FINAL REPORT

on

Investigation of a serious incident related to a loss of separation, realized on September 8, 2016 with involved Airbus by A321-211 aircraft, registration marks TC-ATF, and Boeing B737-8F2 aircraft, registration marks TC-JVS in the controlled air space of the Republic of Bulgaria.

2017

Purpose of the Report and responsibility

In accordance with Annex 13 to the Convention on International Civil Aviation of 7 December 1944, Regulation 996/2010 of the European Parliament and the Council on the investigation and prevention of accidents and incidents in civil aviation and Ordinance 13 of 27.01.1999 of the Ministry of Transport, Information Technology and Communications, the objective of the aviation occurrence investigation is to establish the causes that have led to its realisation in order these to be eliminated and not allowed in the future without apportioning blame or liability.

CONTENTS

01 List of Abbreviations

A/C	-	Aircraft
A/THR	-	Autothrust
AAIU	-	Air Accident Investigation Unit
ACAS	-	Airborne Collision Avoidance System
ACC	-	Air Control Centre;
AFTN	-	Aeronautical Fixed Telecommunication Network
ALT	-	Altitude
AMRAIUD	-	Aircraft, Maritime and Railway Accident Investigation Unit Directorate;
AO	-	Aircraft Operator;
AP	-	Autopilot
ATCAS	-	Air Traffic Control Automated System
ATCO	-	Air traffic controller (officer);
ATS	-	Air Traffic Service
AOM	-	Aircraft Operating Manual;
BULATSA	-	Bulgarian Air Traffic Services Authority;
CALL SIGN	-	Call sign of the aircraft;
CDW	-	Conflict Display Window
CPA	-	Closest Point of Approach
DCT	-	Direct to
DFDR	-	Digital Flight Data Recorder
DFL	-	Division flight level
DG CAA	-	Directorate General "Civil Aeronautical Administration";
EASA	-	European Air Safety Agency
EUROCONTROL	-	European Organization for the Safety of Air Navigation
EXE ATCO	-	Radar Air Traffic Controller;
F/C	-	Flight Crew
FCOM	-	Flight Crew Operating Manual
FCTM	-	Flight Crew Training Manual
FCU	-	Flight Control Unit
FD	-	Flight director
FDP	-	Flight Data Processing;
FDR	-	Flight Data Recorder
FL	-	Flight Level
FLCHG	-	Flight Level Change
FMA	-	Flight Mode Annunciator
FPA	-	Flight Path Angle
FS	-	Family Sectors;
GAT	-	General Air Traffic
GW	-	Gross Weight
HMI	-	Human-Machine Interface
ICAO	-	International Civil Aviation Organization
IFR	-	Instrument Flight Rules
InCAS	-	Interactive Collision Avoidance Simulator
KKK8YJ	-	Airbus A321-211 aircraft, registration marks TC-ATF of Atlasjet AO
M	-	Mach number
MSN	-	Manufacturer Serial Number
MTCD	-	Medium Term Conflict Detection

MTITC	-	Ministry of Transport, Information Technologies and Communications
MTOW	-	Max Take Off Weight
ODS	-	Operational Display Subsystem;
OLDI	-	On Line Data Interface
OPDES	-	Open descent
PF	-	Pilot Flying
PFD	-	Primary Flight Display
PIC	-	Pilot-in-Command
PLN ATCO	-	Planning Air Traffic Controller;
PM	-	Pilot Monitoring
RA	-	Resolution Advisory
RA Downlink	-	Automatic notification to the controller about Resolution Advisories (RAs) generated in the cockpit by the Airborne Collision Avoidance System (ACAS);
RCR	-	en-Route Clearance with Re-routing
SALT	-	Selected Altitude
SBL	-	Family Sector Sofia East
SDU	-	Family Sector Sofia East - Upper;
SSR	-	Secondary surveillance locator
STCA	-	Short-term conflict alert
SVS	-	Selected Vertical Speed
TA	-	Traffic advisory
TCAS/ACAS	-	Traffic Alert and Collision Avoidance System/Airborne Collision Avoidance System;
TCP	-	Control Transfer Point
THY4AV	-	Boeing 737-8F2 aircraft, registration marks TC- JVS of Turkish Airlines AO
UTC	-	Universal Coordinated Time
V/S	-	Vertical speed
XFL	-	Exit Flight Level

1 Introduction

Date and time of air occurrence: 8th of September, 2016, 15:03 h UTC. The difference between the local and Universal Coordinated Time is +3 hours. All times in this report are UTC.
Notified: Aircraft, Maritime and Railway Accident Investigation Unit Directorate and Civil Aircraft Administration Main Directorate at the Ministry of Transport, Information Technology and Communications of the Republic of Bulgaria (MTITC); the European Commission; the International Civil Aviation Organization (ICAO); the National Bureau of Aviation Occurrences Investigation (BEA) of the Republic of France; European Air Safety Agency; Maritime Affairs and Communications Accident Investigation Board of Republic of Turkey and National Transportation Safety Board of USA.
On the grounds of the provisions of Article 9, para.1 of Ordinance No 13 dated 27.01.1999 on Investigation of Aviation Accidents; the occurrence was classified as a serious incident by the Aircraft Accident Investigation Unit at the Aircraft, Maritime and Railway Accident Investigation Unit Directorate (AMRAIU) at the Ministry of Transport, Information Technology and Communications. The materials on the aviation occurrence have been filed in case No 06/08.09.2016 in AAIU archives.
In accordance with the provisions of Article 5, para1 of Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation, Article 142. Para2 of the Civil Aviation Act of the Republic of Bulgaria dated 01.12.1972 and Article 10, para1 of Ordinance No 13 of the Ministry of Transport dated 27.01.1999 on the Investigation of Aviation Occurrences, by Order No RD-08-450 dated 29.09.2016 of the Minister of Transport, Information Technology and Communications, a Commission is appointed for investigation of the serious incident.
At 15:02 UTC on 8 September 2016, an infringement of the minimum standards of radar separation between two aircrafts transiting the upper airspace of Bulgaria was committed in the controlled airspace, family sector Sofia-East. Aircraft Airbus A321-211, reg. marks TC-ATF, of "Atlasjet" performing flight KKK8YJ and Boeing 737-8F2, reg. marks TC-JVS of "Turkish Airlines" performing flight THY4AV, passed by each other at a minimal horizontal distance of 1,2 NM at FL 363 without any vertical separation. After the separation between aircraft was recovered, the flight crew of KKK8YJ reported a technical problem and flight crew of THY4AV reported "TCAS RA.
As a result of the investigation, the Commission considers that the serious incident is due to the following reasons:

Main cause

Violation of the autopilot vertical speed selection process technology of A321-211 aircraft resulted in climbing of the aircraft instead of executing the clearance issued to KKK8JY for descent.

Contributing cause

A state of Expectation Bias of EXE ATCO that led to issuing of clearance to THY4AV for descent during the time when the KKK8JY started to climb in contrary to the previously issued and confirmed by the crew clearance for descent and the presence of indication displayed on the ATCAS screen for selected FL 310 by the crew of KKK8JY.

2 Factual information

2.1 Flight history

2.1.1 Flight number, type of operation, last point of departure, destination point of the involved aircraft

Aircraft	A/C-1	A/C-2
Air Operator	Turkish Airlines	Atlasjet
Type of flight	Civil	Civil
Type	B737-8F2	A321-211
Call sign	THY4AV	KKK8YJ
Registration marks	TC-JVS	TC-ATF
SSR Code	4771	3067
SSR mode	S	S
Flight Rules	IFR	IFR
Flight Stage	Descent	Descent
Take-off Airport	Zurich - LSZH	London - EGKK
Landing Airport	Istanbul - LTBA	Istanbul - LTBA

2.1.2 Flight preparation, description of the flight and events leading to the serious incident

On September 8 th, 2016 B737-8F2 aircraft of Turkish Airlines AO, with registration marks TC-JVS and call sign THY4AV was performing a flight on the route Zurich (LSZH) - Istanbul (LTBA). According the flight plan the aircraft shall enter in Republic of Bulgaria airspace through NISVA TCP at FL370, to fly one-way track T391 and to leave the serviced airspace of Republic of Bulgaria through RILEX TCP at FL270.

A321-211 aircraft of Atlasjet AO, with registration marks TC-ATF and call sign KKK8YJ was performing a flight on the route London (EGKK) - Istanbul (LTBA). According the flight plan the aircraft shall enter in Republic of Bulgaria airspace through ETIDA TCP at FL370, to fly one-way track T390 and to leave the serviced airspace of Republic of Bulgaria through RILEX TCP at FL270.

According to an approved schedule by the Director of ACC - Sofia on September 8th, 2016 at 14:00 h, a shift of ATCO, consisting of an EXE ATCO and PLN ATCO took over, assuming responsibility for air traffic control of the Sofia-East family sector (SBL) in ACC – Sofia.

At 15:01:30, UTC A321-211 aircraft KKK8JY is in cruise heading for RILEX TCP at FL350 at a speed of M 0, 78, with ATHR and AP2 autopilot engaged in ALT/NAV modes.

At 15:01:30, B737-8F2 aircraft THY4AV is in cruise heading for RILEX TCP at FL370 at a speed of M 0,78 with A/THR and AP engaged.

At 15:01:53, EXE ATCO issued clearance to KKK8JY for descending to FL310 at a vertical speed greater than 1000 ft/min. Flight crew confirmed correctly the flight level and confirmed a vertical speed of descent of - 1500 ft/min as well. The distance between KKK8JY and THY4AV, flying at FL370, was 1,9 NM and both aircraft were on converging headings towards RILEX TCP.

At 15:02:03 the flight crew of KKK8JY entered changes to the settings of the FCU: the SALT (Selected Altitude) was changed to FL310, OPDES (Open Descend) was selected for a second and after that the SVS (Selected V/S) was engaged to +1500ft/min and the pitch increased from 1.4° up to 4.2°. The aircraft started to climb because of the positive V/S set.

According the radar information it is visible, that at 15:02:29 A321-211 aircraft KKK8JY started climbing instead of implementing a descent to FL310 as instructed. The distance between KKK8JY and THY4AV at that moment was 1,9 NM, and the vertical separation was 1900 ft. (See Fig. 1)

At 15:02:43, SELEX ATCAS generated an alarm for a short-term conflict (STCA) between THY4AV and KKK8JY, which was displayed on the work position of SBL family sector. At this moment, the EXE ATCO instructed THY4AV to descend from FL370 to FL350. The crew did not confirm the clearance issued and the EXE ATCO instructed the crew to continue descending

to FL330, specifying a V/S of -1000 ft/min or less. Again, there was no confirmation from the crew of THY4AV. At this point KKK8JY was already crossing FL357 in climb to unknown flight level with a V/S of +1500 ft/min, the distance between both aircraft was 1,5 NM and the vertical separation was 1247 ft. (See Fig. 2)

