

Department of Trade

ACCIDENTS INVESTIGATION BRANCH

**BRITISH AIRWAYS TRIDENT G-AWZT
INEX ADRIA DC9 YU-AJR**

**Report on the collision in the Zagreb area,
Yugoslavia, on 10 September 1976**

Reprint of the report produced by
The Yugoslav Federal Civil Aviation Administration
Aircraft Accident Investigation Commission

In accordance with the provisions of Annex 13 of the Convention on International Civil Aviation, an accredited representative of the United Kingdom participated in the investigation of this accident. Responsibility for the conduct of the investigation and the content of the report was that of the Aircraft Accident Investigation Commission of the Federal Civil Aviation Administration in Yugoslavia.

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| 4/77 | Herald G-AWPF at Gatwick Airport, July 1975 | (forthcoming) |

**FEDERAL CIVIL AVIATION ADMINISTRATION
AIRCRAFT ACCIDENT INVESTIGATION COMMISSION**

**REPORT ON THE ACCIDENT OF
THE TRIDENT THREE AIRCRAFT, G-AWZT
AND THE DC-9 AIRCRAFT, YU-AJR
ABOVE ZAGREB VOR**

BEOGRAD 25 December 1976

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INFORMATION ABOUT THE AIRCRAFT AND ACCIDENT

- (a) *Type of aircraft:* TRIDENT THREE
- Registration marks:* G-AWZT, series No. 2320, BE 0476
- Owner:* British Airways, London
- Date and time of accident:* 10 September 1976 at 10.15 (GMT)
- Place of accident:* Over Zagreb VOR in vicinity of Vrbovec, Socialist Republic of Croatia
- (b) *Type of aircraft:* DC-9
- Registration marks:* YU-AJR, series No. 47649
- Owner:* Inex Adria Airways, Ljubljana
- Date and time of accident:* 10 September 1976 at 10.15 (GMT)
- Place of accident:* Over Zagreb VOR in vicinity of Vrbovec, Socialist Republic of Croatia
- Accident category:* Fatal

1. INFORMATION ABOUT THE ACCIDENT

1.1 History of the Flight

(a) Trident Three Aircraft

The Trident Three was on a scheduled transport flight (Bealine 476) from the airport Heathrow – London (England) to Istanbul (Turkey) carrying 54 passengers and a crew of 9.

The aircraft took off from Heathrow airport at 08.32 (GMT). The flight (BE 476) proceeded normally via West Europe and a portion of the airway UB5 above Yugoslavia until the collision near Zagreb with an aircraft of Inex Adria, flight JP 550.

First contact with the Area Control Centre – “upper sector” in Zagreb was established on the frequency 134, 45 MHz at 10.04'12" GMT. The conversation was: “Zagreb, Bealine 476, good afternoon” and Zagreb response was: “Bealine 476, good afternoon, go ahead”.

10.0419" BE 476: 476 Klagenfurt at 02, 330 estimating Zagreb 14.

Zagreb: Bealine 476, roger, call me passing Zagreb, flight level 330, SQUAWK Alfa 2312.*

10.04'40" BE 476: 2312 is coming.

No further calls were received from the aircraft which was required only to keep a listening watch until the time of the next call over Zagreb VOR.**

Immediately after the previous call, the crew heard a Turkish Airlines aircraft reporting to Zagreb Control its position over point “Charlie” (just ahead of the Trident) at flight level (FL) 350. A remark by one of the Trident crew members recorded on the Cockpit Voice Recorder (CVR) indicates that they saw the other aircraft passing overhead in the opposite direction shortly afterwards.

The aircraft maintained a heading of 120-122° until 2 min. 50 sec. before ZAG VOR at flight level 330, recorded indicated airspeed (hereinafter speed) 295 Kts, Ground speed = 489 Kts (905 km/h). The aircraft flew along the airway centreline with slight side deviation (1-2 km) to the right due to wind angle of 220°/45 Kts (measured at 12.00 hours) and probably due to tolerance in the existing characteristics of ZAG VOR.

At 2 min. 50 sec. before the collision, the aircraft changed heading to 115°. Five seconds before the collision heading was 116° and it was maintained until the collision. From plotted data it could be concluded that at the moment of collision the aircraft was 1.5-2 km. north-east of the high cone of ZAG VOR at flight level 330 and at a speed of 295 Kts.

* SQUAWK Alfa 2312 means: select the secondary radar transponder to Mode/Code Alfa 2312. Upon selecting, the radar display at the controller's position shows a symbol of the aircraft at 315 degrees and the number A/2312 and flight level 330 in front of it. On the basis of this information the controller identifies the aircraft.

** VOR: VHF omni-directional range (radio navigational beacon).

The collision between Bealine 476 and JP 550 occurred between the hours 10.14'38" when the aircraft JP 550 reported maintaining flight level 330, and 10.15'06" when Bealine 476 did not reply to a call from Zagreb control.

Subsequent examination of the wreckage showed that the left wing of the DC-9 cut through the flight deck and forward passenger compartment of the Trident. Both aircraft fell to the ground.

(b) DC-9 Aircraft

The purpose of the flight was transportation of 108 West German tourists from Split to Cologne.

The aircraft, with a crew of 5, took-off from Split airport at 09.48 (GMT) on flight JP 550.

In co-ordination between the Approach control in Split and the Area Control Centre in Zagreb – "Lower sector east", the aircraft JP 550 was cleared to climb to flight level 180 and to cross Split VOR at flight level 120. After take-off the aircraft climbed overhead the airport and Split VOR. Seven minutes later, on passing flight level 130, it switched to frequency 124.6 MHz of the Area Control Centre in Zagreb (lower sector east) as follows:

09.54'49" JP 550: Dobar dan Zagreb, Adria 550.
(Good morning Zagreb, Adria 550), crossing 130, climbing 180,
heading Kostajnica.

Zagreb: Roger, recleared 240, Adria 550.

09.55'01" JP 550: Recleared 240.

The aircraft JP 550 proceeded climbing to the cleared flight level 240 along the airway B9 maintaining heading from 359° to 004° with average recorded speed of 285 Kts.

09.55'50" Zagreb: Adria 550, recleared 260, call crossing 220.

As the crew did not call back and did not repeat the instruction, Zagreb air traffic control called again:

09.56'02" Zagreb: Adria 550, Zagreb.
JP 550: 550, cleared 260 and call you crossing 240, do you read me?

09.56'12" Zagreb: Call me crossing 220.

JP 550: I will call you crossing 220.

After about 3, 5 minutes ATC Zagreb required a level check.

09.59'53" Zagreb: Adria 550, level check.

JP 550: 550, crossing 183.

Zagreb: Thanks.

Crossing flight level 220, required by ATC, the crew reported as follows:

10.02'44" JP 550: Zagreb, Adria 550 crossing 220.

Zagreb: Zagreb, Adria 135, 8 Good day.

JP 550: Good bye.

From this moment the aircraft JP 550 switched to operation with the middle sector on the frequency 135.8 which is responsible for safety and regulation of traffic between flight levels 250 and 310.

10.03'21" JP 550: Dobar dan Zagreb, Adria 550.
(Good morning Zagreb, Adria 550), crossing 225, climbing 260.

Zagreb: 550, good morning, SQUAWK Alfa 2506, continue climb 260.

Approximately 18 minutes after take-off the aircraft levelled out at flight level 260, heading 359° and speed of 316 Kts. At 10.04 hours the aircraft was 62 km., to the south from Kostajnica. At that time, Bealine 476 was crossing Yugoslav-Austrian border. The crew reported to the ATC middle sector as follows:

10.05'57" JP 550: Adria 550, levelling 260, standing by for higher.

Zagreb: 550, sorry 330. . . e . . . 310 is not available, are you able to climb maybe to 350?

JP 550: Affirmative, affirmative, with pleasure.

The aircraft was retained 1 min. 48 sec. at flight level 260 in a horizontal flight and only then it was cleared to climb to flight level 350 as follows:

10.07'40" Zagreb: Adria 550 recleared flight level 350.

10.07'45" JP 550: Thank you, climbing 350, Adria 550.

Immediately after this transmission, Zagreb middle sector assistant controller telephoned to Vienna that JP 550 would be at flight level 350 and Vienna acknowledged affirmatively. At 10.09'18" Zagreb control informed JP 550, under radar supervision, that it was approaching Kostajnica, that it should proceed to Zagreb and Graz and report passing flight level 290. The crew acknowledged affirmatively.

