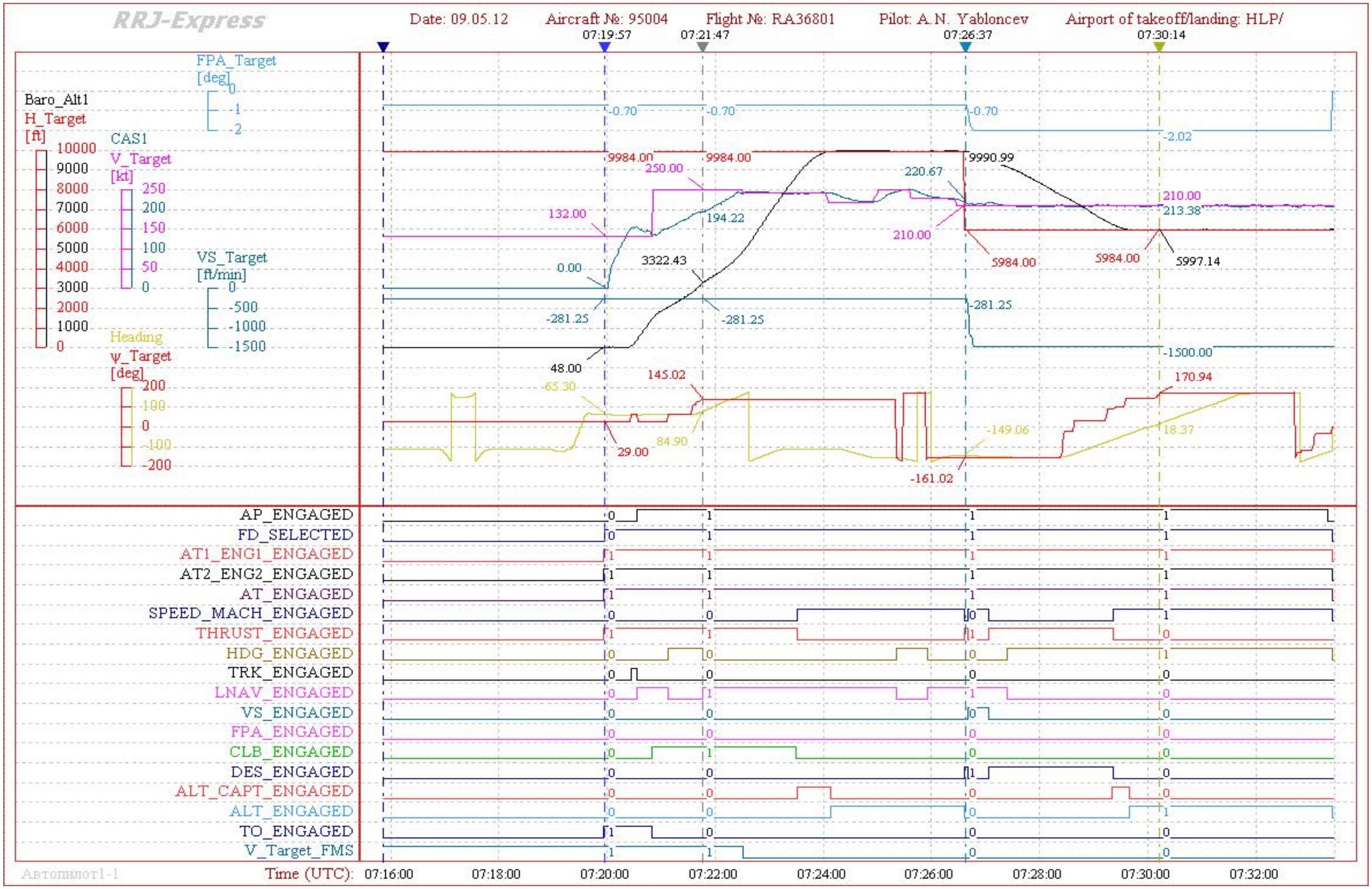


Figure A7-1 - Autopilot parameters (1 of 2)