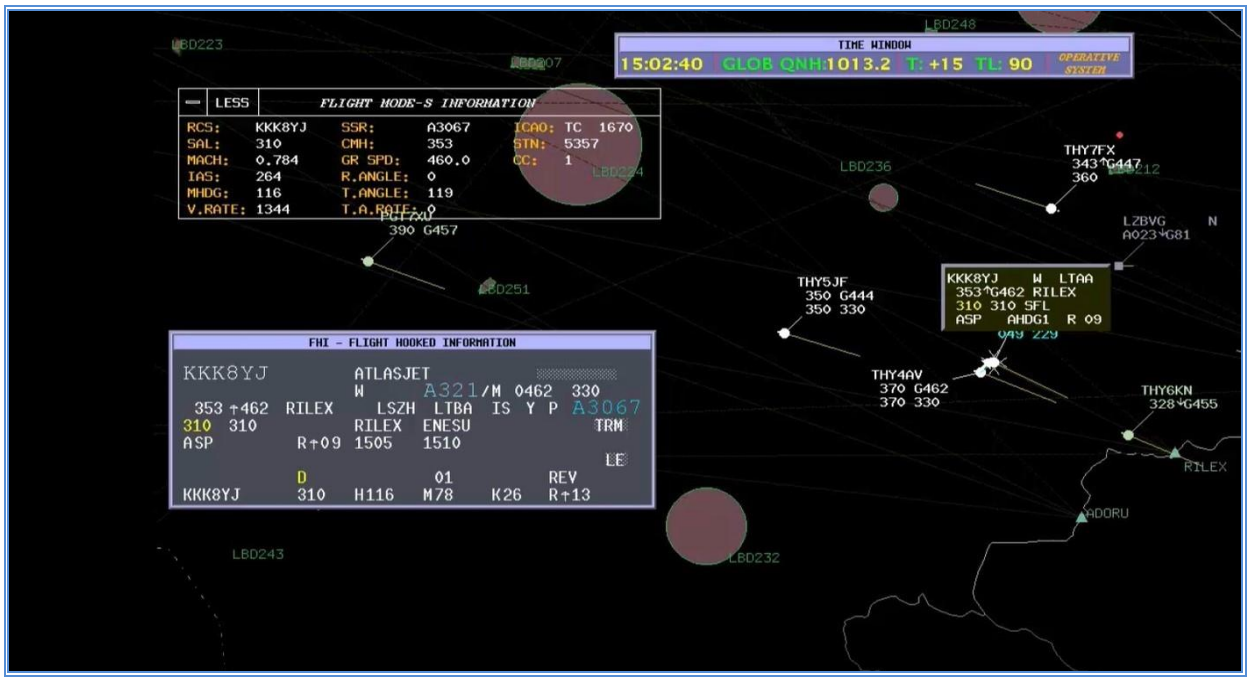


Fig. 1

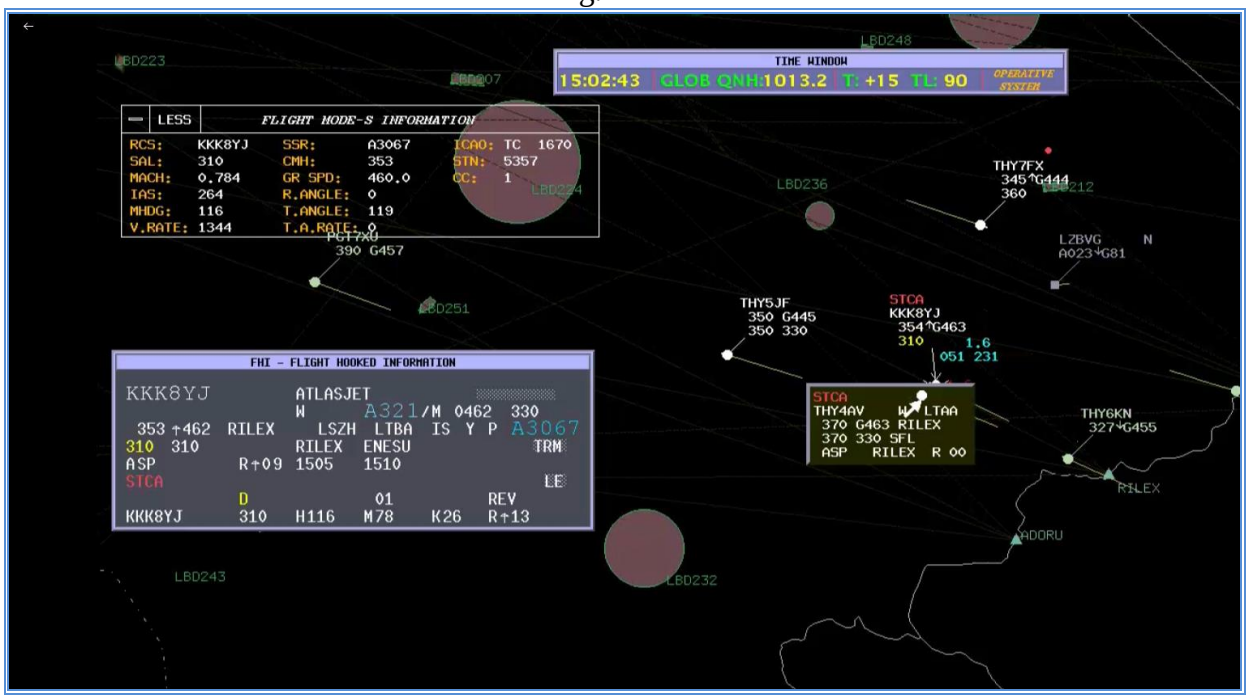


Fig. 2

At 15:02:54, KKK8JY crossed FL358 in climb heading 117° and the flight crew received a TCAS TA warning that lasted for 44 seconds.

At 15:03:07, the standard for minimum radar separation was infringed. THY4AV was descending and crossing FL368 with a V/S of -1300 ft/min, and KKK8JY was crossing FL360 in climb with V/S of +1500 ft/min. The distance between both aircraft was 1,5 NM and the vertical separation was 852ft. (See Fig. 3)

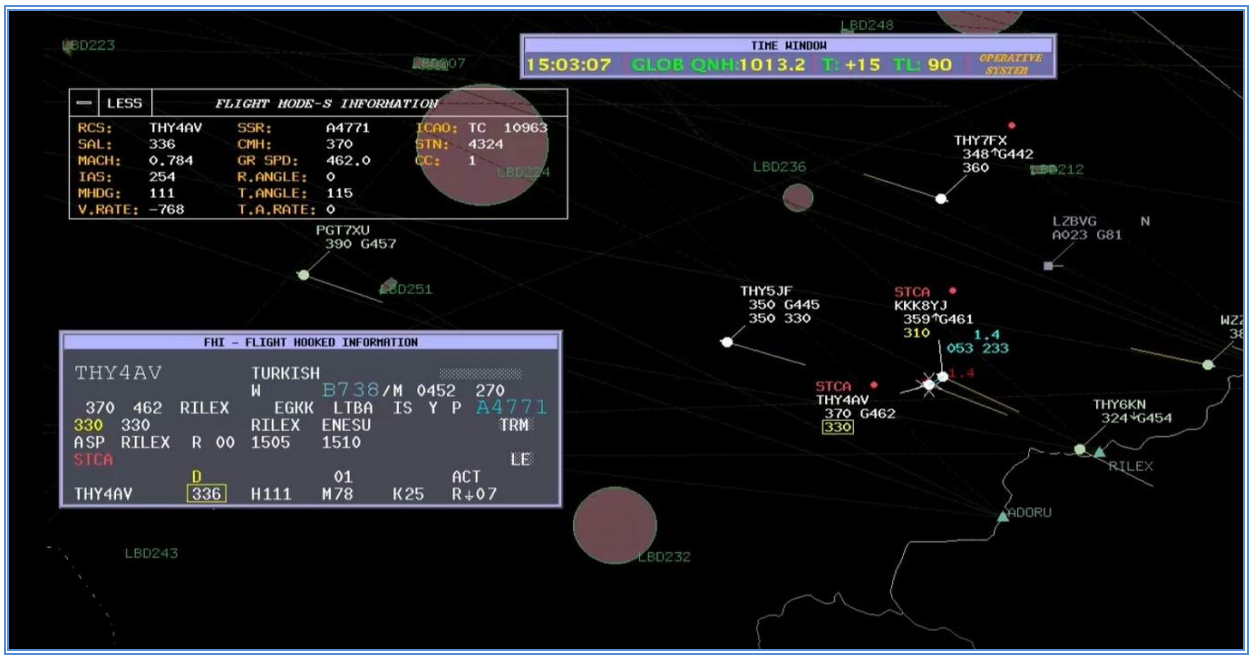


Fig. 3

At 15:03:10 h A321-211 aircraft KKK8JY crosses FL362 in climb, the crew changes FCU SALT (selected altitude) from FL310 to FL330 for 28 s and after that return it to FL310. The crew did not make any changes to the descent mode selected or rate of V/S. Therefore, the positive rate selected remained engaged.

At 15:03:11 h EXE ATCO Control instructed KKK8JY to turn immediately left 30°, and instructed THY4AV to turn immediately right 30°. The distance between both the aircraft was 1.3 NM. Both the crews did not confirm the clearances issued by the EXE ATCO.

At 15:03:14 h KKK8JY crossed FL363 in climb and the crew changed the SHDG setting of FCU from 117° to 91° (left turn). AP lateral mode was switched from NAV to HDG. The a/c roll angle increased to 14.8° left and the heading set to 94° was reached in 35 seconds.

At 15:03:24 h KKK8JY was climbing with a V/S of +1300ft/min and crossed vertically the heading of THY4AV, which was descending with a V/S of -1700ft/min. The distance between both aircraft was 1,3 NM and the vertical separation was 46ft.

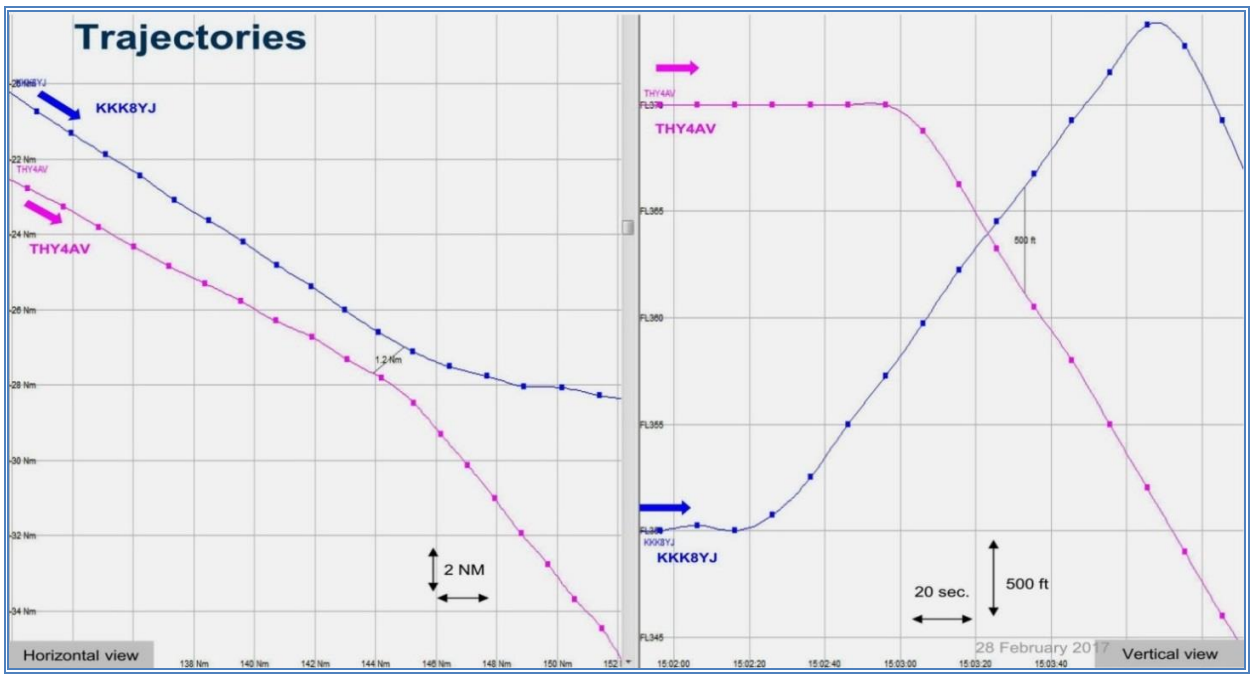


Fig. 4

According to the simulation performed (Annex 2), the closest point of approximation occurred at 15:03:33 h. The horizontal distance between both the aircraft was 1.24 NM and the vertical was 500 ft. (See Fig. 4)

A message of RA downlink shows that THY4AV received indication PREVENTIVE RA (MONITOR VERTICAL SPEED-prohibiting climb) during the time interval between 15:03:34 h and 15:03:36 h.

At 15:03:35 h EXE ATCO attempted to contact THY4AV again, but with no result.

At 15:03:38 h while climbing and at FL368 heading 105°, the warning TCAS TA on board of KKK8JY disappeared.

A message of RA downlink shows, that at 15:03:41 h THY4AV received an indication CLEAR OF CONFLICT while crossing FL359 during descent.

At 15:03:57 h at FL373, the crew of KKK8JY changed the SVS on FCU to -2100 ft/min and after 4s the AP was switched to OPDES mode (engine power was reduced to idle, the pitch angle started to decrease from 4,2° and the altitude also started to decrease. SALT was changed from FL310 to FL340, 15s later to FL330 and 1min later - again to FL310.

At 15:04:40 h EXE ATCO instructed THY4AV to transfer the radio communication to the frequency of Ankara Control. The crew confirmed the clearance and reported about actions undertaken after the TCAS RA received.

At 15:05:17 h the descent mode of KKK8JY was changed again - the aircraft crossed FL344 with a pitch angle of -3,2° in a V/S mode, the SVS was selected on -3700 ft/min, and 4s later the AP was switched to OPDES mode.

At 15:05:22 h KKK8JY reached and levelled at FL310 as set by SALT.