The aircraft assumed a heading of 353° and a speed of 273 Kts. towards Zagreb VOR. It passed a beam and to the west of the KOS NDB, approximately 2-3 km from the airway centreline.

10.09'53" JP 550: Zagreb, Adria 550 is out of 290.

Zagreb: Roger, call me crossing 310, now.

JP 550: Roger.

The aircraft was climbing 2 minutes and 14 seconds from flight level 290 to flight level 310 maintaining constantly the same flight elements.

Flying on this heading it had slightly diverted to the right crossing the airway centreline towards Zagreb VOR.

10.12'03" JP 550: Zagreb, Adria 550 out of 310.

Zagreb: 550, for further Zagreb 134,45 SQUAWK stand by*, and good day, Sir.

10.12'12" JP 550: SQUAWK stand by 134,45 Good day.

At this time the upper sector controller, frequency 134,45 was very busy in conversation with other aircraft. There were four aircraft in radio communication and in addition from 10.13'30" there was a telephone conversation with Beograd in connection with the transfer of two aircraft flying to Sarajevo and proceeding to Kumanovo. One minute and 52 sec. passed from the time of the last transmission by JP 550 with the middle sector to the time when the first contact was established at 10.14'04" with the upper sector. In this period 8 messages were transmitted by Zagreb control – upper sector – and 11 messages received.

Flight JP 550 established its first contact with the upper sector as follows:

10.14'04" JP 550: Dobar dan Zagreb, Adria 550.
(Good morning Zagreb, Adria 550)

14'07" Zagreb: Adria 550, Zagreb dobar dan (good morning) Go ahead.

10.14'10" JP 550: 325 crossing, Zagreb at 14.

This message reported to ATC indicated that the aircraft was crossing flight level 325 and that it would be at Zagreb VOR at 10 14 , continuing its previously cleared climb to flight level 350. It is probable that the crew's watch was not set according to the watch of ATC as there was a difference of approximately 1 minute.

10.14'14" Zagreb: What is your present level?

14'17" JP 550: 327

14'22" Zagreb: (Stuttering) . . . e . . . zadržite se za sada na toj visini i javite prolazak Zagreba (. . . e . . . maintain now that level and report passing Zagreb).

14'27" JP 550: Kojoj visini? (What level?)

14'29" Zagreb: Na kojoj ste sada u penjanju jer . . . e . . . imate avion pred vama na isn . . . (unintelligible) 335 sa leva na desno. (At which you are now climbing, because . . . e . . . you have an aircraft in front of you at . . . (unintelligible) 335 from left to right.

14'38" JP 550: OK, ostajemo točno 330. (OK maintain precisely 330).

This was the last message from the aircraft JP 550.

From flight level 327, 12 seconds passed until the crew realised that they were required to maintain their present level. In these 12 seconds the aircraft gained 150 feet, reaching 32,850 feet. During the next 9 seconds, when the crew reported "OK maintain precisely 330", the aircraft gained another 100 feet and reached 32,950 feet (330).

* Switch the transponder off and keep a listening watch.

The Flight Data Recorder readout shows that before the collision the aircraft was in horizontal flight at a speed of 261 Kts., flight level 330.

Half a minute later, exactly at 10.15'06" Zagreb called the crew of Bealine 476 to report passing Nasice. The crew did not respond to this message because, most probably, the collision between BE 476 and JP 550 had already occurred.

The collision was seen by the crew of a Lufthansa aircraft which was operating along UB 5 in the direction of ZAG VOR some 15 miles behind the Trident Three at flight level 290. According to the statement of the Lufthansa pilot-in-command Captain J. KROESE, who believes he first saw the Trident Three 10 to 15 miles ahead of him, the collision was seen as a flash of lightning and afterwards, out of a ball of smoke, two aircraft falling towards the ground.

From 10.15'36" until 10.18 hours the crew of the Lufthansa aircraft reported several times to the Middle Sector Controller the sighting of what they believed was a mid-air collision. Captain of the Lufthansa aircraft repeated his message several times on the request of the Middle Sector Control until the message was understood. Mr Kroese was called to Zagreb in order to give statement as a witness. On that occasion he was listening to the message which he transmitted to the air traffic control. He had to listen to it several times in order to understand each word. The words were spoken with excited voice and were not quite clear.

According to the statement of witnesses on the ground, the DC-9 aircraft entered a steep dive rolling around the longitudinal axis. The Trident aircraft initially entered a steep dive, pitching occasionally nose upwards. According to the statement of the witnesses on the ground the Trident aircraft started to turn to the left at the height of about 2,000 meters. A substantial part of the aircraft detached during the first turn and descended separately without turning.

The collision occurred above Zagreb VOR 45°53'33" N, 16°18'38" E, in daylight.

The impact location of the DC-9 aircraft was 1 km eastward from the village Dvorište.

The impact location of the Trident aircraft was 1.5 km south of the village Gaj near Vrbovec.

The distance between the impact locations was 7 km.

1.2 Injuries to Persons

(a) Trident Three Aircraft

| Injuries | Crew | Passengers | Others |
|------------|------|------------|--------|
| Fatal | 9 | 54 | -- |
| Serious | -- | -- | -- |
| Minor/None | -- | -- | -- |

(b) DC-9 Aircraft

| Injuries | Crew | Passengers | Others |
|------------|------|------------|--------|
| Fatal | 5 | 108 | — |
| Serious | — | — | — |
| Minor/None | — | — | — |

(c) Total

| Injuries | Crew | Passengers | Others |
|------------|------|------------|--------|
| Fatal | 14 | 162 | — |
| Serious | — | — | — |
| Minor/None | — | — | — |

1.3 Damage to Aircraft

The Trident Three aircraft, registration marks G-AWZT and the DC-9-32 aircraft, registration marks YU-AJR were completely destroyed in this accident.

1.4 Other Damage

(a) The Trident aircraft fell on a corn field and damaged an area of approximately 70 x 70 m. Other parts of the aircraft which were scattered over an area of 7 km., caused, in certain places, slight damage to crops. It was not possible to evaluate this damage.

(b) The DC-9 aircraft fell in a forest area. The impact and fire damaged the forest vegetation over an area of approximately 70 x 70 m. No other damage on the ground was observed.

1.5 Crew Information

(a) Flight crew members of TRIDENT - 3

Captain TANN, DENNIS VICTOR

Born on 21 June 1932.

He joined British Airways on 11 July 1957. He held a licence ALTP 32349 valid until 19 December 1977.

Information on check dates:

simulator: 20 December 1975
27 April 1976

instrument rating: 19 December 1975

route check: as P1 18 July 1976

licence medical: 5 July 1976

survival drills: 31 October 1976

Flying hours:

| | |
|------------------------|---------------|
| total as pilot: | 10,781 hours |
| total British Airways: | 8,855,6 hours |
| total TRIDENT-3: | 399,6 hours |
| total last 28 days: | 33,0 hours |
| total last 3 days: | 2,12 hours |

Duty time last 7 days:

| | |
|--------------------|--|
| Day 1 (04 Sep 76): | Glasgow/Heathrow/Edinburgh/Heathrow On duty 0550 hours Off duty 1417 hours Flight time 3.14 hours |
| Day 2 (05 Sep 76): | Off duty day |
| Day 3 (06 Sep 76): | Off duty day |
| Day 4 (07 Sep 76): | Standby home Duty hours 1600-2200 hours |
| Day 5 (08 Sep 76): | Standby home Duty hours 1000-1600 hours |
| Day 6 (09 Sep 76): | Airport Standby On duty 0730 hours Heathrow/Brussels/Heathrow Off duty 1238 hours Flight time 2.12 hours |
| Day 7 (10 Sep 76): | Airport Standby On duty 0720 hours |

First Officer HELM, BRIAN EDWARD

Born on 17 May 1947.

He joined British Airways on 24 February 1969. He held a licence ALTP No. 68088 valid until 30 December 1979.