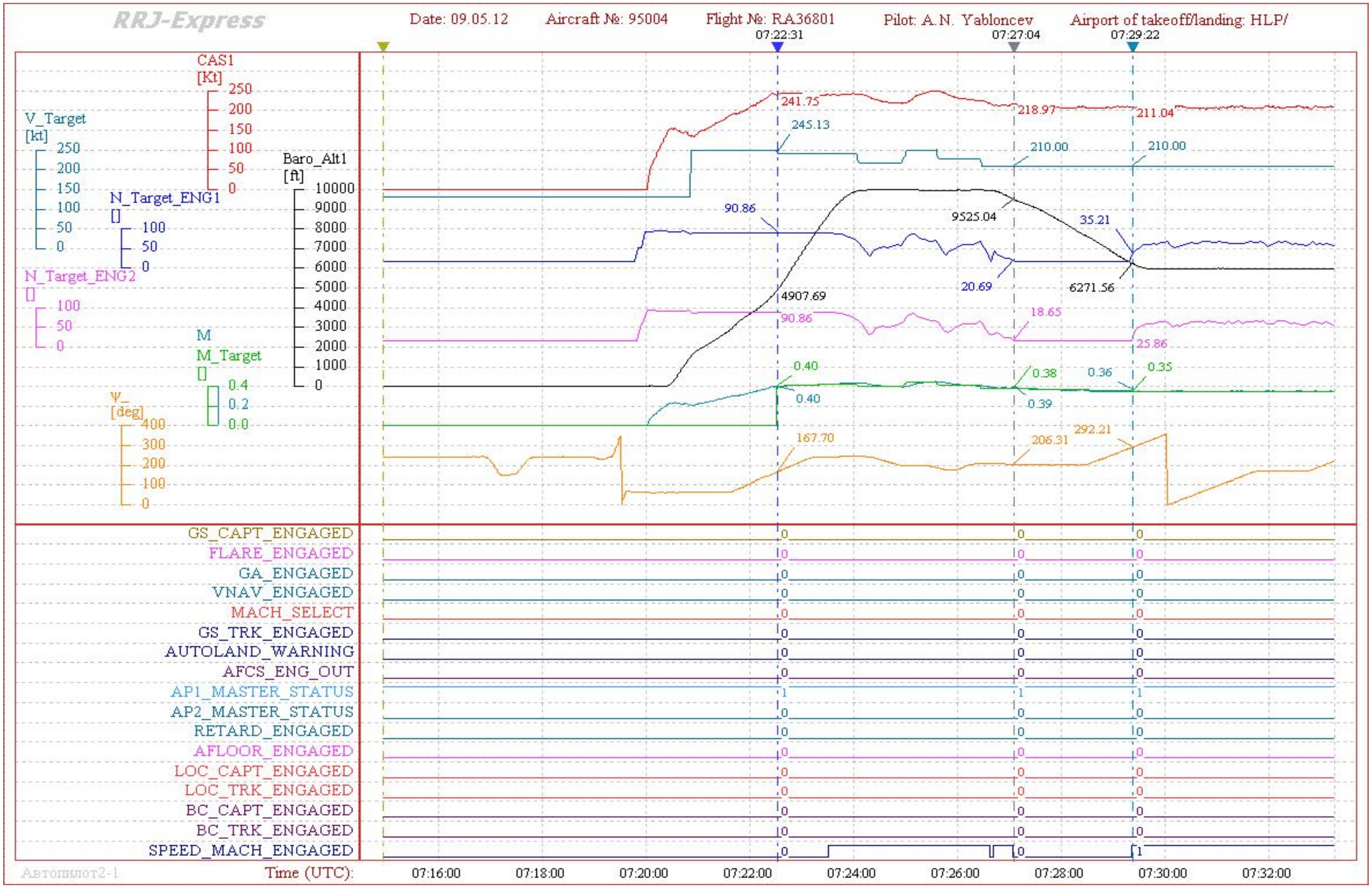


Figure A7-2 - Autopilot parameters (2 of 2)