On the Fig. 5 a diagram with the parameters of descent of KKK8JY with TC-ATF registration marks is shown as it was presented in the report of Airbus (Reference GSI 420.1037/17) following DFDR flight analysis:

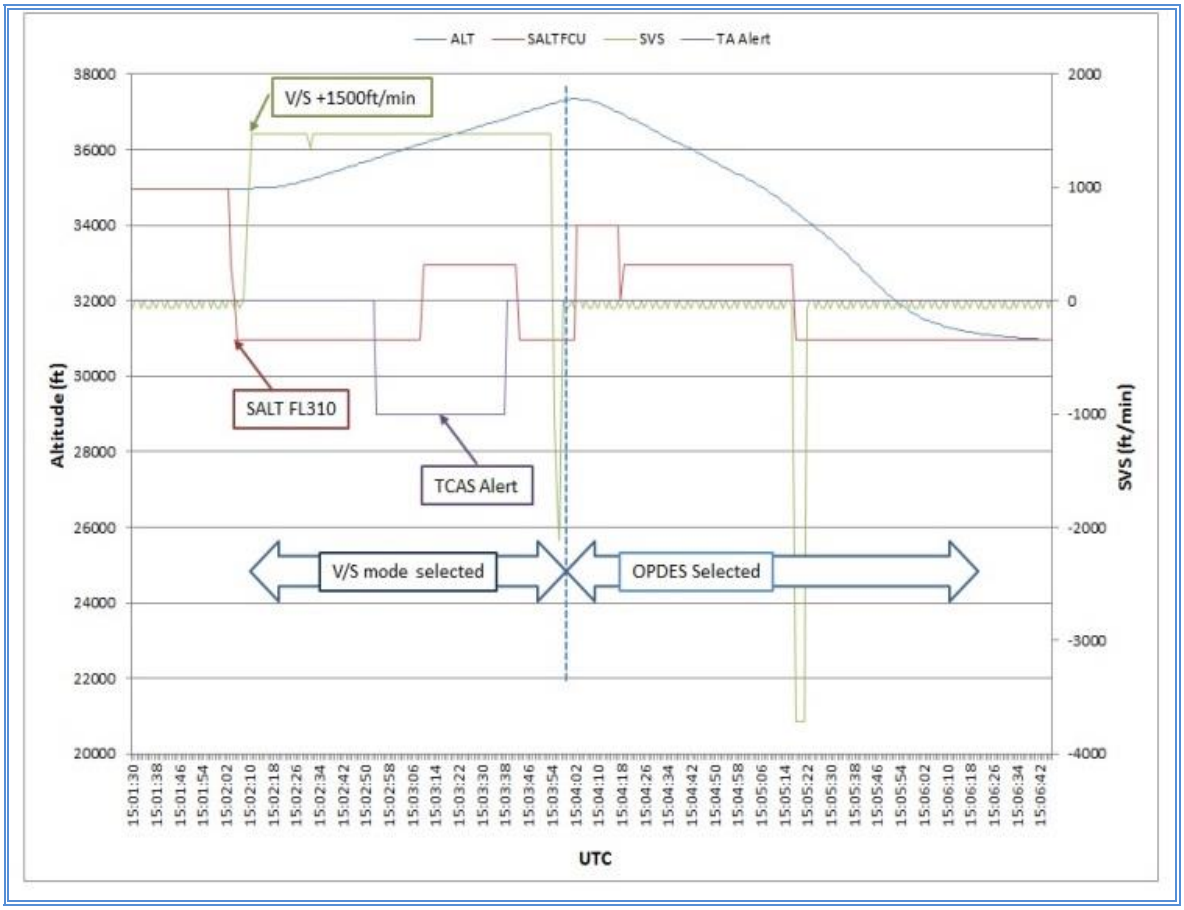


Fig. 5

2.1.3 Location of aviation occurrence

15 NM northwest of RILEX TCP in the controlled airspace of Republic of Bulgaria

Date and time: 8th of September 2016, 15:03:30 h UTC

Airspace: Class C.

2.2 Injuries to persons

No injuries of crews, passengers or other persons as a result of air occurrence.

2.3 Damage to Aircraft

No damages to the aircraft.

2.4 Other damages

No other damages.

2.5 Personnel information

2.5.1 Crew of A321-211 aircraft with a call sign KKK8JY

2.5.1.1 Captain Pilot Flying

Gender:	Male
Age:	56 Years
Employment:	Captain
Experience:	12 150 FH
ATPL valid:	19.05.2021
Medical Certification:	26.01.2017
Line check:	01.12.2015
Type Rating:	A320 28.02.2017
SIM check:	26.07.2016
ENGLISH	LEVEL 6

2.5.1.2 First Officer:

Gender:	Male
Age:	33 Years
Employment:	First Officer
Experience:	337 FH
ATPL valid:	06.06.2017
Medical Certification:	06.06.2017
Line check:	26.07.2016
Type Rating:	A320 17.05.2017
SIM check:	06.05.2016
ENGLISH	LEVEL 4

2.5.2 Crew of B737-8F2 aircraft, call sign THY4AV

2.5.2.1 Captain Pilot Flying:

Gender:	Male
Age:	43 Years
Employment:	Captain
Experience:	2954 FH
ATPL valid:	31.07.2017
Medical Certification:	26.01.2017
Line check:	16.03.2017
Type Rating:	
SIM check:	05.07.2016
ENGLISH	LEVEL 6

2.5.2.2 First Officer:

Gender:	Male
Age:	40 Years
Employment:	First Officer
Experience:	2437 FH
ATPL valid:	31.08.2017
Medical Certification:	04.04.2017
Line check:	25.07.2017
Type Rating:	
SIM check:	21.09.2016
ENGLISH	LEVEL 6

2.5.3 ATS Unit: SOFIA ACC - FS SBL

2.5.3.1 Radar EXE ATCO:

Gender:	Male
Age:	45 Years
Year of birth:	1970
ATCL BGR.ATCL:	Certificate ATCL
Rating :	Permissions FS Sofia ACS – RAD valid till 15.09.2016
ENGLISH:	LEVEL5 valid till 19.05.2017
Medical Certification:	valid till 28.06.2017

2.5.3.2 PLN ATCO:

Gender:	Male
Age:	43 Years
Year of birth:	1972
ATCL BGR.ATCL:	Certificate ATCL
Rating:	Permissions FS Varna ACS – RAD valid till 15.06.2017 Permissions FS Sofia ACS – RAD valid till 05.06.2017
ENGLISH:	LEVEL 5 valid till 19.05.2017

Medical Certification: valid till 13.03.2017

2.5.3.3 STUDENT ATCO:

Gender:	Male
Age:	25 Years
Year of birth:	1991
ACS BGR.ACS:	Permission for student ATCO
Rating:	Permissions of 11.05.2016
ENGLISH:	LEVEL valid till 01.04.2022.
Medical Certification	valid till 01.06.2017

The flight crews of A321-211 aircraft with call sign KKK8JY and B737-8F2 aircraft with call sign THY4AV and ATCOs of ACC - Sofia possess the required qualification and medical certification to carry out their duties.

2.6 Aircraft Information

There are no data about technical failures of the on-board systems neither in the flight crews' reports nor in the analysis of the FDR readouts.

2.6.1 KKK8JY Aircraft

Type of aircraft:	AIRBUS A321-21
Factory serial number:	0761
Manufactured:	11th of February, 1998
Registration:	TC-ATF
Engines:	CFM56-5B
Air Operator:	Atlasjet (KKK)

Total flying time since new as on 29th August 2016: 42,735:58 hours

Certificate of airworthiness No 2500, valid till 24th of September, 2017

2.6.2 THY4AV Aircraft

Type of aircraft:	BOENIG B737-800
Factory serial number:	60021
Manufactured:	May 2016
Registration:	TC-JVS
Engines:	N/A
Air Operator:	Turkish Airlines (THY)

Total flying time since new as on 27th of May 2016: 19:13 h

Certificate of airworthiness, valid till 26th of May, 2017

A321-211 aircraft, registration marks TC-ATF of Atlasjet AO and B737-8F2 aircraft, registration marks TC-JVS of Turkish Airlines AO were airworthy as to the time of air occurrence realization.

2.6.3 Change of selected altitude and heading in FCU of A321 aircraft

Since the occurrence is associated with a change in altitude and heading of A321 aircraft, the information below is given for these modes only.

On the Fig. 6 is shown a panel of FCU on board of A321 aircraft.

Fig. 6

The change of selected altitude is performed by FCU. The selected altitude is set by rotation of ALT knob, followed by:

- Engage OPDES by pulling the ALT knob, or
- Engaging of V/S/FPA mode by pulling the V/S/FPA knob and selection of the necessary V/S by "+"for climb and "-"for descent.

The change of the heading is performed by FCU. The required heading shall be set by pulling the HDG knob and rotation of HDG up to the required heading.

The flight mode annunciator (FMA), which is just above the primary flight display (PFD), shows the status of the autothrust, vertical and lateral modes of the autopilot and flight director, approach capabilities, and the engagement status of the autopilot (AP), flight director (FD) and autothrust (A/THR).

2.7 Meteorological Information

The meteorological conditions at the time of the air occurrence realization were of no effect to the serious incident.

2.8 Navigation

Both aircraft performed the flights with the standard navigation equipment of the type of aircraft. The flights of the two aircraft were carried out in the upper air space of Bulgaria, under the conditions of zonal navigation and in conformity with the Instrument Flight Rules. There is no

information about technical failures of the navigation system of the Bulgarian Air Traffic Services Authority (BULATSA), which could be able to cause the occurrence. All facilities included in the national net operated normally.
In the daily statement of the ACC Sofia no failures of technical means were recorded, which might directly affect the operational ability at the moment of the occurrence.

2.9 Communications

Both aircraft performed the flights with the standard navigation equipment of the type of aircraft. The air-ground radio communication in the FS SBL and the aircraft serviced was carried out at the frequency of 135.025 MHz. The Bulgarian Air Traffic Services Authority provided a transcript of the radio-communication of Sofia Control, FS SBL, at frequency of 135.025MHz, as well telephone communication between PLN ATCO and adjacent ATC sectors before during and after the time of the aviation occurrence. After hearing the radio conversations at the work frequencies of FS SBL, the Investigation Commission found that there had been no loss of radio communication and that there were no interruptions and disturbances during radio broadcasting with the 10 aircraft in the sector at the time.

2.10 Aerodrome information

The occurrence is not realized at an aerodrome.

2.11 Flight data recorders

- Data were used from the flight data recorders of the Common National Air Traffic Control Centre (CNATCC) of the Bulgarian Air Traffic Services Authority (BULATSA) in regards to the radar picture and radio communications, as well as records of the telephone communication of the Planning Air Traffic Controller with the other sectors.
- The FDR data of A321-211 aircraft, registration marks TC-ATF of Atlasjet AO and of B737-8F2 aircraft, registration marks TC-JVS of Turkish Airlines AO.

The records have been enclosed to the investigation materials in case No 06/08.09.2016.

2.12 Wreckage and Impact Information

The occurrence was not related with aircraft destruction.

2.13 Medical and Pathological Information

Because of the nature of the air occurrence medical and pathological research has not been performed.

2.14 Fire

No fire initiated during the occurrence.

2.15 Survival Aspects

No survival equipment was used by the passenger and the crews.

2.16 Tests and Research

The Commission has carried out and conducted the following for the purposes of the investigation in connection with safety.

- Collecting, documentation, studying, listening and analysis of the radar picture recordings, radio exchange, the telephone communication between the work position Sofia - Control – SBL sector and the neighbouring ATS sectors;
- Listening, documentation and analysing of voice exchange records in the SBL sector;
- Discussions with EXE ATCO, PLN ATCO and Air Traffic Controller – Supervisor who performed air traffic control during the serious incident;

- Analysis of the actions of ATCO at SBL sector;
- Analysis of the flight crews actions of both aircraft during the aviation occurrence;
- The Commission also requested, discussed and analyzed data from:
- The flight crew report of B737-8F2 aircraft crew with a call sign THY4AV;
- The flight crew report of A321-211aircraft crew with a call sign KKK8YJ;
- The report from Airbus: Reference GSI 420.1037/17;
- FDR data of Airbus A321-211 aircraft, registration marks TC-ATF of Atlasjet AO about the flight parameters in the area under consideration;
- FDR data of Airbus A321-211 aircraft, registration marks TC-JVSof Turkish Airlines AO about the flight parameters in the area under consideration;

To determine the reasons for triggering of the TCAS as well as the actions of the crews of the aircraft, the Commission for safety investigation coordinated with the EUROCONTROL and a simulation of the event was implemented on InCAS v3.3 (Interactive Collision Avoidance Simulator). The simulation results are given in Annex 2.