Information on check dates:

| | |
|--------------------|----------------------------------|
| simulator: | 02 October 1975 05 March 1976 |
| instrument rating: | 02 October 1975 |
| route check: | as P2/P3 27 March 1976 |
| licence medical: | 15 July 1976 |
| survival drills: | 09 February 1976 |

Flying hours:

| | |
|-----------------------------|---------------|
| total as pilot: | 3,655 hours |
| total with British Airways: | 3,414,3 hours |
| total TRIDENT-3: | 1,592,5 hours |
| total last 28 days: | 35,6 hours |
| total last 3 days: | 1,55 hours |

Duty time last 7 days:

| | |
|--------------------|--|
| Day 1 (04 Sep 76): | Off duty |
| Day 2 (05 Sep 76): | Off duty |
| Day 3 (06 Sep 76): | Off duty |
| Day 4 (07 Sep 76): | Airport Standby On duty 0540 hours Off duty 1140 hours |
| Day 5 (08 Sep 76): | Airport Standby Heathrow/Paris/Heathrow On duty 0540 hours Off duty 1124 hours Flight time 1.55 hours |
| Day 6 (09 Sep 76): | Standby home Duty hours 0955-1555 |
| Day 7 (10 Sep 76): | Airport Standby On duty 0720 hours |

Acting First Officer FLINT, MARTIN JONATHAN

Born on 12 June 1952.

He joined British Airways on 2 April 1973. He held a licence SCPL No. 91376 valid until 24 February 1986.

Information on check dates:

| | |
|-----------------------------|----------------------------------|
| simulator | 30 October 1975 05 March 1976 |
| instrument rating: | 30 October 1975 |
| route check: as P2 as P3 | 17 May 1976 18 May 1976 |
| licence medical: | 25 May 1976 |
| survival drills: | 11 June 1976 |

Flying hours:

| | |
|-----------------|-------------|
| total as pilot: | 1,640 hours |
|-----------------|-------------|

| | |
|-----------------------|---------------|
| with British Airways: | 1,497,7 hours |
| total TRIDENT-3: | 1,444,3 hours |
| total last 28 days: | 32,54 hours |
| total last 3 days: | Nil |

Duty time last 7 days:

| | |
|--------------------|--|
| Day 1 (04 Sep 76): | Heathrow/Rome/Heathrow On duty 0625 hours Off duty 1336 hours Flight time 4.49 hours |
| Day 2 (05 Sep 76): | Heathrow/Edinburgh/Heathrow On duty 0940 hours Off duty 1415 hours Flight time 2.14 hours |
| Day 3 (06 Sep 76): | Off duty |
| Day 4 (07 Sep 76): | Off duty |
| Day 5 (08 Sep 76): | Leave |
| Day 6 (09 Sep 76): | Leave |
| Day 7 (10 Sep 76): | Airport Standby On duty 0720 hours |

(b) *Other crew members of the TRIDENT-3 aircraft*

Chief Steward, CROOK, DAVID JOHN

Born on 24 December 1942.
He joined British Airways on 29 March 1965.

Chief Steward, O'KEEFE, LAWRENCE JOSEPH

Born on 23 April 1946.
He joined British Airways on 13 April 1970.

Chief Stewardess, WHALLEY, ANNE PAULINE

Born on 31 August 1944.
She joined British Airways on 7 March 1966.

Stewardess Grade I, GODDARD-CRAWLEY, RONA

Born on 22 September 1944.
She joined British Airways on 12 April 1966.

Stewardess Grade II, MUNDAY, JENNIFER DIVVERA

Born on 11 February 1946.
She joined British Airways on 19 June 1967 and air crew from 26 April 1976.

Stewardess Grade I, PEDERSEN, RUTH WEINREICH

Born on 26 April 1950.
She joined British Airways on 28 February 1972.

(c) *Flight crew members of the DC-9 aircraft*

Captain KRUMPAK (Anton) JOŽE

Born on 11 March 1925 in Rogaska Slatina. He held an airline transport pilot licence No. 103/335 valid until 27 October 1976. He passed his last medical examination on 30 March 1976 and was found fit according to criteria 'A' for flying on the DC-9 aircraft.

He had flown on the following types of aircraft:

DC-6 B

DC-8

DC-9

He joined Inex Adria Airways in 1962.

He had the last in-flight check on 11 April 1976 and obtained a mark STANDARD.

Flying hours:

total as pilot: 10,157 hours

on the DC-9 aircraft: 3,250 hours

total last month: 94 hours

total last 3 days: 18 hours

Duty time last 7 days:

Day 1 (04 Sep 76): Rest at home

Day 2 (05 Sep 76): Dubrovnik-Stuttgart-Dubrovnik
Dubrovnik-Hamburg

Day 3 (06 Sep 76): Hamburg-Tivat-Ljubljana
Ljubljana-Tunis-Ljubljana

Day 4 (07 Sep 76): Rest at home

Day 5 (08 Sep 76): Pula-Düsseldorf-Pula
Pula-Hamburg

Day 6 (09 Sep 76): Hamburg-Pula-Cologne-Pula-Hamburg

Day 7 (10 Sep 76): Hamburg-Split to Cologne

Second pilot IVANUŠ (Branko) DUŠAN

Born on 15 June 1947 in Ljubljana. He held a professional pilot licence class I No. 357/2493 valid until 16 October 1976. He passed his last medical examination on 30 March 1976 and was found fit according to criteria 'A' for flying on the DC-9 aircraft.

He had flown on the following types of aircraft:

CONVAIR CV-440

DC-9

Upon the request of Inex Adria Airways he joined the company on 28 June 1976, to fly on temporary basis.

He had the last in-flight check on DC-9 on 30 June 1976 and obtained a mark STANDARD, for co-pilots.

Flying hours:

| | |
|-----------------------|-------------|
| total as pilot: | 2,951 hours |
| on the DC-9 aircraft: | 1,583 hours |
| total last month: | 84 hours |
| total last 3 days: | 11 hours |

Duty time last 7 days:

| | |
|--------------------|---------------------------------------|
| Day 1 (04 Sep 76): | Dubrovnik-Bristol-Dubrovnik-Ljubljana |
| Day 2 (05 Sep 76): | Rest at home |
| Day 3 (06 Sep 76): | Rest at home |
| Day 4 (07 Sep 76): | Rest at home |
| Day 5 (08 Sep 76): | Pula-Düsseldorf-Pula-Hamburg |
| Day 6 (09 Sep 76): | Hamburg-Pula-Hamburg |
| Day 7 (10 Sep 76): | Hamburg-Split Split to Cologne |

(d) Other crew members of the DC-9 aircraft

Chief Stewardess, OFENTAVŠEK (Vili) LIDIJA

Born on 30 July 1947 in Maribor. She held a licence No. 196/3408 valid until 10 December 1976. Medically fit.

Stewardess, SILA (Franc) MOJCA

Born on 13 April 1953 in Gornja Bitnja. She held a licence No. 1197/6668 valid until 29 January 1977. Medically fit.

Stewardess, ŽAGAR (Vinko) JELKA

Born on 26 March 1952 in Ljubljana. She held a licence No. 950/6050 valid until 5 November 1976. Medically fit.

(e) Information about air traffic controllers

DAJČIĆ JULIO – Chief of the shift

Born on 17 December 1932 in Pula.

He passed the exam for area radar controller on 27 August 1963.

He passed his last medical examination in 1971 and was found fit according to criteria 'B'.

Duty time last 7 days:

| | |
|--------------------|------------------------------|
| Day 1 (04 Sep 76): | Off duty |
| Day 2 (05 Sep 76): | Off duty |
| Day 3 (06 Sep 76): | 07.00 – 19.00 * |
| Day 4 (07 Sep 76): | 19.00 – 07.00 on 8 September |
| Day 5 (08 Sep 76): | Off duty |
| Day 6 (09 Sep 76): | Off duty |
| Day 7 (10 Sep 76): | 07.00 – 11.15 |

TASIĆ GRADIMIR, Air traffic controller

Born on 29 April 1949 in Niš.

He passed the exam for area radar controller on 26 May 1976.

He passed his last medical examination in 1971 and was found fit according to criteria 'B'.

Duty time last 7 days:

| | |
|--------------------|---------------|
| Day 1 (04 Sep 76): | Off duty |
| Day 2 (05 Sep 76): | Off duty |
| Day 3 (06 Sep 76): | 07.00 – 19.00 |
| Day 4 (07 Sep 76): | Off duty |
| Day 5 (08 Sep 76): | 07.00 – 19.00 |
| Day 6 (09 Sep 76): | 07.00 – 19.00 |
| Day 7 (10 Sep 76): | 07.00 – 11.15 |

TEPEŠ NENAD, Assistant air traffic controller

Born on 2 September 1942 in Zagreb.

He obtained his licence for terminal radar control in December 1975.

He passed his last medical examination on 26 February 1976 and was found fit according to criteria 'B'.