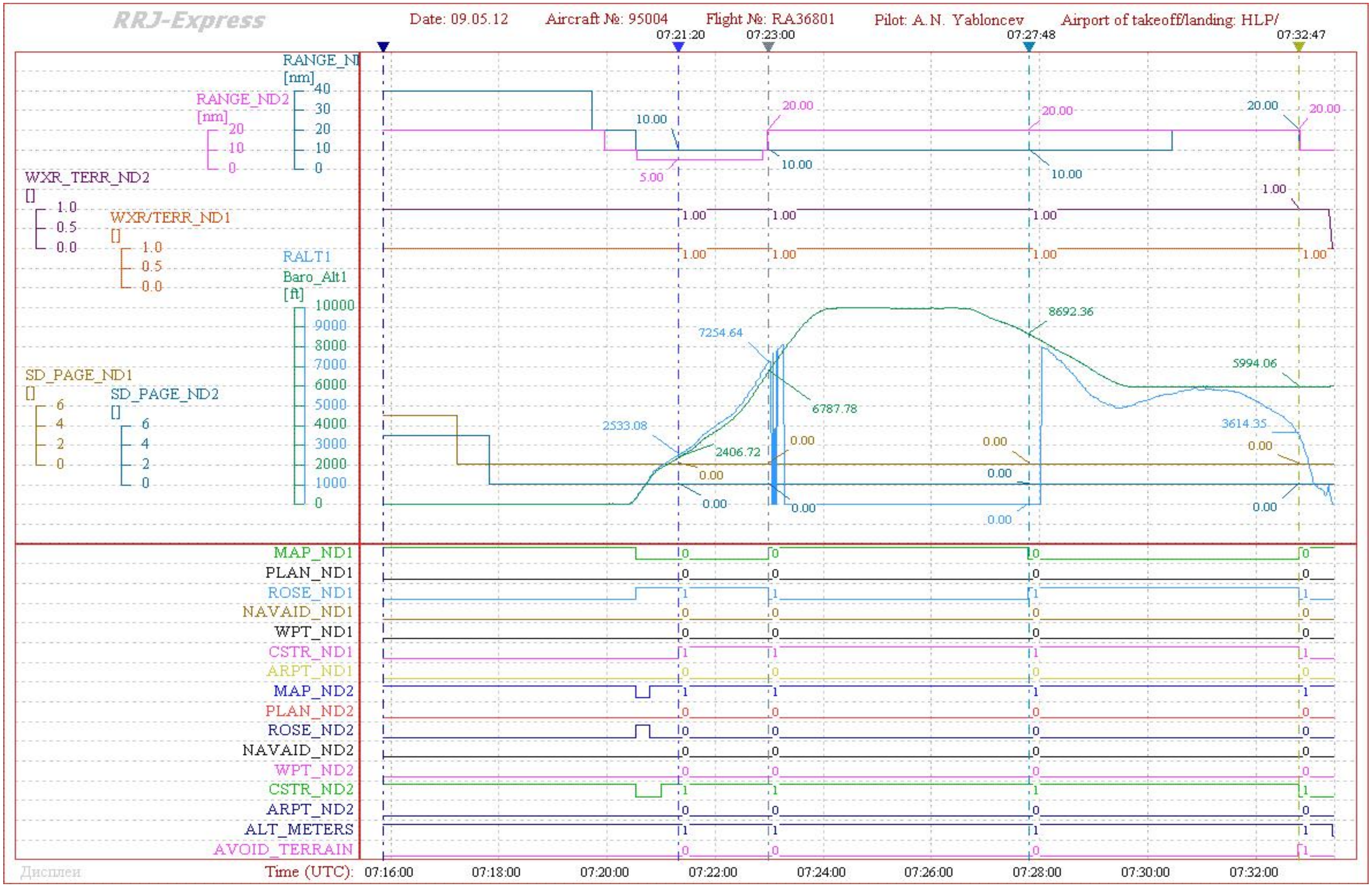


Figure A8 - Display unit parameters

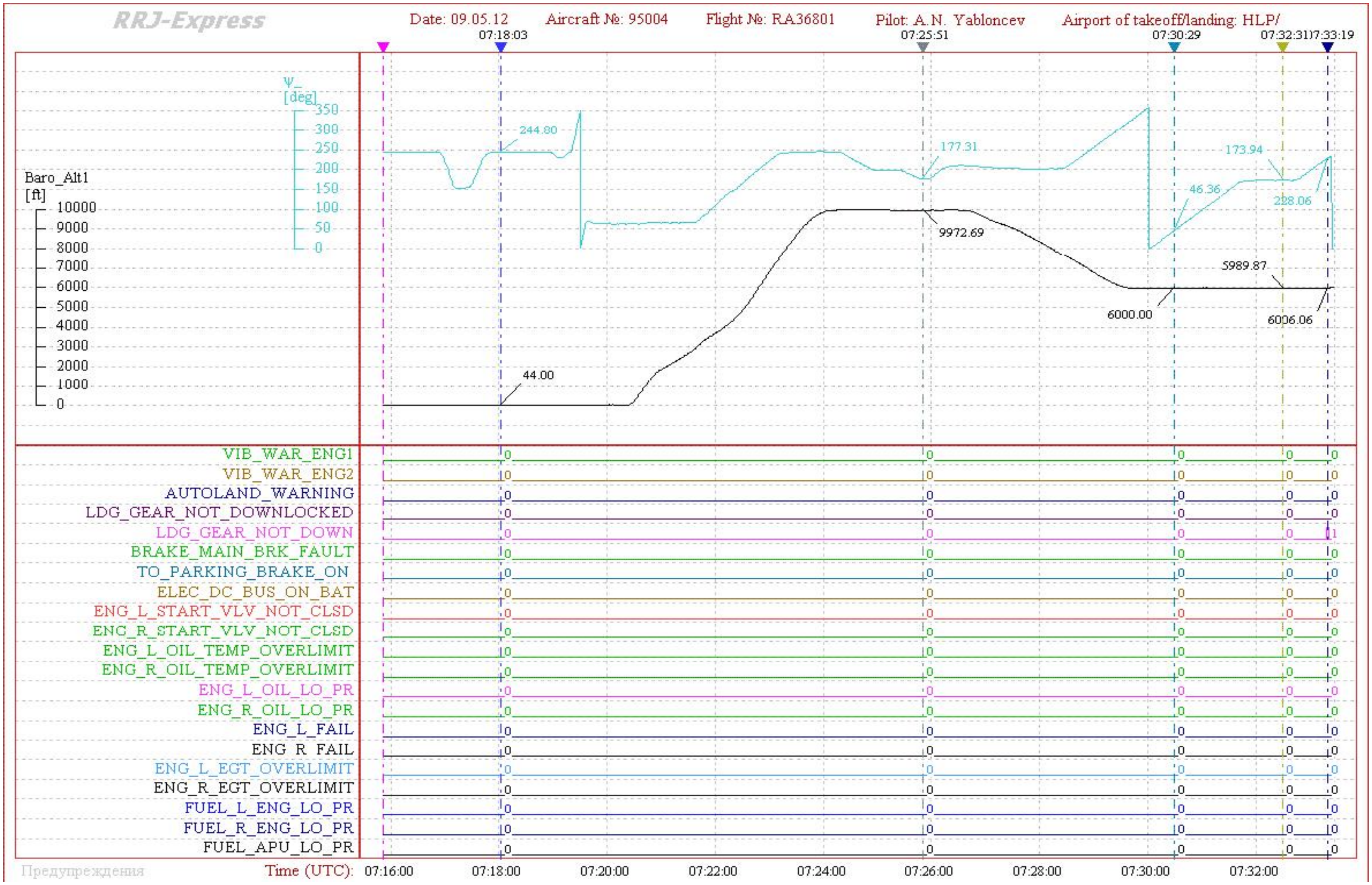


Figure A9-1 - Avionics - Flight warning system (1 of 4)