2.17 Additional information

2.17.1 Sectoring of the air space into Family Sectors Sofia at the time of the incident

Sofia Control, sector SAL (Sofia West)
Sofia Control, sector SBL (Sofia East)
The air space into sectors is shown on Fig 7

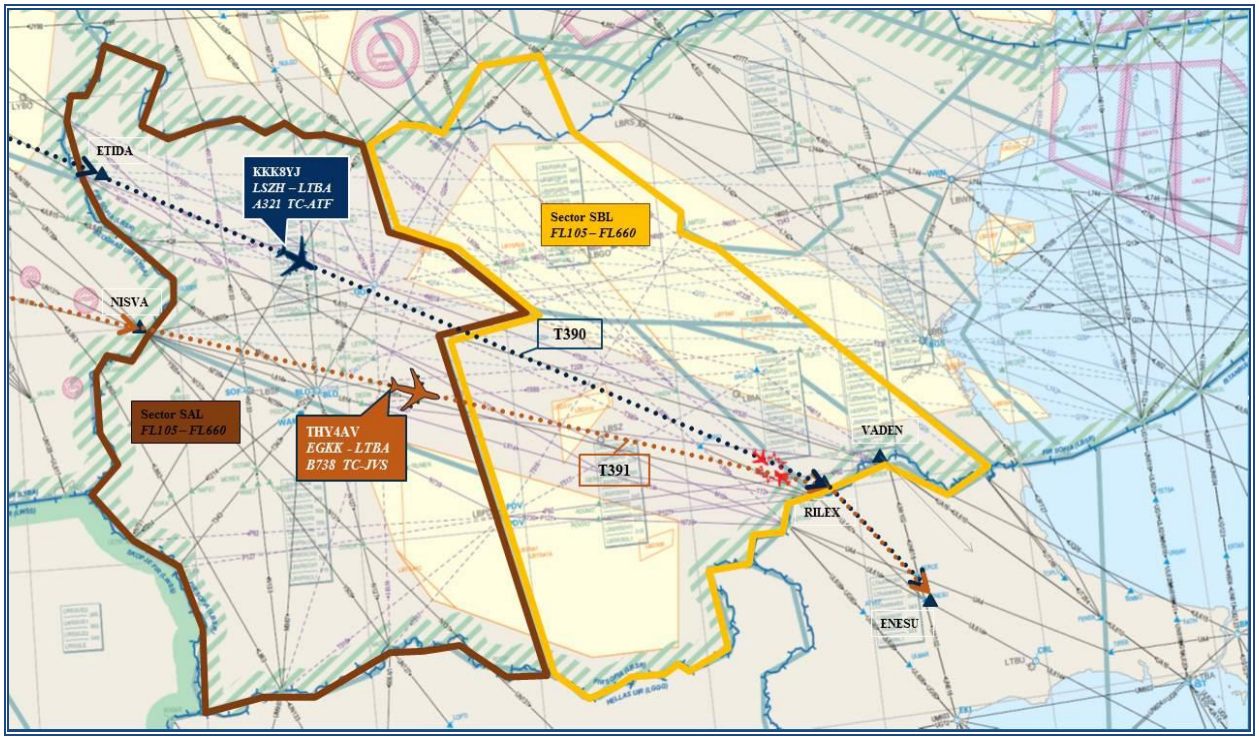


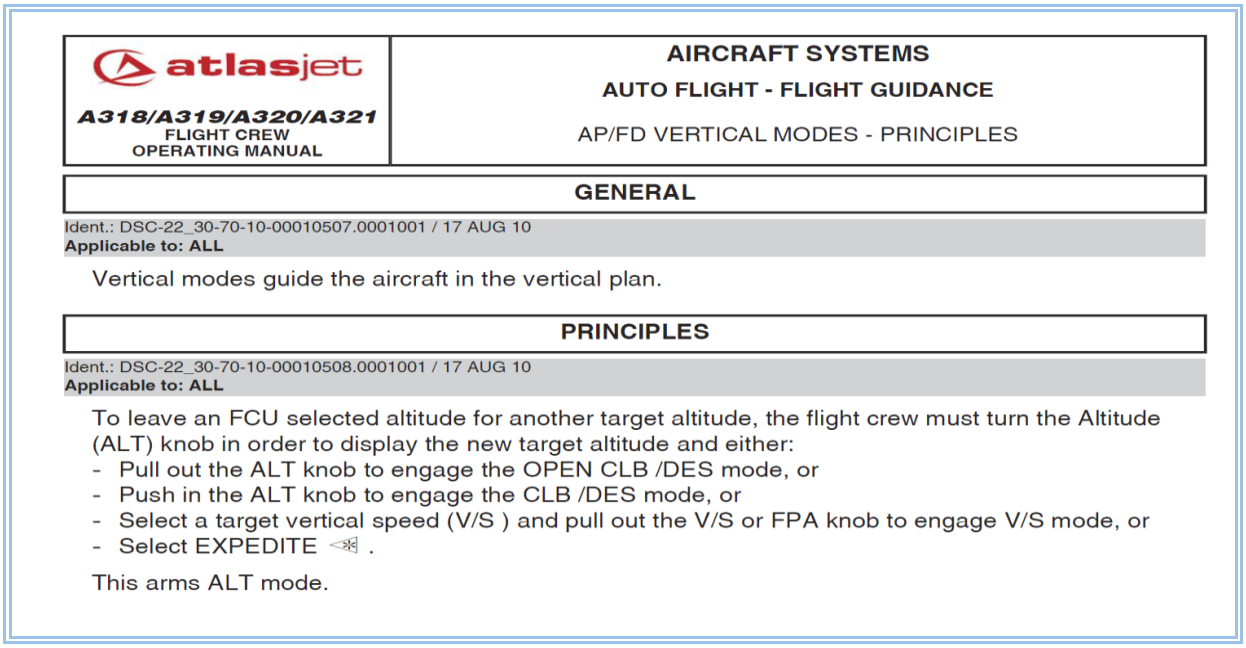
Fig. 7

2.17.2 Activated warning systems and activation procedure

- ACAS/TCAS system on board of B737-8F2 aircraft THY4AV was activated in RA mode and generated Preventive RA command.
- ACAS/TCAS system on board of A321-211 KKK8YJ was activated in TA mode.
- SELEX air traffic automatic control system generated a short-term conflict alarm (STCA) between B737-8F2 aircraft THY4AV and A321-211 aircraft KKK8JY, which was displayed on the workposition of SBL sector. The distance between both aircraft was 1,6 NM and the vertical separation 1600 ft.

2.17.3 AP/FD VERTICAL MODES - RULES

The modes of aircraft control in vertical plane are described by AIRBUS and included in FCOM DSC-20-30-70-10 of Atlasjet AO (Annex 3). (See Fig. 8)



atlasjet
A318/A319/A320/A321
FLIGHT CREW
OPERATING MANUAL

AIRCRAFT SYSTEMS
AUTO FLIGHT - FLIGHT GUIDANCE
AP/FD VERTICAL MODES - PRINCIPLES

GENERAL

Ident.: DSC-22_30-70-10-00010507.0001001 / 17 AUG 10
Applicable to: ALL

Vertical modes guide the aircraft in the vertical plan.

PRINCIPLES

Ident.: DSC-22_30-70-10-00010508.0001001 / 17 AUG 10
Applicable to: ALL

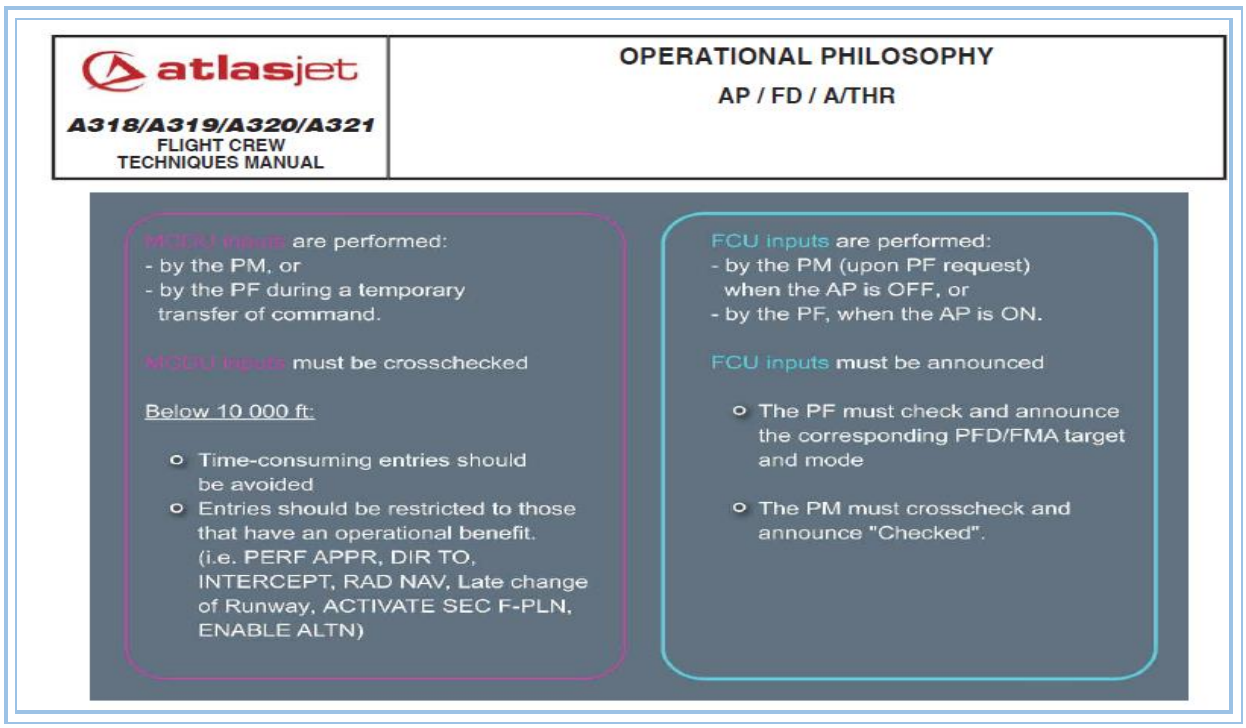
To leave an FCU selected altitude for another target altitude, the flight crew must turn the Altitude (ALT) knob in order to display the new target altitude and either:
- Pull out the ALT knob to engage the OPEN CLB /DES mode, or
- Push in the ALT knob to engage the CLB /DES mode, or
- Select a target vertical speed (V/S) and pull out the V/S or FPA knob to engage V/S mode, or
- Select EXPEDITE .

This arms ALT mode.

Fig. 8

2.17.4 AIRBUS Operational Philosophy AP/FD/A/THR

After processing the command actions in FCU both pilots shall perform a crosscheck in FMA according the operational philosophy for AP/FD/A/THR, described in FCOM DSC-20-30-70-10 of Atlasjet AO. (Annex 4) (See Fig. 9)



atlasjet
A318/A319/A320/A321
FLIGHT CREW
TECHNIQUES MANUAL

OPERATIONAL PHILOSOPHY
AP / FD / A/THR

MCDU inputs are performed:
- by the PM, or
- by the PF during a temporary transfer of command.

MCDU inputs must be crosschecked

Below 10 000 ft:

- Time-consuming entries should be avoided
- Entries should be restricted to those that have an operational benefit. (i.e. PERF APPR, DIR TO, INTERCEPT, RAD NAV, Late change of Runway, ACTIVATE SEC F-PLN, ENABLE ALTN)

FCU inputs are performed:
- by the PM (upon PF request) when the AP is OFF, or
- by the PF, when the AP is ON.

FCU inputs must be announced

- The PF must check and announce the corresponding PFD/FMA target and mode
- The PM must crosscheck and announce "Checked".

Fig. 9

2.17.5 Operational guidelines in form of “Golden Rules”

FCTM OP-010 (Annex 5) provides operational guidelines in form of “Golden Rules” of the manufacturer AIRBUS, which states flight parameters, must be actively monitored…

… and immediately take appropriate or required actions, if the aircraft does not follow the desired flight path. (See Fig. 10)

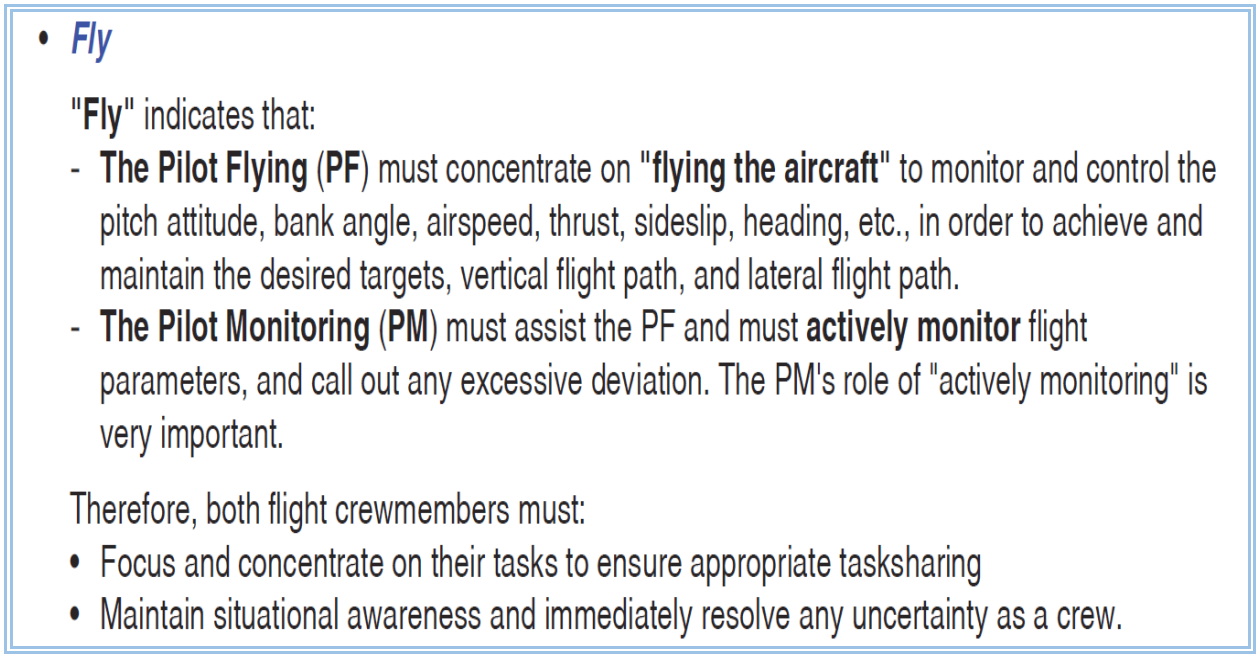


Fig. 10

3 Analysis

The following hypotheses were considered in order to identify the causes of the serious incident realized:

- Eventual technical failure of ground ATCAS;
- Eventual technical failure of any of the aircraft systems;
- Errors of the crews of the B737-8F2 aircraft THY4AV and/or A321-211 aircraft KKK8YJ, associated with aircraft control in change of altitude;
- Inefficient implementation of procedures by ATCO upon the provision of ATS under conditions of reversed performance of a issued clearance by the aircraft crew.