* Local time

Duty time last 7 days:

| | |
|--------------------|---------------|
| Day 1 (04 Sep 76): | Off duty |
| Day 2 (05 Sep 76): | Off duty |
| Day 3 (06 Sep 76): | 07.00 – 19.00 |
| Day 4 (07 Sep 76): | Off duty |
| Day 5 (08 Sep 76): | 07.00 – 19.00 |
| Day 6 (09 Sep 76): | Off duty |
| Day 7 (10 Sep 76): | 07.00 – 11.15 |

HOEHBERGER MLADEN, Air traffic controller

Born on 13 October 1946 in Zagreb.

He obtained his licence for area radar controller on 17 May 1976. He passed his last medical examination in 1971 and was found fit according to criteria 'B'.

Duty time last 7 days:

| | |
|--------------------|---------------|
| Day 1 (04 Sep 76): | Off duty |
| Day 2 (05 Sep 76): | Off duty |
| Day 3 (06 Sep 76): | 07.00 – 19.00 |
| Day 4 (07 Sep 76): | Off duty |
| Day 5 (08 Sep 76): | 07.00 – 19.00 |
| Day 6 (09 Sep 76): | Off duty |
| Day 7 (10 Sep 76): | 07.00 – 11.15 |

ERJAVEC BOJAN, Air traffic controller

Born on 15 June 1947 in Beograd.

He obtained his licence for area procedural controller on 8 March 1976.

He passed his last medical examination in 1974 and was found fit according to criteria 'B'.
During the seven days prior the accident he was on holiday.

PELIN GRADIMIR, Assistant air traffic controller

Born on 18 April 1948 in Beograd.

He obtained his licence for area radar controller on 26 April 1976.

He passed his last medical examination in 1971 and was found fit according to criteria 'B'.

Duty time last 7 days:

| | |
|--------------------|---------------|
| Day 1 (04 Sep 76): | Off duty |
| Day 2 (05 Sep 76): | Off duty |
| Day 3 (06 Sep 76): | 07.00 – 19.00 |

| | |
|--------------------|---------------|
| Day 4 (07 Sep 76): | Off duty |
| Day 5 (08 Sep 76): | 07.00 – 19.00 |
| Day 6 (09 Sep 76): | Off duty |
| Day 7 (10 Sep 76): | 07.00 – 11.15 |

Since 1975, under Federal Civil Aviation Administration Regulations, all Air Traffic Controllers have been required to undergo an annual medical examination. At the date of the accident the re-examination of all controllers had not been completed. However, there is no evidence that medical factors had any bearing on the cause of the accident.

1.6 Aircraft Information

(a) The Trident Three Aircraft

The aircraft TRIDENT-3 B SERIES 101, registration marks G-AWZT, serial number 2320 has been manufactured by HAWKER SIDDELEY AVIATION LTD., England.

Date of manufacture: 5th June 1972. Aircraft category: TRANSPORT CATEGORY (PASSENGER).

Owner of the aircraft: British Airways Board, Air Terminal, Buckingham Palace Road, London SW1W 9SR.

The aircraft had a Certificate of Airworthiness valid until 27 May 1978.

Until the accident the aircraft had flown a total of 8,627.44 hours and had performed 6,952 landings.

POWER PLANT DATA

Three Rolls-Royce Spey MK 512-5W turbo-fan engines and one Rolls-Royce RB 162-86 turbo-jet boost engine were installed.

| Engine No. | Engine serial No. | Hours of operation from O/HAUL | Total operation | T.B.O. |
|--------------|-------------------|--------------------------------|-----------------|--------|
| 1 | 4738 | 2,409.44 | 7,644.31 | 8236 |
| 2 | 4560 | 8,472.03 | 12,600.50 | 9612 |
| 3 | 4708 | 2,648.54 | 8,277.35 | 2750 |
| Boost engine | 1205 | — | 1,240.00 | 1400 |

All checks, maintenance and replacement were carried out regularly until the accident.

Review of documentation revealed that there were no complaints concerning the operation of aircraft systems which would be relevant to the accident.

According to the load sheet at the last take-off, the aircraft was correctly loaded and the position of the centre of gravity was within the approved limits.

Type of fuel was JP 1A aviation kerosene.

(b) *The DC-9 Aircraft*

The aircraft DC-9-32, registration marks YU-AJR, Register No. 1073, serial number 47649, manufactured by McDONELL DOUGLAS CORPORATION, USA.

Date of manufacture: 7th March 1976 (According to the Export Certificate No. E 144587). Aircraft category: TRANSPORT CATEGORY (PASSENGER).

Owner of the aircraft: Inex Adria Airways, Ljubljana, Titova 48, Yugoslavia.

The aircraft had a Certificate of Airworthiness No. 1073 valid until 5 March 1977.

Until the accident the aircraft had flown 1,345.22 hours and had performed 990 landings.

POWER PLANT DATA

The engines P8W JT8D-9A were installed.

| | S/N | TBO | TT | Rest TBO |
|------------------|--------|------|----------|----------|
| Starboard engine | 666996 | 6500 | 1,495.12 | 5,004.48 |
| Port engine | 666995 | 6500 | 1,379.22 | 5,120.38 |

All checks, maintenance and replacement were carried out regularly until the accident.

Review of documentation revealed that there were no complaints concerning the operation of aircraft systems which would be relevant to the accident.

According to the load sheet it was established that at the last take-off the weight of aircraft and the position of the centre of gravity were within the approved limits.

Type of fuel was JP-1 aviation kerosene.

1.7 **Information about Meteorological Conditions**

(a) *Actual weather situation at 'Split' airport on 10 September 1976*

0900 hours (GMT)

ground wind 090°/10 Kts.

visibility: over 10 km.

clouds: 4/8 Sc. with the ceiling at 4,300 feet and
4/8 Cs. with the ceiling at 20,000 feet

temperature: 22°C

QNH: 1013 mb

0930 hours (GMT)

ground wind 120°/12 Kts.

visibility: over 10 km.

clouds: 4/8 Cu. and Sc. with the ceiling at 3,300 feet and
5/8 Cs. with the ceiling at 20,000 feet

temperature: 22°C

QNH: 1013 mb

(b) *Actual weather situation at 'Zagreb' airport*

0900 hours (GMT)

ground wind 230°/8 Kts.
visibility: over 10 km.
clouds: 3/8 Sc. with the ceiling at 4,700 feet
temperature: 19°C
QNH: 1010 mb

0930 hours (GMT)

ground wind 230°/12 Kts.
visibility: over 10 km.
clouds: 2/8 Sc. with the ceiling at 4,700 feet
temperature: 20°C
QNH: 1010 mb.

1010 hours (GMT)

ground wind 210°/11 Kts.
visibility: over 10 km.
clouds: 1/8 Cu. at 4,000 feet and
3/8 Sc. with the ceiling at 4,700 feet
temperature: 21°C
QNH: 1009 mb

(c) *Radiosonde measuring for Zagreb*

Measuring at 0001 hours (GMT)

The data for ICAO standard level 300 mb

temperature was: -43.1°C
upper wind was: 225°/23 Kts.
altitude was: 9,340 gpm

The data for ICAO standard level 250 mb

temperature was: -52.6°C
upper wind was: 230°/27 Kts.
altitude was: 10,550 gpm

The data for ICAO standard level 200 mb

temperature was: -57.9°C
upper wind was: 230°/27 Kts.
altitude was: 11,970 gpm

Measuring at 1200 hours (GMT)

Level 300 mb

temperature was: -42.5°C
upper wind was: 220°/41 Kts.
altitude was: 9,350 gpm

Level 250 mb

temperature was: -52.7°C
upper wind was: 220°/45 Kts.
altitude was: 10,550 gpm

Level 200 mb

temperature was: -56.9°C
upper wind was: 250°/51 Kts.
altitude was: 11,960 gpm

Weather in Zagreb area around 33,000 feet at the time of collision was reported as fine, with no clouds and good visibility.

The position of the sun at 1015 hours (GMT) was Azimuth 166°, Altitude 48°.

1.8 Ground Radio-navigation Aids (Operational & Stand By)

The NDBs 'Zagreb', 'Kostajnica' and 'Vrlika' as well as 'Zagreb' VOR were in operational condition without any failure in operation.

The quoted findings were established on the basis of the following:

- Daily reports on the operation of the aids,
- The results of the control receivers,
- Operational log book,
- No complaints concerning the operation of these aids,
- Measurement lists.