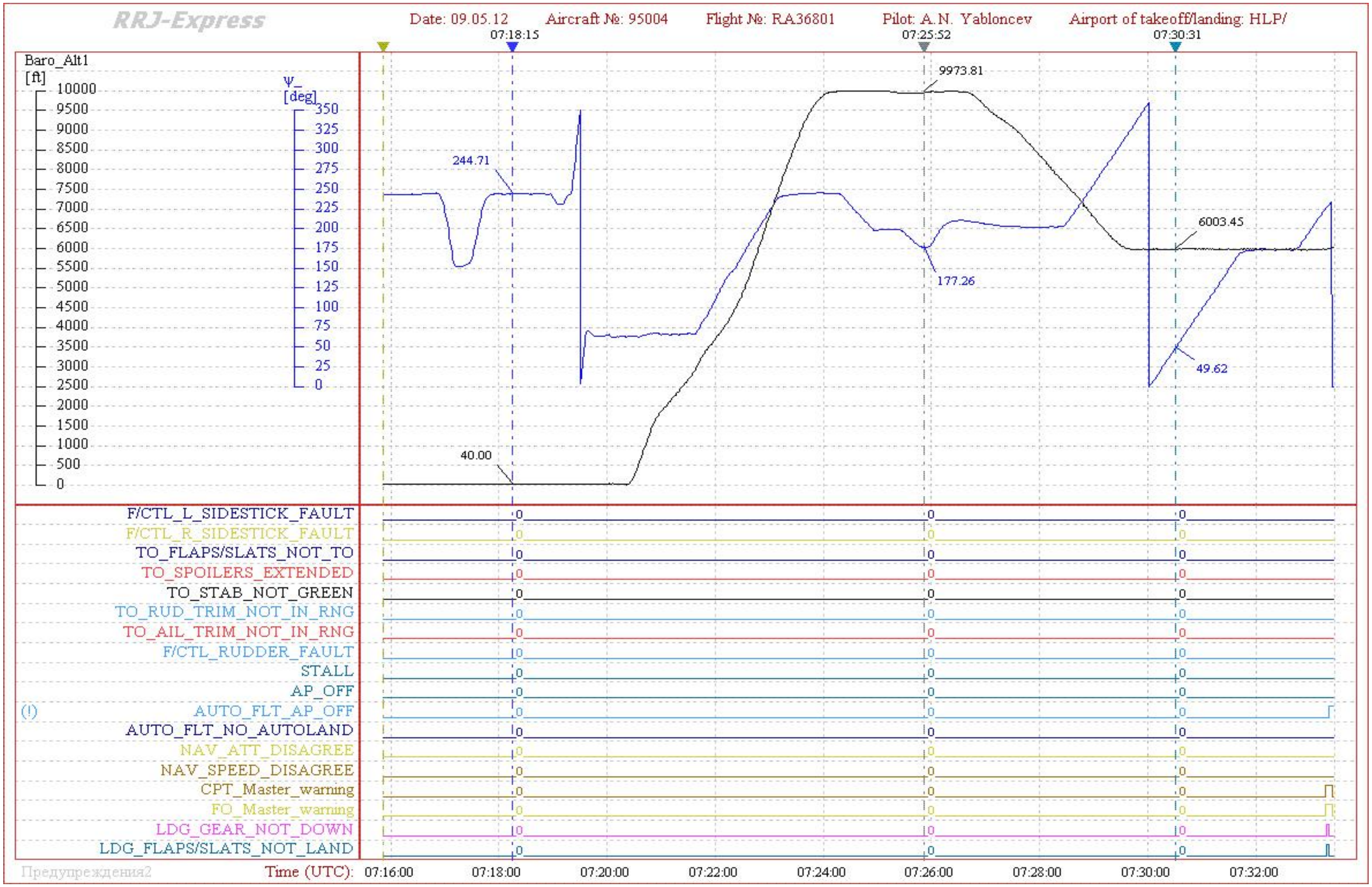


Figure A9-2 - Avionics - Flight warning system (2 of 4)