The first hypothesis is related to the technical failure of ATCAS. On the ground of information received, the Commission established that the ATCAS system - SATCAS v3MS2 - worked without interruption of its functionalities. From the information obtained, it was established that STCA (Short Term Conflict Alert) functionality of the ATCAS v3MS2 Safety Nets subsystem was generated a warning in accordance with the parameters set in the subsystem's specifications.
Considering the contents of paragraphs 2.1.2, 2.6 and 2.17 above, the Commission declines the possibility that the event has resulted from a technical failure of ATCAS.
As for the second hypothesis, during the investigation the Commission did not find any information about irregularity of aircraft systems of B737-8F2 aircraft, registration marks TC-JVS and A321-211 aircraft, registration marks TC-ATF.
It was established from the information received, that both on-board ACAS/TCAS system were activated. In RA mode with a PREVENTIVE RA generated command for B737-8F2 aircraft THY4AV and in TA mode for Airbus A321-211 aircraft KKK8YJ.
An InCAS simulation was implemented in EUROCONTROL for the conflict period where both the aircraft flew at a horizontal distance of 1,2 NM. In accordance with the results of the simulation, it was a slow closure encounter with a horizontal miss distance of approx. 1,2 NM, which was close to the TCAS Miss Distance Filter threshold of 1,1 NM at this altitude of KKK8YJ. Most likely, the KKK8YJ aircraft did not receive an RA indication because its TCAS

system had predicted that the Closest Point of Approach would be outside the TCAS alerting threshold range. Individual TCAS units make their own independent predictions based on their own surveillance data. Conversely, the Miss Distance Filter was invoked on TCY4AV and it received a PREVENTIVE RA against KKK8YJ when it was already below the intruder and descending. Although InCAS simulations did not confirm it, the expert judgment is that TCAS worked as expected and played its role in preventing the escalation of the conflict situation by restricting climb maneuvers to THY4AV.

Considering the contents of paragraphs 2.1.2 and 2.6 above, the Commission declines the possibility that the event resulted from a technical failure of any of the on-board systems of the two aircraft.

The Commission associates the third hypothesis with possible mistakes made by the crews of the B737-8F2 aircraft THY4AV and/or the A321-211aircraft KKK8YJ in the aircraft controlling.

With regard to the flight of a B737-8F2 aircraft with call sign THY4AV:

According to the information received from BULATSA, the explanations of the flight crew of THY4AV with B737-8F2 aircraft, the analyzed data from DFDR provided by Turkish Airlines AO and the one set out in paragraph 2.1.2 during the flight in the controlled airspace of Sofia Control, SBL sector, the aircraft executed correctly the instructions of EXE ATCO for descent to RILEX TCP up to the moment of TCAS RA activation. After that, the aircraft crew changed the descent profile in accordance with indications of PREVENTIVE RA of TCAS. During the conflict situation the crew of THY4AV was not responding to and did not acknowledge any of the EXE ATCO instructions. Subsequently, after transferring the control to Ankara Control, the aircraft crew reported to EXE ATCO for the indication and actions undertaken related to TCAS RA. Perhaps the delay of the report to EXE ATCO was due to the rapidly evolving situation and the two pilots were busy with its handling.

With regard to the flight of A321-211 aircraft with call sign KKK8YJ:

According to the received information from BULATSA, the explanations of the flight crew of flight KKK8YJ with A321-211 aircraft, the analyzed data from DFDR provided by Airbus and the statement in paragraph 2.1.2 above, the flight in the controlled airspace of FS SBL, was normal to the moment of issuing the clearance for descent to RILEX TCP by the EXE ATCO. After issuing of a clearance for descending to FL310 with V/S of no less than 1000 ft/min, the Pilot Flying correctly set the required altitude using the SALT knob of FCU, initially switching the OPDES mode on, but in a second he changed his decision and switched to V/S/FPA mode by pulling the V/S/FPA knob and selecting +1500 ft/min. In his last action, the PF mistakenly chose a positive V/S instead of a negative one. The aircraft started to climb from FL350 in contrary to the clearance issued by EXE ATCO. PF did not sense physically and did not notice that the aircraft was climbing, since he did not control this change on FMA and PFD. During that time, the PIC (PM) was not in the cockpit and for this reason no crosscheck, which is to be made by the two pilots, was made in accordance with procedures specified in the "Golden Rules" of the Airbus manufacturer and the Flight Crew Techniques Manual FCTM OP-010 of Atlasjet AO. After the aircraft reached FL363, the PIC entered the cockpit and found out the wrong actions undertaken by the first officer. The crew implemented the clearance of EXE ATCO to change heading for avoiding the conflict situation and adjusted its actions by repeatedly switching the OPDES and V/S modes and selecting a negative V/S for descent.

Probably the wrong actions of the crew resulted from the short experience of the second pilot as PF with the aircraft of the type, insufficient theoretical training with regard to the AP behavior at altitude changes and the breach of procedures made in the absence of one crew member from the cockpit.

In view of the third hypothesis above, the following conclusions could be drawn:

- The crew of THY4AV implemented the preventive command MONITOR VERTICAL SPEED generated to keep the ongoing flight path unchanged with increased caution. The

Commission considered that the actions of THY4AV crew during the conflict situation had been correct and they had had no contribution for further complication of the situation.

- The crew of KKK8YJ violated the technology for changing the altitude using wrong V/S selection on FCU resulting in climb of the aircraft contrary to the clearance for descent and this way complicated the situation and increased the risk of collision.

The fourth hypothesis is related to the ineffective implementation of procedures by ATCO when providing ATS in the context of an erroneous execution of an issued clearance by the flight crew. During the period of the occurrence realization, 10-15 aircraft were serviced simultaneously in SBL. The preliminary plan of EXE ATCO/PLN ATCO for descent of KKK8JY and THY4AV was correct according to the Letter of Agreement between SOFIA ACC and ANKARA ACC related.

EXE ATCO issued a clearance for descent to FL310 to KKK8JY, indicating a descent rate of 1000ft/min or more. Immediately after that, the crew of NJE614R's requested FL400 for a final cruise of and EXE ATCO informed him to wait. Fifteen seconds later, EXE ATCO called the crew of Chan-ex 798 and transferred its communication to Bucharest Control. Immediately after, EXE ATCO issued a clearance for descent to THY4AV to FL350. During the communication, ATCAS generated a STCA related to KKK8JY and THY4AV. During the following 6 seconds, the crew of THY4AV was not answering to the clearance issued and the EXE ATCO reissued again the clearance for descent to FL330 with a vertical speed of no more than 1000ft/min.

In this evolving situation, the EXE ATCO perceived the STCA as per caused by the assumed large vertical speed of THY4AV and therefore he issued the clearance again, complemented with a specified vertical speed of descent. Furthermore, the EXE ATCO received a confirmation of the issued clearance for descent from the crew of KKK8JY and observed the displayed indication from Mode S for setting FL310 in cockpit on board, which created a wrong perception on the situation.

During the next 5 seconds, the crew of THY4AV continued not to respond to the issued clearance, and then called the flight crew of THY377 informing that they were climbing to FL340 and wishing the final FL400. The EXE ATCO interrupted this radio communication, as he noticed that a conflict situation between KKK8JY and THY4AV took place and he issued two consecutive instructions to both the aircraft for turning 30° left and turning 30° right respectively in order to ensure the separation. Immediately after, the vertical separation between the two aircraft was infringed. Given the situation created, the actions of the EXE ATCO for resolving the conflict and restoring the separation and to ensuring safety are assessed as correct.

In view of the fourth hypothesis content given above, it is concluded that the EXE ATCO issued clearance to THY4AV for descent in result of his Expectation bias including the correct repetition of the clearance for descent given by the crew of KKK8JY and observed the displayed indication of Mode S for selected FL 310 on board of KKK8JY.

In view of the above, it is concluded that the serious incident under investigation is most probably a result of the following dominant factors related to the third and fourth hypotheses:

1. Violation of the autopilot vertical speed selection process technology of A321-211 aircraft resulted in climbing of the aircraft instead of executing the clearance issued to KKK8JY for descent.

2. A state of Expectation Bias of EXE ATCO that led to issuing of clearance to THY4AV for descent during the time when the KKK8JY started to climb in contrary to the previously issued and confirmed by the crew clearance for descent and the presence of Mode S indication displayed on the ATCAS screen for selected FL 310 by the crew of KKK8JY.

4 Conclusion

4.1 Findings

4.1.1 Findings regarding the aircraft and its systems

- A321-211 aircraft, registration marks TC-ATF, is airworthy at the time of the realization of air occurrence;

- A321-211 aircraft, registration marks TC-ATF, is airworthy at the time of the realization of air occurrence;
- According the FDR record of A321-211 aircraft, registration marks TC-ATF of Atlasjet AO, the ACAS/TCAS system was triggered in TA mode;
- According the FDR record of B737-8F2, registration marks TC-JVS of Turkish Airlines AO, the ACAS/TCAS was triggered RA mode and generated a command PREVENTIVE RA for continuation of the flight without change of current trajectory.

4.1.2 Findings regarding aircraft crew:

- The flight crew of KKK8JY aircraft, Captain Pilot Flying and First Officer, possesses the required qualification and medical fitness for flights in accordance with existing regulations;
- The flight crew of KKK8JY aircraft set correctly the altitude after the clearance issued for descent.
- The flight crew of KKK8JY aircraft wrongly selected positive V/S for climbing instead negative for descent.
- The flight crew of KKK8JY aircraft did not notice the climb;
- The flight crew of KKK8JY aircraft did not control the climb by FMA and PFD;
- The flight crew of KKK8JY aircraft started to climb without a clearance of the EXE ATCO.
- The flight crew of KKK8JY aircraft did not perform a cross-checking according the procedures, given in the form of "Golden Rules" by the manufacturer of Airbus and in Flight Crew Techniques Manual FCTM OP-010 of Atlasjet AO;
- Abnormal interaction in the flight crew of KKK8JY.
- The flight crew of KKK8JY aircraft executed the EXE ATCO clearance for a change of heading in order to avoid the conflict situation;
- The flight crew of THY4AV aircraft executed the command generated PREVENTIVE RA for continuation of the flight without change of current trajectory.
- The flight crew of THY4AV aircraft did not inform ATCO about its actions at TCAS RA during the conflict situation, but after the CLEAR OF CONFLICT indication received few seconds later.
- The flight crew of THY4AV aircraft did not respond or confirm any of the clearances issued by EXE ATCO during the conflict situation.

4.1.3 Findings regarding aircraft operation

- The flight of A321-211 aircraft, registration marks TC-ATF is carried out in accordance with the flight plan along the route London - Istanbul (call sign KKK8YJ).
- The flight of B737-8F aircraft, registration marks TC-JVS is carried out in accordance with the flight plan along the route Zurich - Istanbul (call sign THY4AV).

4.1.4 Findings regarding Air Traffic Service

- The ATCOs performing official duties at the time of the event are licensed, have the necessary qualifications and medical fitness;
- The minimal standard for radar separation in the Controlled Air Space of Sofia Control is infringed;
- The Safety Net of SELEX of ATCAS detected a conflict between THY4AV and KKK8YJ and generated an alarm at the working position of EXE ATCO in SBL sector;
- The EXE ATCO issued clearance to THY4AV for descent considering his Expectation bias, caused by the correct repetition of the clearance for descent by the crew of KKK8JY and observed the displayed indication from Mode S for setting FL310 in cockpit on board, which created a wrong perception on the situation.
- In the information from Mode S for KKK8JY aircraft, it was shown that the crew selected FL310 after receiving the clearance for descending.

- The EXE ATCO detected with a delay the conflict between the two aircraft caused by the opposite execution of the clearance by the crew of one of them due to expectation bias.
- The EXE ATCO issued correct instructions to both aircraft for ensuring of safety after triggering of STSA and before infringement of minimum separation took place.

4.2 Causes

Based on the analysis performed, the Commission points out that the serious incident resulted from the following causes:

Main cause

Violation of the autopilot vertical speed selection process technology of A321-211 aircraft resulted in climbing of the aircraft instead of executing the clearance issued to KKK8JY for descent.

Contributing cause

A state of Expectation Bias of EXE ATCO that led to issuing of clearance to THY4AV for descent during the time when the KKK8JY started to climb in contrary to the previously issued and confirmed by the crew clearance for descent and the presence of Mode S indication displayed on the ATCAS screen for selected FL 310 by the crew of KKK8JY.