On the basis of the review of the operational condition of the radar system (primary and secondary) in the Area Control Centre Zagreb on 10 and 11 September 1976, and particularly of the operational post No. 26 (upper sector), review of documentation and consultations with the employees in the shift, it was established that:

- the entire radar system was in operational condition,
- the targets and data from primary and secondary radar and video maps were clear without disturbances. There were no complaints concerning the operation.

On the basis of the above, it was established that the radar system was fully operational.

The Decision of FCAA No. 561/1 dated 31 January 1974 approved the operational usage of the radar TH-CSF LS-23 and on the basis of Commission report with the following limitations:

operational usage is approved within the range of 100 NM,

during separation of aircraft double ICAO standards should be used.

According to NOTAM class IIa 8 dated 15 September 1974, the usage of SSR on a trial basis was approved in Beograd and Zagreb starting on 1 October 1974, with allocation of codes for each sector within the area.

1.9 Ground-air Communication (Operational & Stand By)

Radio-telephone equipment for ground-air communication on the frequency 124.6 MHz (lower sector), 135.8 MHz (middle sector) and 134.45 MHz (upper sector) was in operational condition without any failure.

1.10 Information about Zagreb Airport

The airport and airport services and handling facilities were in operational condition and are not relevant to the accident.

1.11 Flight Recorders

(a) *The Trident-3 flight recorders*

Three flight recorders were installed on the aircraft:

1. DAVAL RECYCLING WIRE RECORDER, Type 1192, Series No. 631

This flight recorder records the flight parameters, aircraft movements and engine parameters for a total of 25 hours.

The recorder consists of reels with flexible wire on which the flight parameters are recorded every second.

The recorder is placed in a strong metal sphere resistant to external shocks. It is located in the tail section of the aircraft and records the following flight parameters:

time in seconds,

altitude according to standard pressure,

recorded instrument airspeed,

pitch and roll angle,

normal acceleration,

turning around longitudinal axes,

radio altitude,

movement of flaps,

movement of rudder,

magnetic heading,

autopilot engagement.

Besides the mentioned flight parameters the recorder records many parameters of each engine operation.

During the investigation the flight recorder was found at the site of the accident. The Commission took it to British Airways where it was opened. The wire was broken at one place, but not at the place where the portion of the flight from Klagenfurt to ZAG VOR was recorded.

The flight recorder data were fed into the computer from which the processed numerical and graphic data were obtained.

Every second the recorder recorded all parameters of the flight from the take-off at Heathrow until the moment of collision.

The collision occurred under the following flight conditions:

Altitude: H = 33,380 feet

| | |
|---|-------------|
| Taking into account the tolerance it comes out that total altimeter error was | – 420 feet |
| therefore the recorded altitude was | 33,380 feet |
| | – 420 feet |
| Corrected altitude | 32,960 feet |

The aircraft was operating at 32,960 feet – FL 330

Heading

From crossing the Yugoslav-Austrian border, towards ZAG VOR until 2 minutes 50 seconds before the collision the aircraft was flying on a heading 120°-122° (the heading for this airway is 120°).

2 minutes 50 seconds before the collision the aircraft changed heading to 115° and for the last 5 seconds to 116° which was maintained until the collision with the DC-9.

Instrument airspeed

During the flight along the airway UB5 the aircraft maintained IAS (instrument airspeed) of 291-295 Kts which corresponded to TAS (true airspeed) – 479 Kts or 905 km/h (0.81 Mach).

As the side wind was at an angle of 90-100°, the ground speed was 489 Kts.

At the time of the accident the autopilot was engaged.

The characteristics of the other parameters suggest that the height lock was also engaged.

Other parameters were not relevant to the accident.

2. Voice recorder

‘Cockpit voice recorder’ Fairchild Model A, series 3804 (magnetic tape), installed on the Trident-3 aircraft, G-AWZT, records the conversation between the pilots and the conversation of pilots with the air traffic controllers. Therefore it records all voice communications.

It is located in the fuselage, on the rear right side. It was found at the site of the accident. The tape was not damaged. During the transcription it was established that three channels of the voice recorder on the Trident-3 were unintelligible. On the fourth channel only the conversation in the cockpit was recorded. All four channels were affected by noise. The conversation between the crew members in the cockpit was the following:

First part of the conversation referred to the condition and prices at the market, afterwards they were talking about the accident to some helicopter and the transportation of the injured to hospital. It was also heard that one of the crew was doing a crossword, but that was 30 minutes before the collision. The moment of collision was not recorded because the cockpit was cut through and the crew suffered fatal injuries.

It was possible to read the time of the collision but not the collision itself. For the last 5 minutes and 20 seconds there was no conversation which showed that there were no RTF communications and no distractions on the flight deck.

3. Quick Access Data Recorder

The recorder (DAVAL CASSETTE RECTURE 1089) is a cassette recorder designed to be either a part of the AIDS system or to operate independently as a Quick Access Data Recorder. A Davall cassette, type 1223 with a tape 1/2 inch wide and minimum length of 325 feet is used. It is located in the cockpit.

It was not found at the site of the accident, therefore it could not be used for analysis.

(b) The DC-9 aircraft recorders

The following recorders were installed in the aircraft:

1. Flight recorder

A flight recorder SUNDSTRAND Model No. FA-542, series No. 5078 was installed on the DC-9 aircraft, YU-AJR. The recorder was calibrated on 10 December 1974.

The recorder records five parameters on metal tape located in a very resistant steel cassette. It records the following parameters:

altitude according to standard pressure

instrument airspeed

magnetic heading

normal acceleration

time of microphone switching on*

The recorder is located in the tail cone of the fuselage. Before the beginning of the flight a pilot records a flight number and the date on the tape by means of a mechanism in the cockpit.

Re-winding of the tape is performed with a speed of 6 inches per hour and its capability is 400 hours on each side of the tape, ie. 800 hours in total. After that the tape has to be replaced.

* This parameter revealed the information that the last switching on of the microphone and the message to the control were 22 seconds before the end of the flight parameters recording.

The recorder was found at the site of the accident. The decoding was performed at JAT Technical Centre, the flight parameters were read and the diagrams made.

The recorder recorded every second all flight parameters from the take-off at Split airport.

The collision occurred under the following conditions:

Altitude

H = 32,445 feet.

Calibration tolerance for this height was extracted from TABLE 701 (attached) – ALTITUDE RECORD CALIBRATION DATA Sensor Part No. 100,435, which shows at 33,000 feet that calibration correction was + 450 feet and a readout tolerance was ± 50-100 feet.

| | |
|------------------------|------------------|
| Recorded altitude | 32,445 ft |
| Calibration correction | + 450 ft |
| Readout tolerance | ± 50-100 ft |
| Corrected altitude | 32,900-33,050 ft |

Heading

From Split VOR the aircraft maintained a heading of 359⁰ to +005⁰. At the moment when it overflew NDB KOS, the heading was reduced to 353⁰ and this was maintained until the collision.

Instrument airspeed

As the aircraft was mostly climbing it maintained an instrument airspeed of 261-283 Kts. In the transition to level flight, 18,6 minutes after the take off indicated airspeed was 316,6 Kts.

At the moment of collision, in level flight indicated airspeed was 261 Kts., or true airspeed was 430 Kts., and the ground speed, due to tail and side wind was 465 Kts or 861 km/h.

2. Voice recorder

A voice recorder, installed on the DC-9 aircraft YU-AJR, recorded the conversation between the pilots and the conversation of the crew with the air traffic control. Therefore it recorded all voice communications.

The recorder was located in the rear hold in front of the cargo compartment door and it was found in the wreckage. The tape was not damaged and it was heard and transcribed.

On the basis of the transcription of tape recordings of the voice recorder, the following was found out:

1. The recordings of the conversation in the DC-9 aircraft cockpit were found on the second channel. The other channels contained the recordings of the conversation with the air traffic control.

2. Reviewing the recordings on all channels it was established that the voice recorder was not recording constantly but with several interruptions. This could be concluded on the basis of the following:

there was a report about the position of an unidentified aircraft with the data about being over an unidentified fix at 08.46 min., and an estimated time over the next fix at 09.08 min. This was heard on the tape 1 minute 15 seconds before the accident;

the conversation between the crew of JP 550 and JP 548 was recorded. It was held on the apron of Split airport about 09.40 min. which is 35 minutes before the accident;

a message from Split aerodrome control was recorded. It referred to the take-off of JP 550 which was at 09.48 min. with the instruction to report passing Split VOR at FL 120. This message was transmitted about 25 minutes before the accident. It is believed that soon after this message the voice recorder ceased recording and restarted at the moment of the accident;

on the basis of listening to all channels it was established that the tape was not moving at constant speed at the time of recording. This was established on the basis of distortion of the recorded tones;

it was established that the tape of the voice recorder ceased moving on several occasions in total duration of 1 hour and 25 minutes.