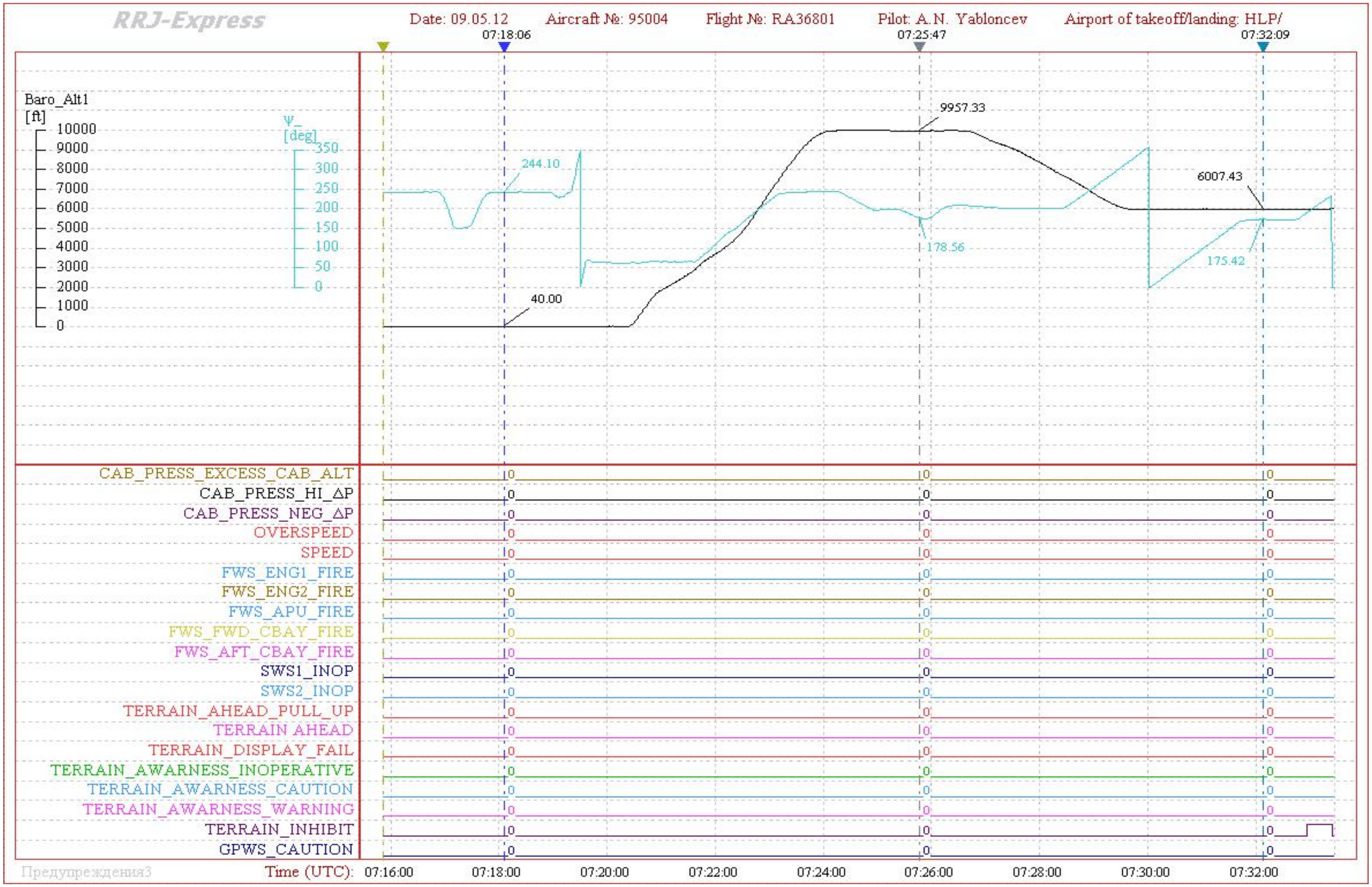
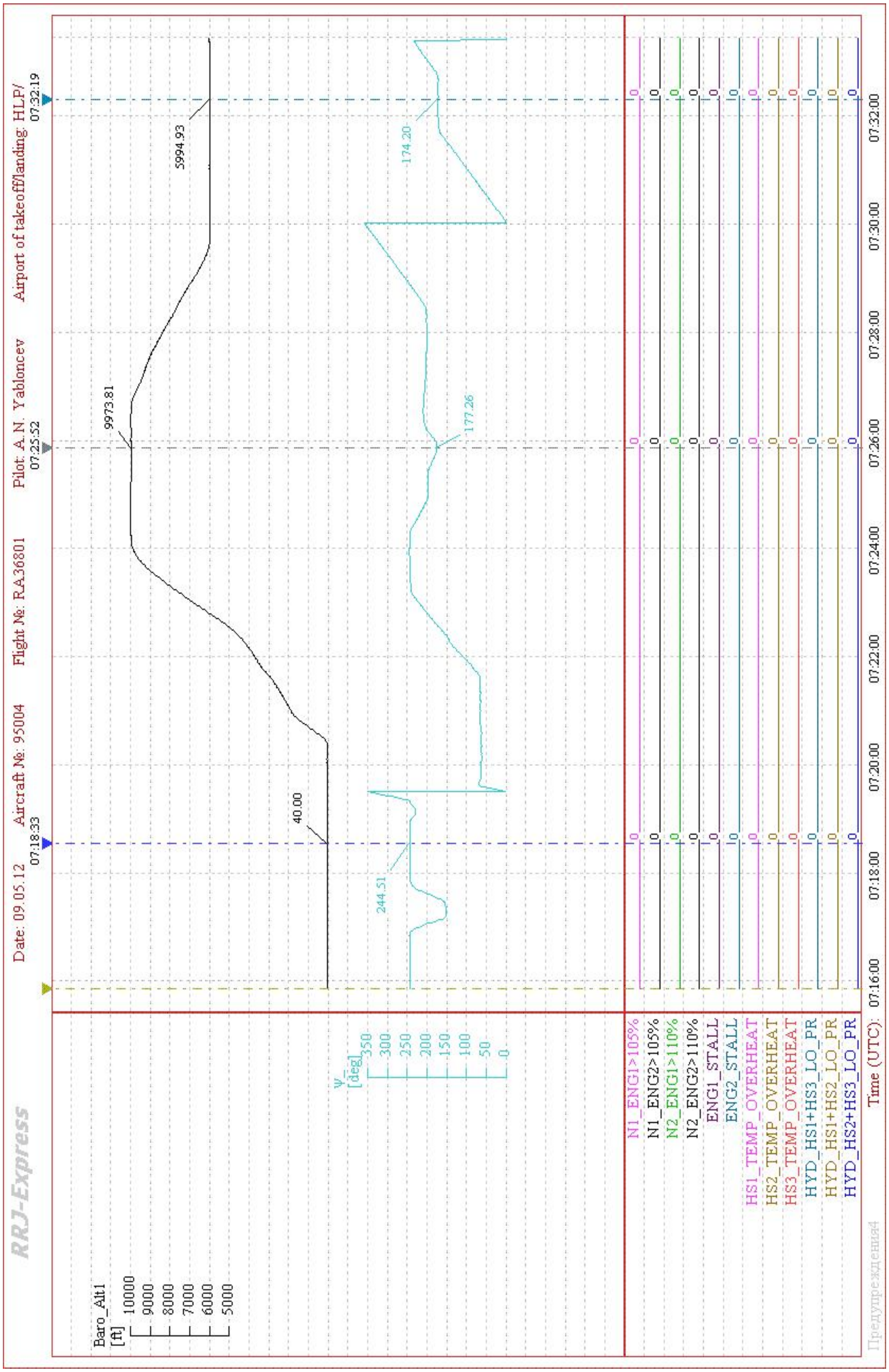