5 Safety recommendations:

In view of the causes for the realized serious incident and the deficiencies found in the course of investigation, the Commission proposes following safety recommendations to be fulfilled:

BG.SIA-2016/06/01. BULATSA shall carry out a workshop with ATCOs from the ACC-Sofia, where to discuss the causes and conclusions related to ATS as addressed in the Final Report on the event investigation. A record of proceedings on the conduct of the workshop shall be drawn up and submitted to the Aircraft, Maritime and Railway Accident Investigation Unit Directorate with the Ministry of Transport, Information Technology and Communications.

BG.SIA-2016/06/02. BULATSA to incorporate in the program for periodic training of the ATCOs simulator exercise scenarios covering the issuing of instructions and recommendations from the ATCOs to prevent collision between the aircraft following a STCA warning regardless of the reason of its generation.

BG.SIA-2016/06/03. Atlasjet AO to include additional theoretical and practical training in the recurrent training program on a simulator for train the actions for setting the vertical speed of the autopilot.

BG.SIA-2016/06/04. Atlasjet AO to include additional training in the Crew Resource Management to improve their interaction in situations that imperil the flight safety.

Annexes 1,2,3,4 & 5 constitute an inseparable part of this report.

NOTES:

During the period from October 20, 2017, when the Draft Final Report for the investigation was provided to the parties concerned until December 20, 2017, the Commission on safety investigation received responses as follows:

1. No comments or remarks related were received from the National Bureau of Aviation Occurrences Investigation (BEA);
2. The EASA declared they had neither comments or remarks on the draft FR content;
3. The EUROCONTROL made one comment related to p. 3.2 USE OF ACAS INDICATIONS of ICAO PANS-OPS (Doc 8168) that was to be followed by the flight crew, which was reflected on page 18;
4. No comments or remarks related were received from Bulgarian DG CAA;
5. BULATSA declared they had no comments and no remarks on the report content;
6. No comments or remarks related were received from the Turkish Accident Investigation Board (KAIK), Republic of Turkey;

7. After the 60 days period the Commission received by e-mail two comments made by the Turkish Airlines AO – one for a typing mistake made in the THY4AV registration marks, which was corrected and second regarding information provided by THY4AV's crew to ATCO supported by a copy of the FDM that the crew informed ATCO twice during the event. The FDM data provided do not match to the data records on the radio transmissions provided by BULATSA as these (at 15:03:37 and 15:04:37) are missing;
8. A finding in regards to the communication timing was further clarified in p. 4.1.2. above.

The Investigation Commission reminds all organizations to which safety measures have been sent, that on the basis of Article 18 of Regulation 996/2010 on Investigation and Prevention of Accidents and Incidents in Civil Aviation and Art19, Para7 of Ordinance No. 13 for investigation of aviation accidents, thet are obliged to notify in writing the Directorate AMRAIUD of MTITC for the status of the safety measures.

Chairman of the Commission:

Valery Karaliyski

Annex 1

ATC-Aircraft communication transcripts.

15:01:35 ATCO – Atlasjet 8YJ start descend FL 310 rate of descend 1000 ft/min or greater.

15:02:02 KKK8YJ - FL 310 and 1500 or greater

15:02:43 ATCO - Turkish 4AV descend FL 350

15:02:53 ATCO - Turkish 4AV descend FL 330 rate of descend 1000 ft/min or less

15:03:10 ATCO - Atlasjet **6**YJ turn immediately left 30 degrees.

15:03:20 ATCO - Turkish 4AV turn right 30 degrees immediately.

15:03:34 ATCO - Turkish 4AV, Sofia.

15:04:10 ATCO - Atlasjet 8YJ what is the reason for climbing FL.

15:04:10 KKK8YJ - A there is a problem a technical problem and now we are descending 330 now.

15:04:25 KKK8YJ - and on heading 090, heading 090 Atlasjet 8YJ.

15:04:33 ATCO Atlasjet 8YJ copied.

15:04:36 THY4AV - Sofia Turkish 4AV.

15:04:40 ATCO - THY4AV contact, contact Ankara 132.6

15:04:46 THY4AV 132.6 and regarding TCAS RA we are now Cleared of conflict and do you want to us keep heading 135°.

15:04:55 ATCO - THY4AV maintain FL 330 when reach.

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Annex 2

TCAS analysis for the Bulgarian Aircraft, Maritime and Railway Investigation Unit Directorate

KKK8YJ & THY4AV on 8 September 2016

(version 3)

Stan Drozdowski
Senior ACAS Expert
28 February 2017
stanislaw.drozdowski@eurocontrol.int

Background

- An airprox between KKK8YJ and THY4AV occurred on 8 September 2016 at 15:03 UTC in Bulgarian airspace.

	Aircraft 1	Aircraft 2
Callsign	KKK8YJ	THY4AV
Aircraft type	A321	B737-800
Registration	TC-ATF	TC-JVS
Mode S address	4B8686	4BAAD3
SSR Code	3067	4771

- The Aircraft, Maritime and Railway Investigation Unit Directorate of the Bulgarian Ministry of Transport, Information Technology and Communications asked EUROCONTROL to conduct analysis of the event to establish whether TCAS II performed as required.

Previous analysis of this event

- EUROCONTROL previously conducted an assessment of this event on 18 January 2017 based on the tracker data.
- As now ASTERIX recording files have become available, the analysis are repeated as it is believed the information contained in the ASTERIX files is of higher fidelity and will produce results of higher credibility.

- **The current version of the report (version 3 dated 28 February 2017) supersedes all previous versions of this report.**

TCAS II equipage

- Both aircraft, based on their MTOM and/or passenger seating were required to be equipped with TCAS II (Traffic alert and Collision Avoidance System) version 7.1[1)].

- No radar data (BDS10 register) regarding the equipage was available (probably because the equipage interrogation occurred outside the timeframe of the provided recordings). For the purpose of this report, it has been assumed that KKK8YJ & THY4AV were equipped as required.

[1)] Commission Regulation (EU) No 1332/2011 and Commission Regulation (EU) No 2016/583

InCAS v3.3
(Interactive Collision Avoidance Simulator)

- InCAS shows events with horizontal and vertical views.

- InCAS can also:
  - Show pilot displays;
  - Simulate idealised pilot response;
  - Give details of ACAS decision making.

- InCAS altitudes and vertical rates are interpolated between radar updates.

Data source & processing

- The following radar data was provided by the Bulgarian Aircraft, Maritime and Railway Investigation Unit Directorate :
  - Pilot reports (ASRs)
  - KKK8YJ FDM analysis printout
  - THY4AV FDR records (TCAS-relevant fields)
  - Binary ASTERIX files from Otopeni and Vitosha radars.
- ASTERIX data was converted to .eu1 format for InCAS processing.
- Additionally, RA downlink messages (BDS30) were extracted.
  - Note: TA are not downlinked.
- Data from the Vitosha radar was used to recreate trajectories.
- Results were cross checked versus THY4AV FDR data and KKK8YJ FDM printout.

Analysis of the event

- For clarity of results, the trajectories were truncated to start at ~15:00:30 and terminate at ~15:06:00 (i.e. ~180 seconds before and ~150 seconds after the Closest Point of Approach).

RA downlink vs. InCAS simulation

- Typically, InCAS is used for this type of incident analysis to recreate TCAS alerts.
- In the case examined here, RA downlink messages were available and were compared with InCAS simulation.
- Since InCAS produced different sequences and times of events from those obtain via RA downlink, it has been decided to use only RA downlinks for further analysis.
  - RA downlink messages provide information on RAs as they occurred on the aircraft (with the latency of up to the time of radar rotation cycle).
  - InCAS assumes “perfect” TCAS air-to-air surveillance, i.e. there is no possibility to reproduce “as was” TCAS air-to-air surveillance.
  - The results on InCAS recreation are shown in the Appendix.
  - Finally, expert judgement was used to assess if TCAS performance was as expected.

Timings of RA downlink messages

Event *(cockpit aural annunciation)*	Vitosha Radar first/last detection (10 sec. update rate)	Otopeni Radar first/last detection (8 sec. update rate)	Derived time of the event
THY4AV Monitor Vertical Speed RA *(Monitor vertical speed)*	15:03:36 15:03:36	Nil	**15:03:34 – 15:03:36**
THY4AV RA Terminated *(Clear of conflict)*	15:03:46 15:03:56	15:03:41 15:03:57	**15:03:41**

RA downlink messages identified KKK8YJ as the intruder (by Mode S address)

No RA downlink messages were registered for KKK8YJ.

Notes:

- Perfect reliability of radar detection has been assumed.
- The timing of RA based on the RA downlink message is delayed up to the number of seconds representing the update rate.
- The earliest the derived times is used in the subsequent analysis.

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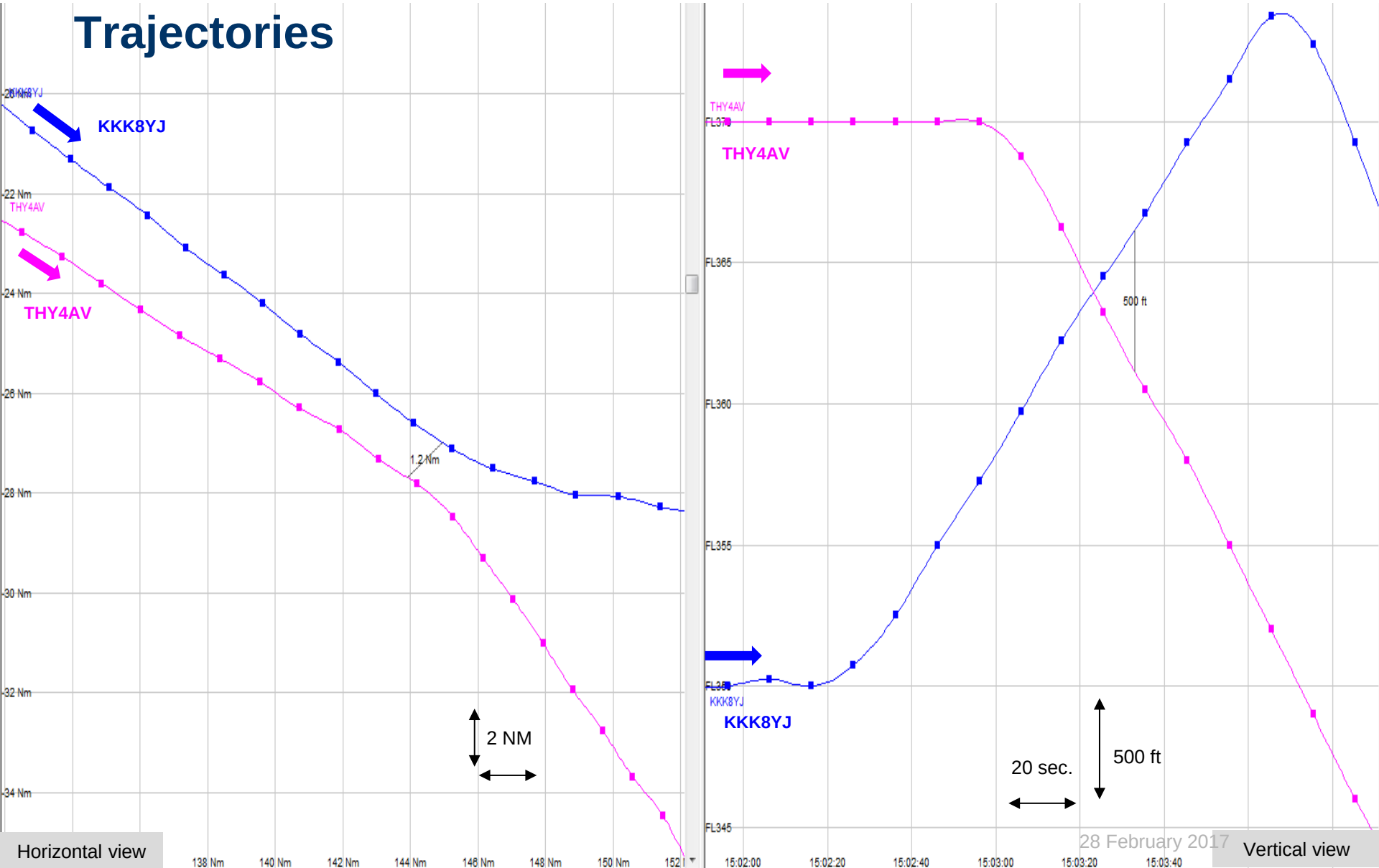
Trajectories