Approximately 20 minutes before the accident no conversation was recorded in connection with the critical flight, due to the tape stopping. At the moment of the crash the voice recorder reactivated and recorded for 25 seconds the conversation and sounds in the cockpit of the DC-9 aircraft.

It is believed that at the 8th second after the crash the crew realised the hopeless situation in which they were and for 12 seconds some noises could be heard in the cockpit which lasted until the 25th second.

1.12 Information about the Condition at the Site of the Accident

The collision between the aircraft, as seen from the air and from the ground is described in item 1.1.

The site of impact may be divided into the following zones:

The site on which the Trident-3 fell and the immediate surroundings of this location;

The site on which the DC-9 fell and the immediate surroundings of this location;

The area between the two impact zones;

The area upon which light material was blown away by wind.

(a) *The site on which the Trident-3 fell*

The aircraft struck the ground in a tail down, starboard wing low attitude. There was no apparent forward movement of the aircraft. Due to severe vertical impact and slight drift to the left, the aircraft was completely deformed but the outlines were visible. The starboard wing was deformed more than the port wing. Tail surfaces and engines were on the ground and were deformed and broken (rear centre of gravity during the impact).

All bodies within the aircraft were displaced to the right side of the fuselage. A part of the tail surfaces was found 30 m to the east of the aircraft; probably it broke during impact and due to inertia it slid laterally from the aircraft. At the site of the main impact was the fuselage aft of frame 33 up to the tail surfaces, both wings and the engines.

Some 600 m north-west from this site was the cockpit, cut horizontally, together with the fuselage structure up to frame 18. The cockpit was cut at the junction of the pilot's windshield and the upper cowling of the aircraft nose. Two crew members were found to the right of the cockpit and one crew member was found to the left in the cockpit.

This part of the cockpit and fuselage fell vertically in the normal level attitude without any forward movement.

Scratches were visible on the cut part of the cockpit, these ran from the right side at a small angle in relation to the horizontal centreline.

The fuselage cowling was bent from the right to the inner side and from the left to the outer side.

Both control columns were cut. The upper part of one column (about 20 cm.) was found close to the cockpit.

The instruments, controls and switches were deformed.

The indications of some instruments in the cockpit were as follows:

airspeed indicator 305 Kts

fuel contents indicator 2,020 kg
(there were five fuel tanks)

Co-pilots flight compass showed left of radial

VOR showed FROM

autopilot height selector was deformed and showed ... 3 0

navigation aid No. 1 showed 2
113.1 MHz

altimeter 33,050 feet

It was established at the site of the accident that a part of the fuselage from the 18th to 33rd frame was missing.

(b) The site on which the DC-9 fell

The aircraft fell on the ground touching it with the right wing and in a flat inverted position. At the site of the accident the aircraft was without the tail surfaces and the tail cone and also without a part of the left wing to a length of 5 meters.

The left engine was found with substantial damage to the compressor blades.

After the impact there was no forward movement of the aircraft.

After the impact the aircraft burned out. Tail surfaces and minor parts of the DC-9 were found in the area 2,5 km around the aircraft. A part of the left wing was not found. The cockpit and the installations burned out and no data could be seen on the instruments.

The bodies within the aircraft were rather disintegrated and burned.

(c) Area between the two impact zones

Many small and large parts of the aircraft and heavier passenger baggage were found in the area between the places Krkac – Graberanec to the north and Pirakovec-Vrboveč to the south. Several bodies and parts of passenger bodies were also found (cf. Attachment No.3). With the assistance of the British representatives – experts, the pieces of wreckage which were found were identified as the parts of the Trident Three aircraft and these were mainly the parts of the disintegrated fuselage from 18 to 33rd frame and the top of the cockpit. Some major parts were taken away for the purpose of reconstruction of the air collision.

(d) The area in which light material was scattered

The area extended from north-east of Vrbovec to 8 km. north-east from Križevci. The direction of this area is north-east (40°) to a distance of 32 km. (Tiny pieces of paper were blown away by wind to a distance of 90 km.). This area is marked on the chart at a scale 1 : 50,000. Small and light items such as parts of clothes, documents, magazines, journals, books and other tiny pieces of paper were found in this area.

1.13 Medical and Pathological Findings

(a) Crew of the Trident Three aircraft

On 12 October 1976 the Department of Aviation and Forensic Pathology, Institute of Pathology and Tropical Medicine, Royal Air Force, Halton, submitted a pathology report concerning the flight crew members of this aircraft.

The autopsy revealed that all three crew members were without complete bodies, therefore the investigation was limited to the existing parts of bodies.

The cause of death of all crew members was severe injuries obtained in the aircraft collision.

No other causes of death were found and the state of health during the flight was not impaired by excessive usage of medicines, drugs, narcotics, etc.

(b) Crew of the DC-9 aircraft

Institute of Forensic Medicine and Criminology, Medical University, Zagreb, has submitted the findings of the DC-9 aircraft crew members.

Severe injuries which caused death were found on the body of Captain Krumpak Jože.

On the basis of toxicological analysis it was established that liver tissue contained small quantities of largactil, in therapeutic values. It was established that the medicine was taken shortly before death.

It was also established that at the moment of death, Captain Krumpak was healthy.

Due to disintegration and late identification it was impossible to make any analysis on the body of Co-pilot Ivanuš.

1.14 Fire

After impact, the DC-9 aircraft caught fire. 8 minutes after the impact a fire brigade "PRESKA" consisting of 12 voluntary firemen, vehicles and equipment came to the site of the accident. They immediately started extinguishing the fire with water.

At 10.36 (GMT) a fire brigade in Zagreb was informed about the accident and fire. At 11.06 they were at the site on which the DC-9 fell and at 11.07 started extinguishing the fire.

Three different types of vehicles were used.

After the impact, the Trident-3 aircraft did not catch fire. Smoke emerged from some parts of the power plant, but it was extinguished soon. On this occasion the fire brigade used one appliance for technical intervention, one mechanism with dry chemicals and one auto crane. At the site on which the Trident-3 fell two hoses with dry chemicals were placed for the purpose of security; one hose for slow foam and one hose for water mist.

In the first phase of fire extinguishing there were 21 firemen and later on the number increased to 31 firemen and rescuers.

The fire on the DC-9 aircraft was extinguished around 11.15 hrs.

Both sites on which the aircraft fell were secured by fire brigades who kept guard.

The fire brigade from Zagreb used the following technical appliances:

fire vehicle "VM 1300"

fire vehicle "MAGIRUS"

water tanks "FAP" with 8,000 l. of water

fire vehicle "MAGIRUS" for fire extinguishing with foam

autocranes Mercedes of 10 tonnes

fire vehicle with dry powder "TOTAL" - 2 x 750 kg.

two vehicles "MAGIRUS" equipped with tools for cutting, braking, lifting and lighting including one generator of 70 KW.

1.15 Search, Rescue and Evacuation

Rescue and evacuation of passengers and crew members started immediately after the collision. Approximately 1,200 persons, medical teams, police, soldiers, firemen and local people took part in this action.

No one survived the collision, therefore medical teams could not render assistance though they reached the site of the accident in the shortest possible time.

Searching for and evacuation of dead passengers and crew members from the Trident lasted two days and from the DC-9 lasted three days.

After the search of the terrain, the position of bodies, parts of aircraft, passengers baggage were plotted on a chart (attached).

The search of the terrain was difficult due to the large area (32 x 10 km), wet terrain after rain, forest vegetation and crops. Regardless of the difficulties the entire area was searched in 4 days.

1.16 Test and Research

Using remaining parts of the aircraft a reconstruction was made for the purpose of establishing the position of the aircraft immediately before the accident and their movement as well as disintegration after the collision.

The following parts of the aircraft were used for the reconstruction:

TRIDENT-3

lower part of the cockpit

upper part of the cockpit

radar antenna radome

forward right service door with frames

right, lateral part of fuselage skin from service door to frame 23

partition wall between cockpit and passenger cabin and a folding seat

DC-9

remaining left wing

The mentioned parts of the Trident-3 were collected and brought to Zagreb airport where they were put together so that the approximate shape of the forward part of the fuselage could be reconstructed.