Figure A9-3 - Avionics - Flight warning system (3 of 4)


RRJ-Express
Date: 09.05.12
Aircraft №: 95004
Flight №: RA36801
Pilot: A.N. Yabloncev
Airport of takeoff/landing: HLP/
07:18:33
07:25:52
07:32:19
Baro_Alt1
[ft]
10000
9000
8000
7000
6000
5000
40.00
9973.81
5994.93
ψ
[deg]
350
300
250
200
150
100
50
0
244.51
177.26
174.20
N1_ENG1>105%
N1_ENG2>105%
N2_ENG1>110%
N2_ENG2>110%
ENG1_STALL
ENG2_STALL
HS1_TEMP_OVERHEAT
HS2_TEMP_OVERHEAT
HS3_TEMP_OVERHEAT
HYD_HS1+HS3_LO_PR
HYD_HS1+HS2_LO_PR
HYD_HS2+HS3_LO_PR
Time (UTC):
07:16:00
07:18:00
07:20:00
07:22:00
07:24:00
07:26:00
07:28:00
07:30:00
07:32:00
Предупреждения4

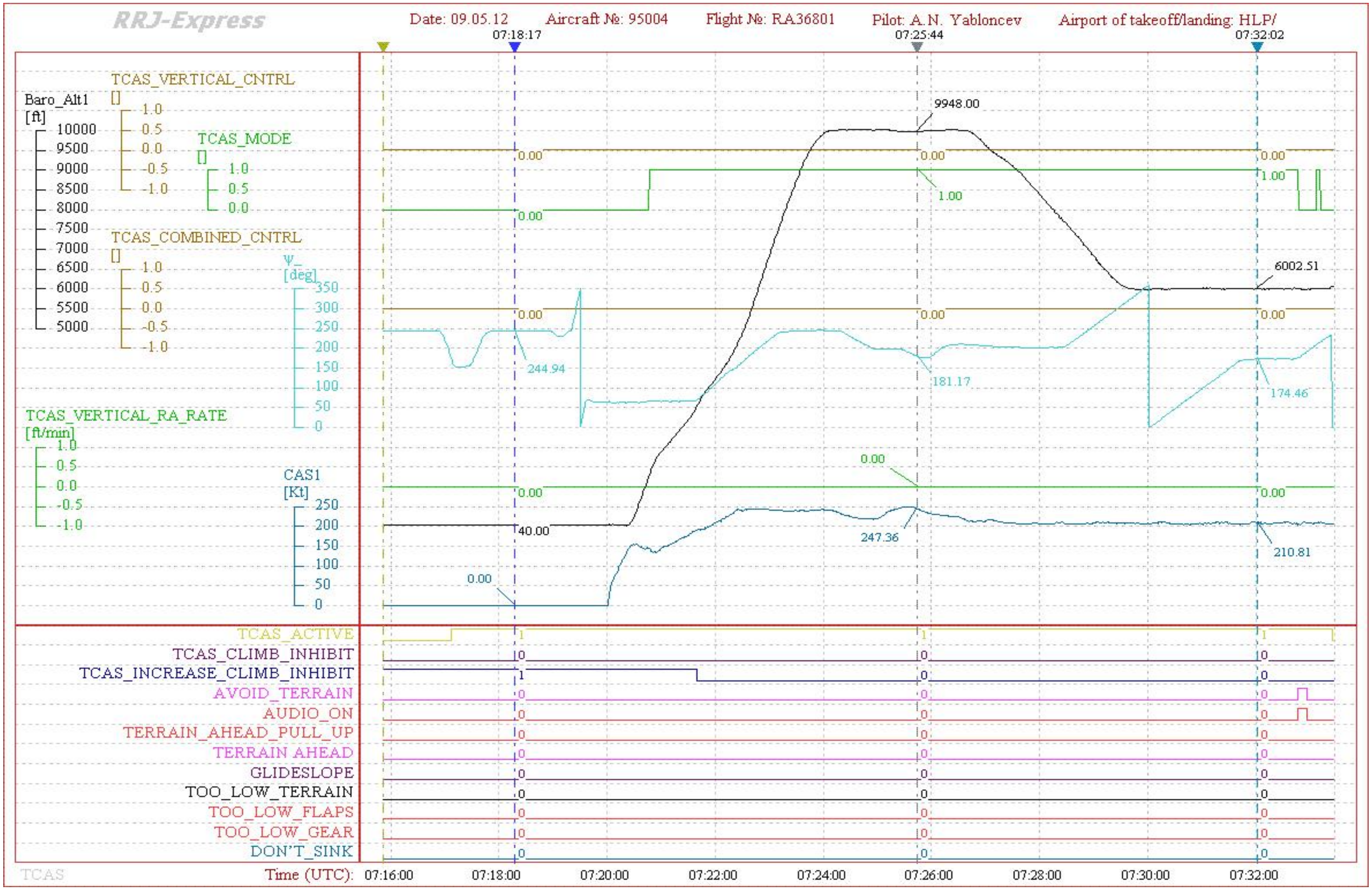


Figure A10-1 - Avionics - T^{2}CAS (1 of 2)

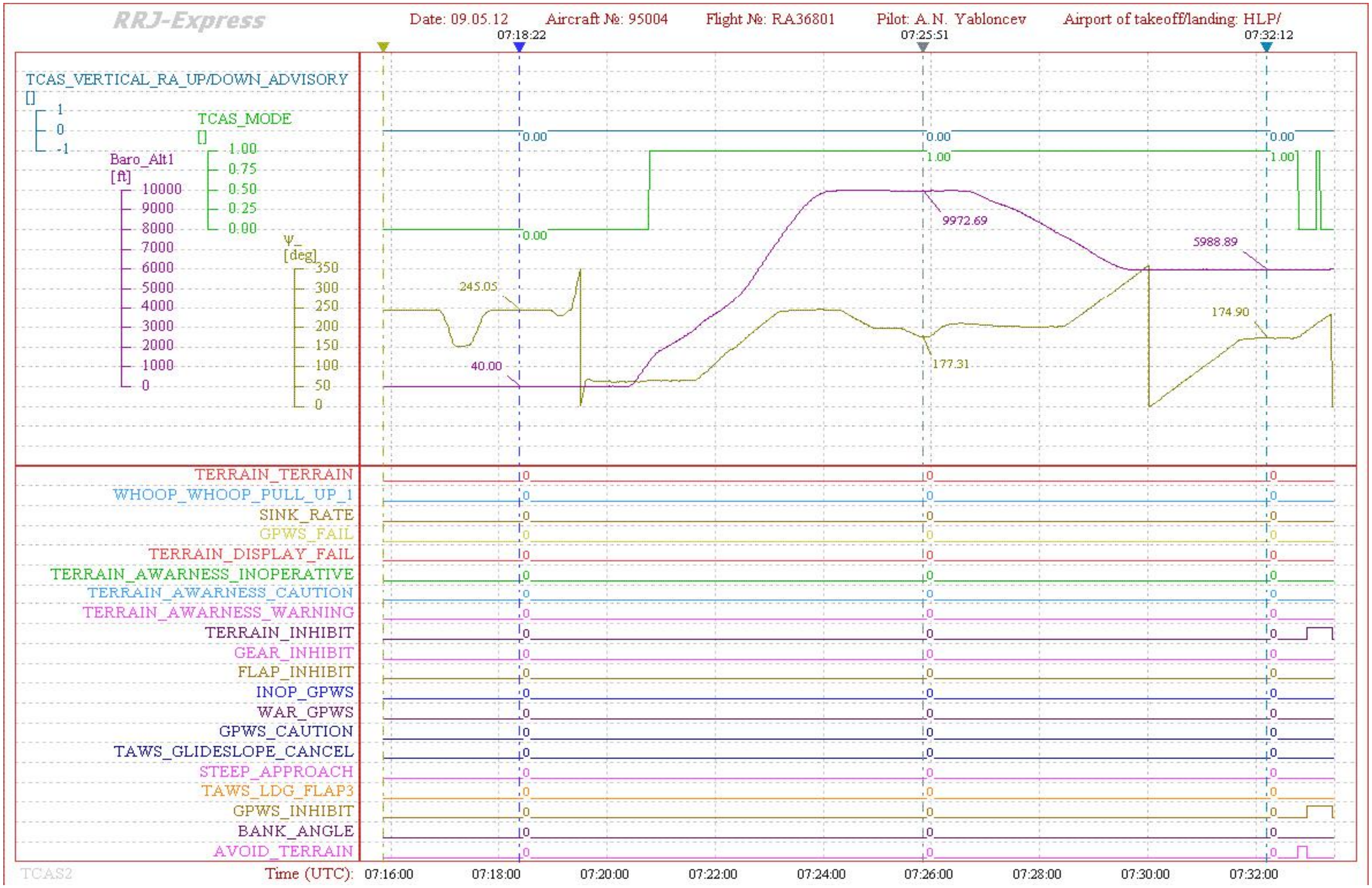


Figure A10-2 - Avionics - T^2CAS (2 of 2)