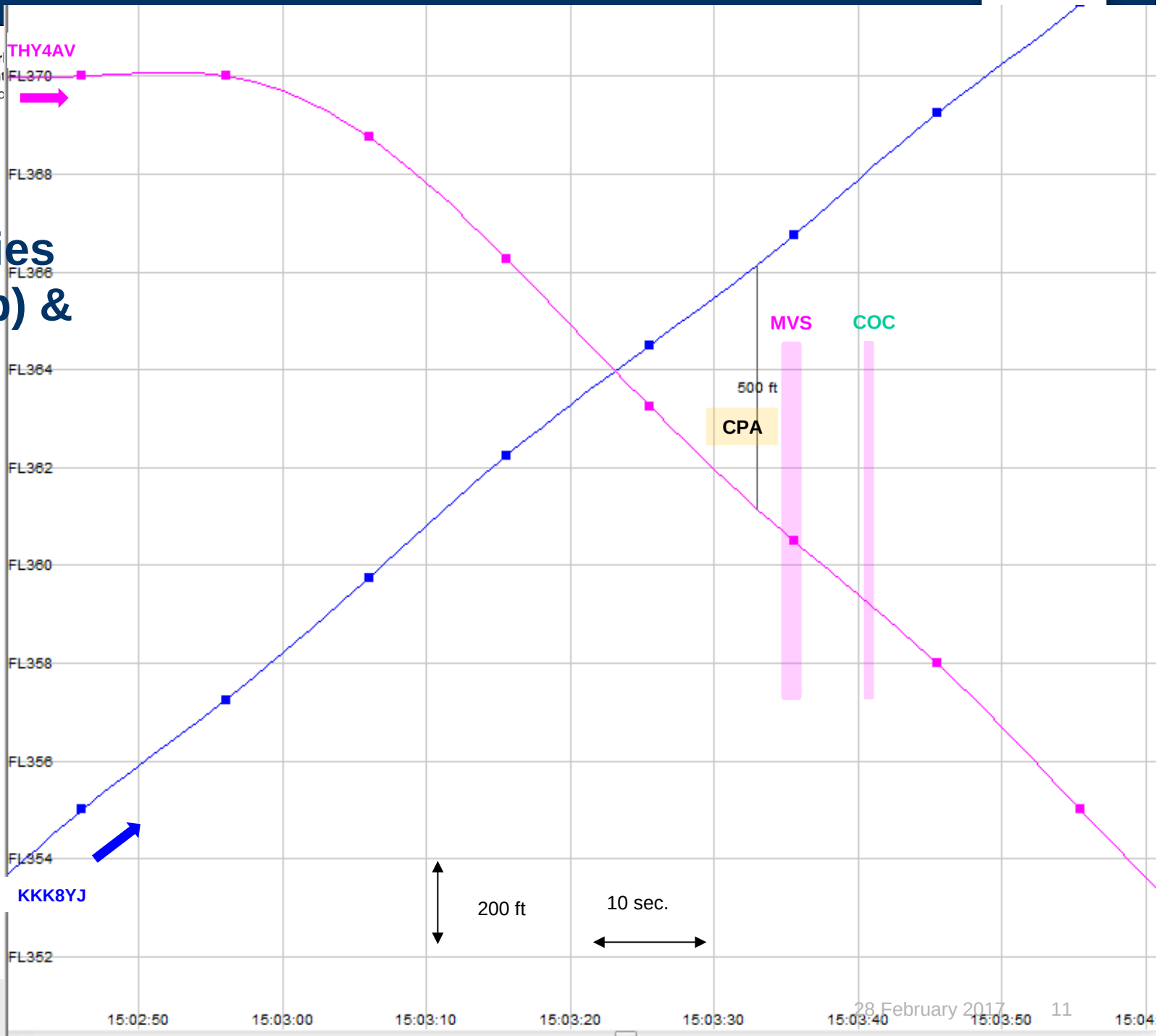


Horizontal view

28 February 2017

Vertical view

Vertical trajectories (close-up) & RAs



Timing of events (1)

Time	Event *(cockpit aural annunciation)*	Horizontal separation [NM]	Vertical Separation [ft]	KKK8YJ		THY4AV	
				Altitude [ft]	Vertical Rate [ft/min]	Altitude [ft]	Vertical Rate [ft/min]
15:00:30	Start of simulation	2.7	+2025	34975	0	37000	0
15:02:19	KKK8YJ starts to climb	1.9	+1992	35008	+300	37000	0
15:02:57	THY4AV starts to descend	1.5	+1247	35747	+1400	36994	-300
15:03:07	KKK8YJ crosses FL360	1.5	+852	36001	+1500	36853	-1300
15:03:24	KKK8YJ & THY4AV cross vertically	1.3	-46	36416	+1300	36371	-1700
15:03:33	Closest Point of Approach	1.24	-500	36614	+1300	36115	-1500

… continued on the next page …

Timing of events (2)

Time	Event *(cockpit aural annunciation)*	Horizontal separation [NM]	Vertical Separation [ft]	KKK8YJ		THY4AV	
				Altitude [ft]	Vertical Rate [ft/min]	Altitude [ft]	Vertical Rate [ft/min]
15:03:34*)	THY4AV Preventive RA *(Monitor vertical speed)*	1.2	-549	36638	+1400	36089	-1500
15:03:38	THY4AV crosses FL360	1.3	-749	36737	+1500	35988	-1400
15:03:41*)	THY4AV RA terminates *(Clear of conflict)*	1.4	-899	36814	+1500	35915	-1400
15:03:50	KKK8YJ crosses FL370	1.8	-1355	37024	+1200	35669	-1800

*) The earliest of the times derived from RA downlink messages.

Note:
In the Vertical Separation column, the + sign indicates that THY4AV was above KKK8YJ, the – sign indicates that THY4AV was below.
In the Vertical Rate columns, the + sign indicates a climb, the – sign indicates a descent.

Analysis of responses to RAs: THY4AV

- THY4AV received a Preventive RA prohibiting a climb (announced “Monitor Vertical Speed”)
- A Preventive RA indicates ranges of prohibited vertical speed (rather than required vertical speeds).
- For the duration of the RA THY4AV continued to descend.

THY4AV: InCAS trajectory, RA downlink message and FDR recordings compared

- FDR and ground system clocks are not synchronised; therefore it is not possible to reliably compare the timing of events. Altitudes were used instead for comparison.
- The following events were compared:

Event	FDR Altitude [feet]	Recreation Altitude [feet]	Δ
Preventive RA	36083	36089	-6
RA termination	35956	35915	41

- The FDR recording shows the RA duration to be 6 sec.
- RA downlink messages indicate the RA duration of 5 to 7 sec.

KKK8YJ: InCAS trajectory, RA downlink message and FDR recordings compared

- The provided FDM recordings do not show any RA.
- No RA downlink messages for KKK8YJ were received.

Sequence of events

- KKK8YJ started to climb at 15:02:19.
- THY4AV started to descend at 15:02:57.
- RA downlink messages indicate that THY4AV received a Preventive RA (prohibiting climb) between 15:03:34 and 15:03:36.
- RA downlink messages indicate that THY4AV received a Clear of Conflict annunciation at 15:03:41.
- The Closest Point of Approach occurred at 15:03:33. The separation was 1.24NM and 500 feet.

Analysis

- It was a slow closure encounter with a horizontal miss distance (~1.2 NM) close to the TCAS Miss Distance Filter threshold (1.1 NM at this altitude).
- No RA was issued prior to KKK8YJ-THY4AV altitude crossing as, most likely, TCAS predicted that at the CPA the range will be outside alerting thresholds.
- KKK8YJ did not receive an RA as, most likely, its TCAS predicted that at the CPA range will be outside the alerting thresholds (invoking the Miss Distance Filter). Individual TCAS units make their own independent predictions based on their own surveillance data.
- Conversely, the Miss Distance Filter was not invoked on THY4AV and it received a Preventive RA against KKK8YJ when it was already below the intruder and descending.
- The RA terminated after 5-7 sec. as the aircraft were diverging.

Conclusions

1. Radar data together with Mode S RA downlink messages and airborne recordings provided a credible picture of the event.

2. Although not confirmed by InCAS simulations, expert judgement is that TCAS worked as expected and played a role in preventing the escalation of the conflict situation by restricting climb manoeuvres to THY4AV.

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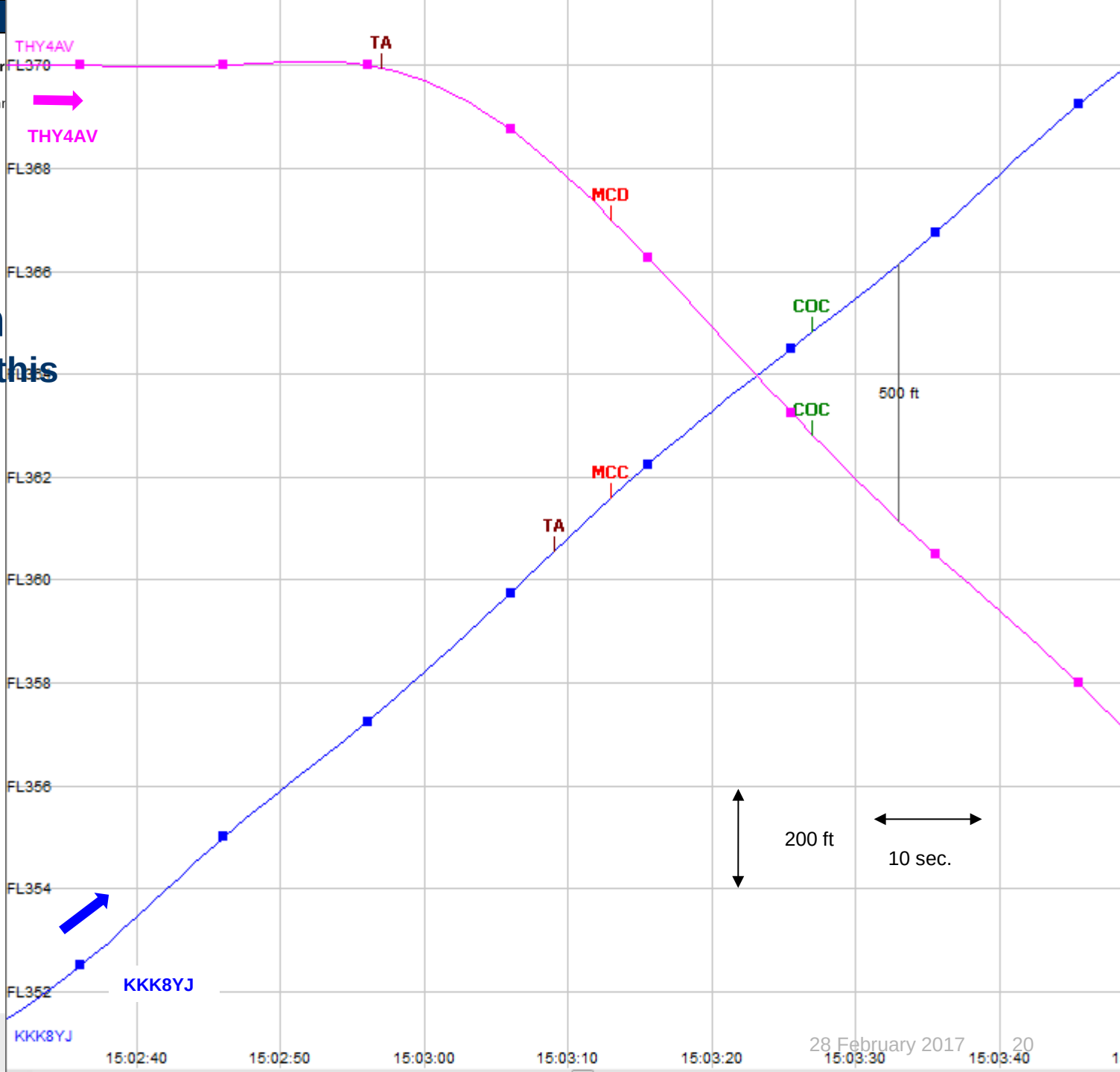
Appendix: InCAS simulation (not used for this analysis)



GENERAL

Ident.: DSC-22_30-70-10-00010507.0001001 / 17 AUG 10
Applicable to: ALL

Vertical modes guide the aircraft in the vertical plan.

PRINCIPLES

Ident.: DSC-22_30-70-10-00010508.0001001 / 17 AUG 10
Applicable to: ALL

To leave an FCU selected altitude for another target altitude, the flight crew must turn the Altitude (ALT) knob in order to display the new target altitude and either:

- Pull out the ALT knob to engage the OPEN CLB /DES mode, or
- Push in the ALT knob to engage the CLB /DES mode, or
- Select a target vertical speed (V/S) and pull out the V/S or FPA knob to engage V/S mode, or
- Select EXPEDITE ✲ .

This arms ALT mode.

AUTOPILOT/FLIGHT DIRECTOR

Ident.: OP-030-00005439.0001001 / 30 JUN 15
Applicable to: ALL

OBJECTIVE

The Auto Pilot (AP) and Flight Director (FD) assist the flight crew to fly the aircraft within the normal flight envelope, in order to:

- Optimize performance in the takeoff, go-around, climb, or descent phases
- Follow ATC clearances (lateral or vertical)
- Repeatedly fly and land the aircraft with very high accuracy in CAT II and CAT III conditions.

To achieve these objectives:

- The AP takes over routine tasks. This gives the Pilot Flying (PF) the necessary time and resources to assess the overall operational situation.
- The FD provides adequate attitude or flight path orders, and enables the PF to accurately fly the aircraft manually.