Upon the reconstruction of the remaining parts of the Trident-3 and the DC-9 aircraft, the following conclusions were reached:

With the end of its left wing in length approximately 5 meters, the DC-9 struck the base of the forward windows on the Trident-3 cockpit. At the moment of the crash the DC-9 was in a horizontal position. During further movement wing was breaking through the fuselage of the Trident-3 at the angle of collision. A part of the right fuselage skin was bent inwards while a part of the left fuselage skin was bent outwards.

Due to decompression a forward part of the Trident-3 fuselage disintegrated to the frame 33. An unidentified part of the disintegrated forward part of the fuselage of the Trident-3 struck the rudder of the Trident-3 which disintegrated and fell separately on the ground. The parts of the Trident-3 aircraft from the frame 33 to tail surfaces fell to the ground as an integral part. Due to the weight of the engines the aircraft struck the ground first with the aft part and after the final impact the aircraft slid 4-5 meters to the left and stopped. There was no forward movement.

During penetration of the DC-9 left wing in the length of 5 meters through the fuselage of the Trident-3, the wing was completely cut. Unidentified parts of the DC-9 wing or a part of the forward Trident-3 fuselage reached the left engine of the DC-9 and damaged it.

Due to rotation forces, the broken compressor blades on the left engine of the DC-9 fell out of their housing striking the left side of the stabilizer and rudder and a lower left side of the elevator, damaging their skin.

After the collision the tail surfaces and cone portion of the DC-9 fuselage broke and disintegrated probably due to the aerodynamic overloading of the tail surfaces or because the vertical surfaces were damaged by secondary impact of the disintegrated parts of the aircraft.

The DC-9 continued falling without tail surfaces and the cone portion of the fuselage, together with the aft staircase. The aircraft struck the ground in a starboard wing low attitude and stopped in an inverted position, thus completely damaging the aircraft structure. Other disintegrated parts of the aircraft were scattered at the distance of 2.5 km.

1.17 Air Traffic Control Operation

1. Operation of the aircraft JP 550 within the Lower Sector East of the Zagreb Area Control Centre (frequency 124.6 MHz), which extends from 300 m above ground to FL 250.

Before departing from Split for Cologne the crew of the aircraft JP 550 filed a flight plan in the Flight Information Office requesting FL 310. In the coordination between the Approach Control in Split and the Lower Sector of Zagreb ACC it was agreed that after take-off the aircraft could climb above Split VOR to FL 120 and then set course to NDB Kostajnica climbing to FL 180.

At 09.54'49'' the aircraft JP 550 established first contact with the Lower Sector of Zagreb ACC, while it was passing FL 130 and continuing to climb to FL 180 towards NDB Kostajnica. The Lower Sector controller cleared JP 550 to climb to FL 240 and the crew of JP 550 acknowledged the clearance.

At 09.55'50'' JP 550 obtained a clearance to climb to FL 260 and to report passing FL 220 and FL 240. This clearance was issued with the approval of the middle sector.

JP 550 was not given clearance for a flight level higher than FL 260 within the Middle Sector because the higher flight levels were occupied: FL 280 by JP 548 which took-off from Split to Nurnberg at 09.42'; FL 310 by OA 187 operating from Athens to Vienna and estimating overhead ZAG VOR at 10.11 hours.

After passing FL 220, there being no conflicting traffic between FL 230 and FL 250, the Lower Sector East transferred JP 550 to the Middle Sector frequency 135.8 MHz.

The transfer of JP 550 from the Lower East to the Middle Sector was carried out as follows:

10.02'44'' JP 550: Zagreb, Adria 550 crossing 220.
Zagreb: Zagreb 135.8 Good day.

The coordination and transfer of information between the Lower and Middle Sector was carried out in time on the basis of agreement and transfer of a strip with flight data.

In accordance with Zagreb ACC regulations, flight progress strips should be prepared in advance for all sectors through which the aircraft passes. However, for the flight JP 550, a flight progress strip was not prepared for the Middle Sector. But, this did not affect flight safety within the Middle Sector because the coordination, transfer of information and communications were timely made at the moment of crossing FL 220, i.e. while the aircraft was in the airspace of the Lower Sector East.

2. Operation of JP 550 within the Middle Sector (frequency 135.8 MHz) which extends from FL 250 to FL 310 within Zagreb ACC.

At 10.03'21" JP 550 established a radio contact with the Middle Sector and reported passing FL 225 climbing to FL 260.

The Middle Sector controller instructed JP 550 to select mode/Code A2506 on its transponder and confirmed the clearance to climb to FL 260. Then JP 550 was given instructions to fly towards Kostajnica, Zagreb and Graz.

At 10.05'57" JP 550 reached FL 260 awaiting clearance to climb to a higher flight level (FL 310), as had been indicated in the flight plan before take-off. As the controller knew that the flight levels 280 and 310 were occupied, he apologized to the crew of JP 550 and asked whether they could climb to FL 350. The crew answered affirmatively and "with pleasure".

For 1 minute 48 seconds JP 550 was retained in a horizontal flight at FL 260, while, in the meantime the coordination was carried out between the Middle and Upper Sector for climbing to FL 350.

According to the controllers' statement the coordination was effected in the following way. The Middle Sector controller stated that he signalled by hand to the Upper Sector controller that he wished to talk to him. The Upper Sector controller signalled also by hand that he was busy. Therefore, the Middle Sector assistant-controller, who held a radar licence, moved across to the Upper Sector controller who was sitting to his right, at the distance of about 50 cm., to coordinate the climbing. He fingered the target of JP 550 to the Upper Sector controller at his radar display, requesting a clearance for climbing. According to his statement, the Upper Sector controller cleared JP 550 to climb to FL 350.

The Upper Sector controller stated that he only remembers that the Middle Sector assistant-controller showed him some aircraft in vicinity of Kostajnica.

After the clearance was given to JP 550 to climb to FL 350, the Upper Sector assistant-controller was obliged to prepare the appropriate flight progress strip for this sector. The strip was not prepared in advance because in its filed flight plan the aircraft did not anticipate flying in the upper sector. As at the time the clearance was given the Upper Sector assistant-controller was not at his position the flight progress strip should have been prepared by the Upper Sector controller who, due to business, failed to do that.

The statements and the transcripts of telephone conversation confirm that at that time, the Upper Sector controller was working alone.

At 10.07'40" the Middle Sector controller issued the clearance to JP 550 to climb to FL 350. Shortly afterwards, the assistant controller in this sector informed Vienna by telephone that JP 550 would enter Austrian territory at FL 350.

At 10.09'18" the Middle Sector controller, on the basis of radar monitoring, informed the crew of JP 550 that they were approaching Kostajnica. He instructed the crew to report passing FL 290 and then 310 and the crew acted accordingly.

It was established that the Middle Sector controller who was in radio contact with JP 550 held a licence of area procedural controller while his assistant controller held a licence of area radar controller.

Those two controllers skillfully carried out all radar operations (monitoring, identification, control, separation and transfer of radar identity).

At 10.12'06'' when passing FL 310, the crew of JP 550 was instructed to SQUAWK STANDBY temporarily and to change frequency to 134.45 MHz.

The crew of JP 550 maintained a radio communication with the Middle Sector until 10.12'12''.

Temporary SQUAWK STANDBY deleted from the radar display in this sector the code and altitude of the aircraft while only the indication of his position remained.

Thus, the presentation of the aircraft's target on the Upper Sector display was not changed because until the switching off the aircraft was flying on the altitudes monitored by the Middle Sector.

Each sector in the Area Control is allocated a clearly defined, numerically limited group of secondary radar codes, which is used for the purpose of easier identification and control of aircraft within a sector.

Therefore, the Middle Sector has at its disposal the codes from A (Alpha) 2500 to A2577 and the Upper Sector from A2300 to A2377.

As the aircraft JP 550 was transmitting the code from the Middle Sector group (A2506) and because during the coordination the Upper Sector did not require transmission of any code from its group, the Middle Sector controller, in order to release his code during the transfer, required the aircraft to "SQUAWK STAND BY".

The application of "SQUAWK STAND BY" procedure during the transition of an aircraft from one sector to another is not separately regulated either by national or international regulations.

3. Operation of JP 550 and BE 476 with the Upper Sector on the frequency 134.45 MHz within Zagreb Area which extends from FL 330 upwards with no limit.