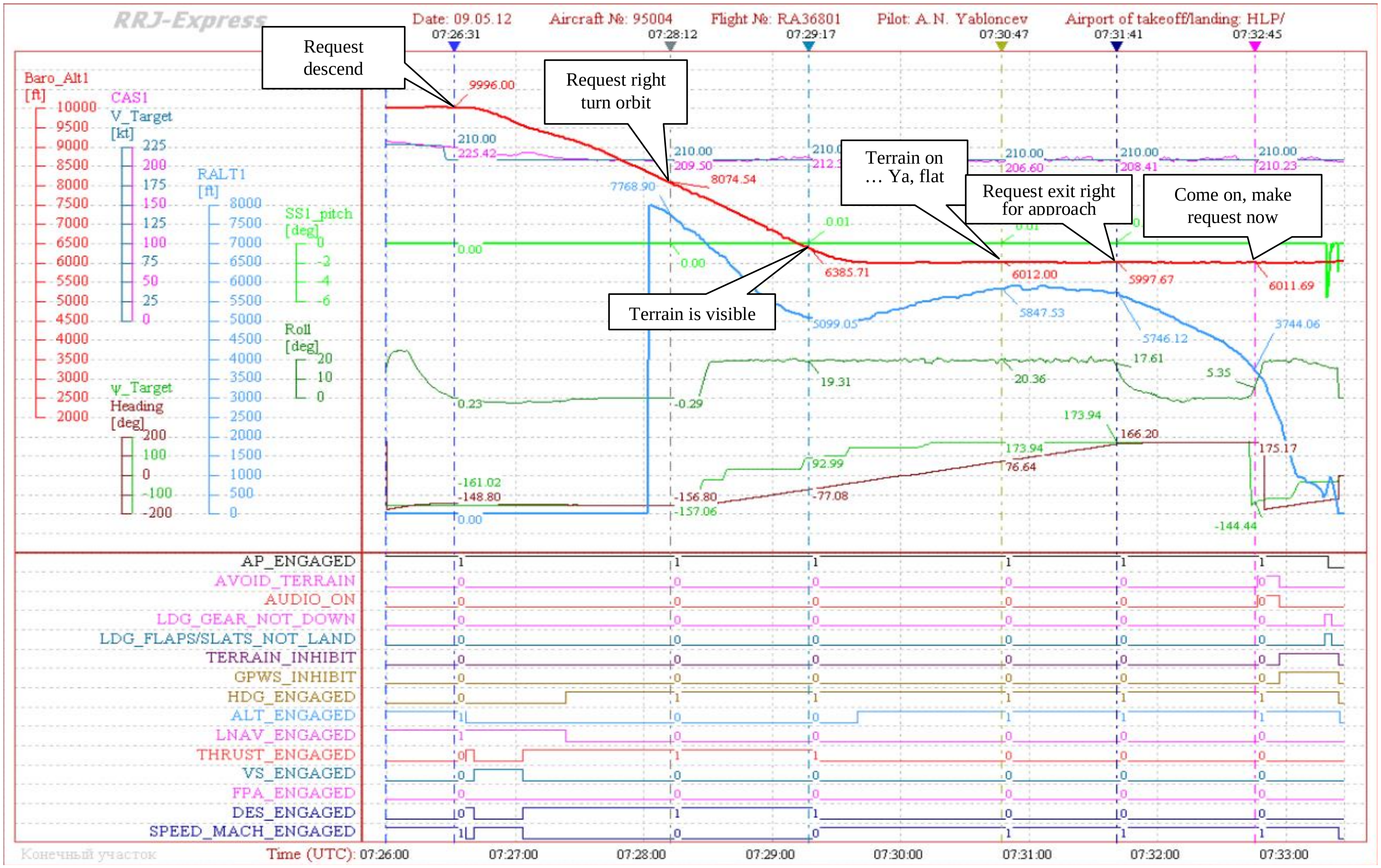


Figure A11-1 - Control parameters for the flight final phase

6.2 Advisory Circular (AC) 170-02, Capacity Management

CHAPTER 3. ATS SYSTEM CAPACITY AND AIR TRAFFIC FLOW MANAGEMENT

3.1 CAPACITY MANAGEMENT

3.1.1 General

3.1.1.1 The capacity of an ATS system depends on many factors, including the ATS route structure, the navigation accuracy of the aircraft using the airspace, weather related factors, and controller workload. Every effort should be made to provide sufficient capacity to cater to both normal and peak traffic levels; however, in implementing any measures to increase capacity, the responsible ATS authority shall ensure, in accordance with the procedures specified in Chapter 2, that safety levels are not jeopardized.

3.1.1.2 The number of aircraft provided with an ATC service shall not exceed that which can be safely handled by the ATC unit concerned under the prevailing circumstances. In order to define the maximum number of flights which can be safely accommodated, the appropriate ATS authority should assess and declare the ATC capacity for control areas, for control sectors within a control area and for aerodromes.

3.1.1.3 ATC capacity should be expressed as the maximum number of aircraft which can be accepted over a given period of time within the airspace or at the aerodrome concerned.

Note.— The most appropriate measure of capacity is likely to be the sustainable hourly traffic flow. Such hourly capacities can, for example, be converted into daily, monthly or annual values.

3.1.2 Capacity assessment

In assessing capacity values, factors to be taken into account should include, *inter alia*:

a) the level and type of ATS provided;

b) the structural complexity of the control area, the control sector or the aerodrome concerned;

c) controller workload, including control and coordination tasks to be performed;

d) the types of communications, navigation and surveillance systems in use, their degree of technical reliability and availability as well as the availability of back-up systems and/or procedures;

e) availability of ATC systems providing controller support and alert functions; and

f) any other factor or element deemed relevant to controller workload.