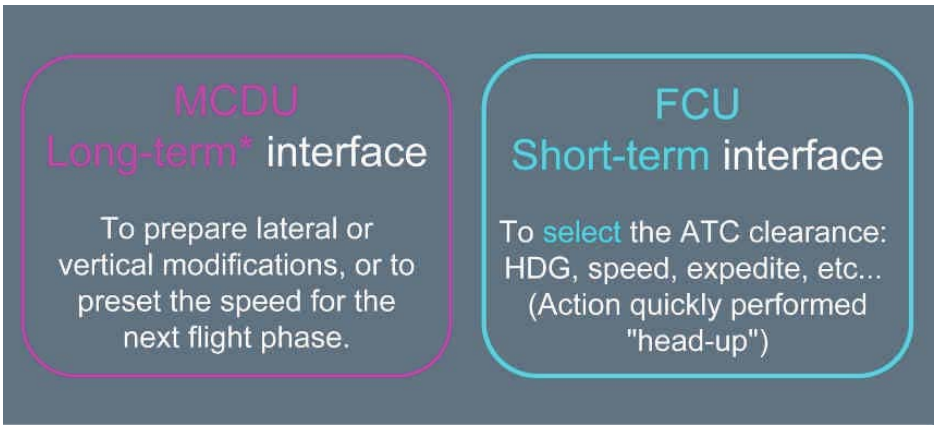
MANAGED AND SELECTED MODES

The choice of mode is a strategic decision that is taken by the PF.

Managed modes require:

- Good FMS navigation accuracy (or GPS PRIMARY)
- An appropriate ACTIVE F-PLN (i.e. the intended lateral and vertical trajectory is entered, and the sequencing of the F-PLN is monitored).

MAIN INTERFACES WITH THE AP/FD



*The DIR TO function is an exception to this rule.

OPERATIONAL RECOMMENDATION:

With the FMS, anticipate flight plan updates by preparing:

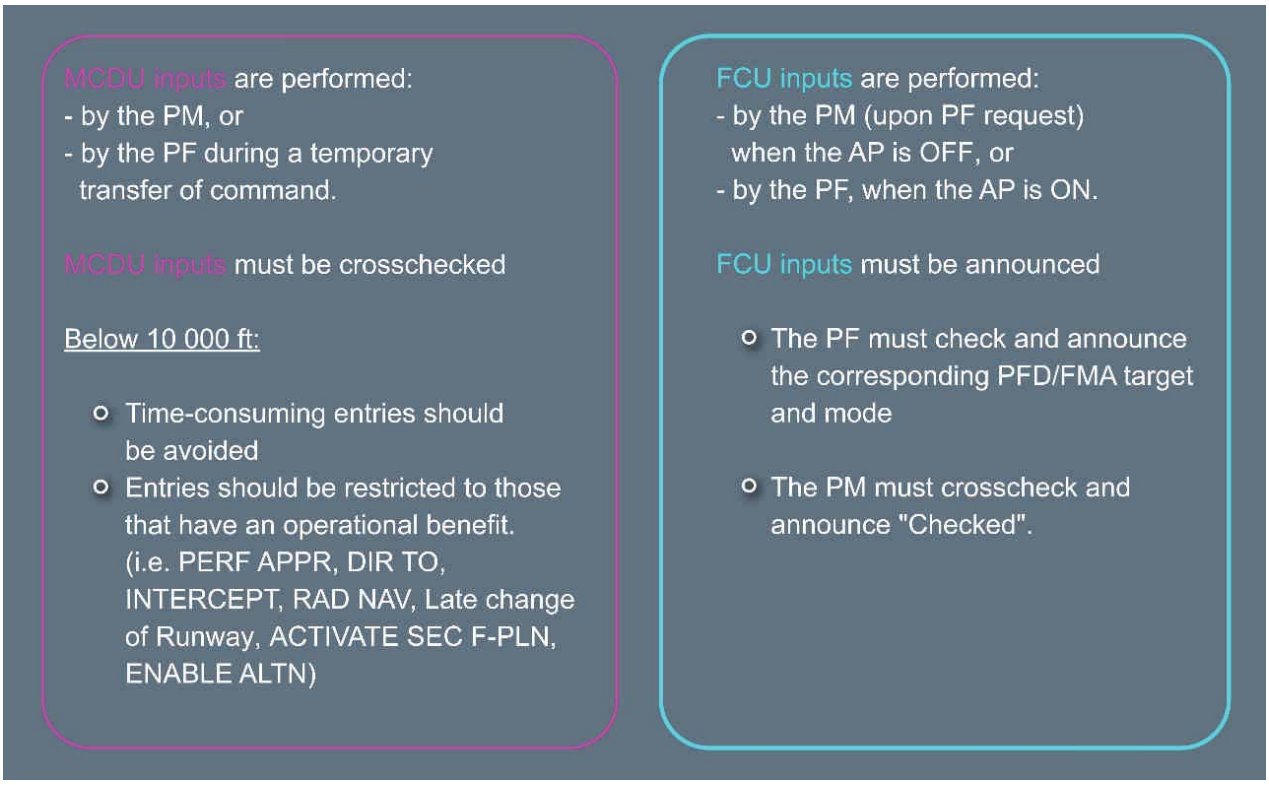
- EN ROUTE DIVERSIONS
- DIVERSION TO ALTN
- CIRCLING
- LATE CHANGE OF RWY

in the SEC F-PLN. This enables the MCDU to be used for short-term actions.

TASKSHARING AND COMMUNICATIONS

The FCU and MCDU must be used, in accordance with the rules outlined below, in order to ensure:

- Safe operation (correct entries made)
- Effective inter-pilot communication (knowing each other's intentions)
- Comfortable operations (use "available hands", as appropriate)

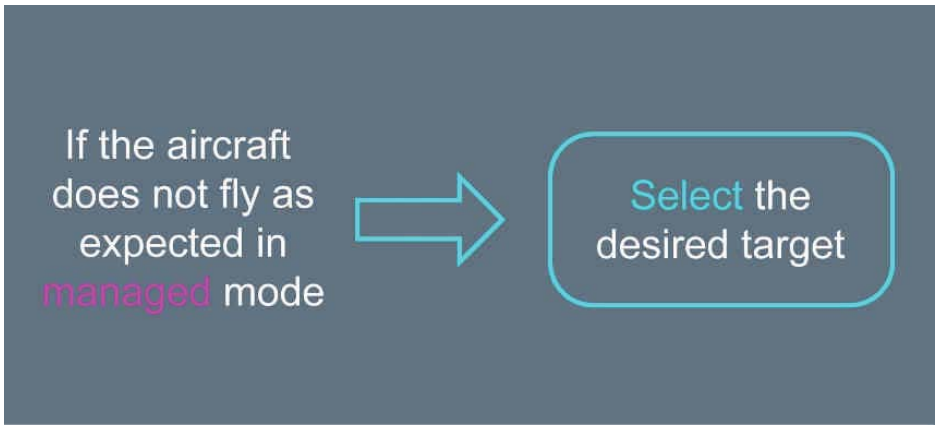


AP/FD MONITORING

The FMA indicates the status of the AP, FD, and A/THR, and their corresponding operating modes. The PF must monitor the FMA, and announce any FMA changes. The flight crew uses the FCU or MCDU to give orders to the AP/FD. The aircraft is expected to fly in accordance with these orders.

The main concern for the flight crew should be:

WHAT IS THE AIRCRAFT EXPECTED TO FLY NOW ?
WHAT IS THE AIRCRAFT EXPECTED TO FLY NEXT ?



- Or, disengage the AP, and fly the aircraft manually.

INTRODUCTION

Ident.: OP-010-00005425.0001001 / 26 MAR 08
Applicable to: ALL

The Airbus cockpit is designed to achieve pilot operational needs throughout the aircraft operating environment, while ensuring maximum commonality within the Fly by Wire family.

The cockpit design objectives are driven by three criteria:

- Reinforce the safety of flight
- Improve efficiency of flight
- Answer pilot requirements in a continuously changing environment

Airbus operational rules result from the design concept, more particularly from the following systems:

- The **Fly by wire** system with its control laws and protections, commanded through the side stick,
- An integrated **Auto Flight System** (AFS) comprising:
  - The FMS interfaced through the MCDU,
  - The AP/FD interfaced through the FCU,
  - The A/THR interfaced through the non back driven thrust levers,
  - The FMA, providing Guidance targets and Information, to monitor the AFS
- A set of **Display units** (DU) providing information and parameters required by the crew
  - To operate and to navigate the aircraft (the EFIS)
  - To communicate (the DCDU)
  - To manage the aircraft systems (the ECAM)
  - FMA interface to provide Guidance targets and information to monitor the AFS/FD
- A **Forward Facing Cockpit Layout** with "Lights out" or "Dark Cockpit" concept assisting the crew to properly control the various aircraft systems.

The operational rules applicable to these specific features are given in the other sections of this chapter.

GOLDEN RULES FOR PILOTS

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Applicable to: ALL

INTRODUCTION

The Airbus "Golden Rules for Pilots" are operational guidelines, based on all of the following:

- Basic flying principles
- The adaptation of these basic flying principles to modern-technology aircraft
- The provision of information about required crew coordination for the operation of Airbus aircraft.

The objective of these Golden Rules is to also take into account the principles of flight crew interaction with automated systems, and the principles of Crew Resource Management (CRM), in order to help prevent the causes of many accidents or incidents and to ensure flight efficiency.

GENERAL GOLDEN RULES

The following four Golden Rules for Pilots are applicable to all normal operations, and to all unexpected or abnormal/emergency situations:

1. ***Fly. Navigate. Communicate:*** *In this order and with appropriate tasksharing.*
   Fly! Navigate! Communicate! The flight crew must perform these three actions in sequence and must use appropriate tasksharing in normal and abnormal operations, in manual flight or in flight with the AP engaged.

The following explains each of the three actions, and the steps associated with the performance of these actions:

- ***Fly***

  "**Fly**" indicates that:
  - **The Pilot Flying** (**PF**) must concentrate on "**flying the aircraft**" to monitor and control the pitch attitude, bank angle, airspeed, thrust, sideslip, heading, etc., in order to achieve and maintain the desired targets, vertical flight path, and lateral flight path.
  - **The Pilot Monitoring** (**PM**) must assist the PF and must **actively monitor** flight parameters, and call out any excessive deviation. The PM's role of "actively monitoring" is very important.

  Therefore, both flight crewmembers must:
  - Focus and concentrate on their tasks to ensure appropriate tasksharing
  - Maintain situational awareness and immediately resolve any uncertainty as a crew.

- ***Navigate***

  "**Navigate**" refers to and includes the following four ***"Know where ..."*** statements, in order to ensure situational awareness:
  - Know **where you are…**
  - Know **where you should be…**
  - Know **where you should go…**
  - Know **where the weather, terrain, and obstacles are**.

- ***Communicate***

  "Communicate" involves effective and appropriate crew communication between the:
  - PF and the PM
  - Flight crew and Air Traffic Control (ATC)
  - Flight crew and the cabin crew
  - Flight crew and the ground crew.

  Communication enables the flight crew to safely and appropriately perform the flight, and enhance situational awareness. To ensure good communication, the flight crew should use **standard phraseology** and the **applicable callouts.**

  In abnormal and emergency situations, the PF must recover a steady flight path, and the flight crew must identify the flight situation. The PF must then inform ATC and the cabin crew of:
  - The flight situation
  - The flight crew's intentions.

The flight crew must therefore always keep in mind the key message:
Fly the Aircraft, Fly the Aircraft, Fly the Aircraft...

To safely and appropriately perform a flight, both flight crewmembers must have basic flying skills, and must be able to fly with appropriate tasksharing in all situations.

2. ***Use the appropriate level of automation at all times.***

Aircraft are equipped with several levels of automation, used to perform specific tasks. The flight crew must determine the appropriate level of interaction with automated systems, based on the flight situation (e.g. Visibility, incapacitation, system malfunction, etc.), and the task to be performed.

To use the appropriate level of automation at all times, the flight crew must:

- **Determine and select** the appropriate level of automation that can include manual flight
- **Understand** the operational effect of the selected level of automation
- **Confirm that the aircraft reacts as expected.**

3. ***Understand the FMA at all times.***

The flight crew must confirm the operational effect of all actions on the FCU, or on the MCDU, via a crosscheck of the corresponding annunciation or data on the PFD and on the ND.

At all times, the flight crew should be aware of the following:

- Guidance modes (armed or engaged)
- Guidance targets
- Aircraft response in terms of attitude, speed, and trajectory
- Transition or reversion modes.

Therefore, to ensure correct situational awareness, at all times, the flight crew must:

- **Monitor the FMA**
- **Announce the FMA**
- **Confirm the FMA**
- **Understand the FMA**.

4. ***Take action if things do not go as expected***

If the aircraft does not follow the desired vertical or lateral flight path, or the selected targets, and if the flight crew does not have sufficient time to analyze and solve the situation, the flight **crew must immediately take appropriate or required actions**, as follows:

The PF should change the level of automation:

- From managed guidance to selected guidance, or
- From selected guidance to manual flying.

The PM should perform the following actions in sequence:

- Communicate with the PF
- Challenge the actions of the PF, when necessary
- Take over, when necessary.


GOLDEN
RULES
FOR PILOTS
AIRBUS


1 Fly, navigate and communicate:
In this order and with appropriate tasksharing
2 Use the appropriate level of automation at all times
3 Understand the FMA at all times
4 Take action if things do not go as expected
AIRBUS