Note.— Summaries of techniques which may be used to estimate control sector/position capacities are contained in the Air Traffic Services Planning Manual *(Doc 9426).*

3.1.3 Regulation of ATC capacity and traffic volumes

3.1.3.1 Where traffic demand varies significantly on a daily or periodic basis, facilities and procedures should be implemented to vary the number of operational sectors or working positions to meet the prevailing and anticipated demand. Applicable procedures should be contained in local instructions.

3.1.3.2 In case of particular events which have a negative impact on the declared capacity of an airspace or aerodrome, the capacity of the airspace or aerodrome concerned shall be reduced accordingly for the required time period. Whenever possible, the capacity pertaining to such events should be predetermined.

3.1.3.3 To ensure that safety is not compromised whenever the traffic demand in an airspace or at an aerodrome is forecast to exceed the available ATC capacity, measures shall be implemented to regulate traffic volumes accordingly.

3.1.4 Enhancements of ATC capacity

3.1.4.1 The appropriate ATS authority should:

a) periodically review ATS capacities in relation to traffic demand; and

b) provide for flexible use of airspace in order to improve the efficiency of operations and increase capacity.

3.1.4.2 In the event that traffic demand regularly exceeds ATC capacity, resulting in continuing and frequent traffic delays, or it becomes apparent that forecast traffic demand will exceed capacity values, the appropriate ATS authority should, as far as practicable:

a) implement steps aimed at maximizing the use of the existing system capacity; and

b) develop plans to increase capacity to meet the actual or forecast demand.

3.1.5 Flexible use of airspace

3.1.5.1 The appropriate authorities should, through the establishment of agreements and procedures, make provision for the flexible use of all airspace in order to increase airspace capacity and to improve the efficiency and flexibility of aircraft operations. When applicable, such agreements and procedures should be established on the basis of a regional air navigation agreement.

3.1.5.2 Agreements and procedures providing for a flexible use of airspace should specify, *inter alia*:

a) the horizontal and vertical limits of the airspace concerned;

b) the classification of any airspace made available for use by civil air traffic;

c) units or authorities responsible for transfer of the airspace;

d) conditions for transfer of the airspace to the ATC unit concerned;

e) conditions for transfer of the airspace from the ATC unit concerned;

f) periods of availability of the airspace;

g) any limitations on the use of the airspace concerned; and

h) any other relevant procedures or information.

3.2 AIR TRAFFIC FLOW MANAGEMENT

3.2.1 General

3.2.1.1 An air traffic flow management (ATFM) service shall be implemented for airspace where traffic demand at times exceeds the defined ATC capacity.

3.2.1.2 ATFM should be implemented on the basis of a regional air navigation agreement or, when appropriate, as a multilateral agreement.

3.2.1.3 The ATFM service within a region or other defined area, should be developed and implemented as a centralized ATFM organization, supported by flow management positions established at each area control centre (ACC) within the region or area of applicability.

3.2.1.4 Certain flights may be exempt from ATFM measures, or be given priority over other flights.

3.2.1.5 Detailed procedures governing the provision of the ATFM measures, and service within a region or area should be prescribed in a regional ATFM manual or handbook.

3.2.2 Flow management procedures

ATFM should be carried out in three phases:

a) *strategic planning*, if the action is carried out more than one day before the day on which it will take effect. Strategic planning is normally carried out well in advance, typically two to six months ahead;

b) *pre-tactical planning*, if the action is to be taken on the day before the day on which it will take effect;

c) *tactical operations*, if the action is taken on the day on which it will take effect.

3.2.3 Strategic planning

3.2.3.1 Strategic planning should be carried out in conjunction with ATC and the aircraft operators. It should consist of examining the demand for the forthcoming season, assessing where and when demand is likely to exceed the available ATC capacity and taking steps to resolve the imbalance by:

a) arranging with the ATC authority to provide adequate capacity at the required place and time;

b) re-routing certain traffic flows (traffic orientation);

c) scheduling or rescheduling flights as appropriate; and

d) identifying the need for tactical ATFM measures.

3.2.3.2 Where a traffic orientation scheme (TOS) is to be introduced, the routes should, as far as practicable, minimize the time and distance penalties for the flights concerned, and allow some degree of flexibility in the choice of routes, particularly for long-range flights.

3.2.3.3 When a TOS has been agreed, details should be published by all States concerned in a common format.

3.2.4 Pre-tactical planning

Pre-tactical planning should entail fine tuning of the strategic plan in the light of updated demand data. During this phase:

a) certain traffic flows may be re-routed;

b) off-load routes may be coordinated;

c) tactical measures will be decided upon; and

d) details for the ATFM plan for the following day should be published and made available to all concerned.

3.2.5 Tactical operations

3.2.5.1 Tactical ATFM operations should consist of:

a) executing the agreed tactical measures in order to provide a reduced and even flow of traffic where demand would otherwise have exceeded capacity;

b) monitoring the evolution of the air traffic situation to ensure that the ATFM measures applied are having the desired effect and to take or initiate remedial action when long delays are reported, including re-routing of traffic and flight level allocation, in order to utilize the available ATC capacity to the maximum extent.

3.2.5.2 When the traffic demand exceeds, or is foreseen to exceed, the capacity of a particular sector or aerodrome, the responsible ATC unit shall advise the responsible ATFM unit, where such a unit is established, and other ATC units concerned. Flight crews of aircraft planned to fly in the affected area and operators should be advised, as soon as practicable, of the delays expected or the restrictions which will be applied.

Note.— Operators known or believed to be concerned will normally be advised by the regional air traffic flow management service, when established.

3.2.6 Liaison

During all phases of ATFM the responsible units should liaise closely with ATC and the aircraft operators in order to ensure an effective and equitable service.

Note.— Attention is drawn to the guidance material contained in the Air Traffic Services Planning Manual *(Doc 9426) regarding flow control as well as to procedures contained in* the Regional Supplementary Procedures *(Doc 7030) and regional ATFM Handbooks.*