(a) The Upper Sector controller was in radio contact with the Trident-3 aircraft BE 476 which was flying from London to Istanbul. Radio contact was established at 10.04'12'' as follows:

BE 476: Zagreb, Bealine 476, Good afternoon.

Zagreb: Bealine 476, Good afternoon, go ahead.

BE 476: 476 Klagenfurt at 02, 330 estimating Zagreb at 14.

The air traffic controller acknowledged this information and required the aircraft to report passing Zagreb VOR, to maintain FL 330 and to select the transponder of the Secondary Radar to mode/code Alpha 2312. The crew of BE 476 did so and acknowledged that code A 2312 was being selected.

10.04'19'' Zagreb: Bealine 476, Roger, call me passing Zagreb, flight level 330, SQUAWK Alpha 2312.

10.04'38'' BE 476: 2312 coming.

It is believed that on the basis of SQUAWK Alpha 2312 the aircraft BE 476 was identified and the Upper Sector controller saw it on his radar display. Alongside the target of the aircraft the controller should also have seen the selected code and its flight level.

The Upper Sector controller has stated that the altitude readout for BE 476 as displayed on his radar was FL 332 or FL 335. He also stated that the Radar was unreliable and that he therefore decided not to use it.

On that day there had been no reports at the Zagreb Area Control Centre of any malfunction of the radar or height encoding facility and these facilities were normally used before the accident and also when the equipment was subsequently checked after the accident.

The data from Munich and Vienna referring to the operation of the flight BE 476 above those area showed that the altitude readout was 330, coincidental with the pilot's in flight report.

Air Traffic Control Instructions of the Federal Civil Aviation Administration require the verification of transponder altitudes which vary more than ± 300 feet from the aircraft reported level. The Upper Sector controller stated that he did not report the discrepancy because he thought it unimportant.

(b) At 10.12'12" the aircraft JP 550 was instructed to change to the Upper Sector frequency and immediately before that or at that time, the Upper Sector was given a flight progress strip which was previously used in the Middle Sector.

From the moment this instruction was given until the first contact of JP 550 with the Upper Sector on the frequency 134.45 MHz, 1 minute 52 seconds passed. This could be seen from the transcript of tape recordings. During this time the Upper Sector frequency was continuously occupied by transmissions with the following overflying aircraft: F 1673, LH 310, OA 172 and BE 932.

Before it had established a radio contact with the Upper Sector, JP 550 was climbing to FL 350 in accordance with the clearance issued by the Middle Sector. Radio contact was established as follows:

| | | |
|-----------|---------|--|
| 10.14'04" | JP 550: | Good morning Zagreb, Adria 550. |
| 14'07" | Zagreb: | Adria 550, Zagreb, Good morning, go ahead. |
| 14'10" | JP 550: | 325 crossing, Zagreb at 14. |
| 14'14" | Zagreb: | What is your present level? |
| 14'17" | JP 550: | 327 |

The controller realised that a critical situation existed after he had received information from JP 550 that it was passing flight level 327, because he knew that BE 476 at FL 330 was flying in the opposite direction towards Zagreb VOR.

On the Upper Sector radar display the aircraft JP 550 was visible as a circle with dash (e) without indications of code and altitude.

Then the controller issued JP 550 the following instruction in the Serbocroatian language.*

| | | |
|-----------|---------|---|
| 10.14'22" | Zagreb: |e..... maintain now on that level and report passing Zagreb. |
| 14'27" | JP 550: | What level? |

* Use of any other language except English in the Air Traffic Control phraseology is contrary to the DGCA Order No. 04-2192 dated August 22, 1967.

14'29" Zagreb: At which you are now climbing because you have an aircraft in front of you at (unreadable) 335 from left to right.

14'38" JP 550: OK maintain precisely 330.

At, or shortly after 1000 hours, the assistant Upper Sector controller had rotated his duty position to become the sector radar controller. At the same time a relief assistant controller should have arrived for duty.

It has been established that the Upper Sector assistant controller was absent from his duty position between the hours 10.05' and 10.10' and probably until about 10.13'.

As a result of his absence, the controller had to perform the function of controller and of the assistant controller as well.

The total number of aircraft within the Upper Sector was 12, requiring numerous RTF transmissions and associated telephone calls. (See Attachment 17).

The Chief of the Shift stated that he was at his post throughout the period from 1,000 hours to the time of the collision and that he was unaware of the absence of the Upper Sector assistant controller from his duty position.

However, the Upper Sector controller who had been relieved at 1,000 hours or shortly after stated that he informed the Chief of the Shift of the absence of the Upper Sector assistant controller.

The Air Traffic Control received the first information about the collision at 10.18' from the crew of LH 360 flying from Frankfurt to Belgrade at FL 290 about 15 NM behind BE 476. The information was given through the Middle Sector controller who was in regular radio contact with the crew.

1.18 Information on the DC-9 Climb Performance

During climb the DC-9 aircraft uses four climb regimes:

1. High speed climb 320 kts/0.74 m

(this speed is used when total flight hours are factor No. 1 – short flights)

2. Long range climb 290 kts/0.72 m

(it is used when fuel consumption is factor No. 1 – long flights)

3. Maximum rate of climb 255 kts

(it is used when it is desired to achieve the highest altitude in a specific climb time and most often upon the request of ATC)

4. Single engine climb – maximum gradient $GW^*/1,000 \text{ Lb} + \text{kts}$

(it is used when one engine fails and for overjumping of obstacles after take-off.)

* Gross weight – total weight in thousands librae

The flight recorder data showed that the DC-9 aircraft applied the Long Range Climb (0.72m)

Using this regime of climb the crew of the DC-9 aircraft complied with the policy of its company in respect of economy and exploitation of the aircraft in flight. The Air Traffic Control did not require a special climb regime. After the fuel crisis, many companies were applying the Long Range Climb.

1.19 In Flight Look Out*

Flight Operations Manual for jet aircraft

Look out – When weather conditions make this possible it is the duty of the crew to keep a sharp look-out during all stages of a flight, as the increased traffic and the higher speeds have also increased the near collision incidents to a critical point.

In the vicinity of an aerodrome, during descent and climb out to/from an aerodrome and in areas where traffic is dense, crew members shall avoid paper work, map reading, etc.

Observe that when flying in VMC on an IFR flight plan it is the same direct responsibility of the PIC to avoid collision with other aircraft as when flying on a VFR flight plan. The value of information given by ATC as regards other traffic is great but may be doubtful in so far as this information only includes known traffic. Such information may temporarily sharpen the look-out at specified times or altitudes and it might be reduced thereafter in the belief that other traffic does not exist. However, information about traffic within the “blind angles of the aircraft” (aircraft on approximately the same heading) is always valuable.

Thus, during VMC, a continuous look-out is an absolute necessity. It is the responsibility of PIC to assign 1 Pilot primarily for this look-out duty, and to ensure that all other duties, such as strict adherence to ATC clearance (check of navigation instruments), are still properly performed.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

(a) The Trident-3 aircraft

The aircraft operated on its scheduled flight BE 476 and the flight proceeded normally via West Europe and a portion of the airway above Yugoslavia.

At 10.02' (GMT) it passed Klagenfurt (Austria) and at 10.04' reported to Zagreb Area Control Centre at FL 330 estimating ZAG VOR at 10.14'. Zagreb ACC cleared BE 476 to fly at FL 330 on the airway UB 5.

For the purpose of avoidance of aircraft collision it is the duty of the crew to look-out even though a flight is being made with IFR plan in visual conditions. In the region of collision the weather was fine with great visibility and there was nothing to prevent the crews in that respect. However, in order to sight another aircraft converging at high speed, at a sufficient distance to allow time for avoiding action it is necessary to monitor the appropriate RTF channel and keep a good look-out.

* Extract from JAT Flight Operations Manual. Similar provisions are contained in the Manuals of the airlines in the following countries: Switzerland, Federal Republic of Germany, Holland, Sweden, Norway, Denmark and Great Britain.

At high altitudes and at high speed, particularly in nearly opposite heading it is very difficult to observe another aircraft. However, when the aircraft fly under certain angle and produce condensation trails, it is possible to sight another aircraft.

On this occasion there was evidence that the Trident, and probably for the latter part of its climb, the DC-9, were forming such trails.

Another and most important aid to crews in the avoidance of a collision is the monitoring of the appropriate RTF channel for any information of conflicting traffic. The Trident Voice Recorder revealed that the crew of the Trident saw a Turkish Airlines aircraft passing in the opposite direction 2,000 feet above them shortly after they had heard it report its position to the Upper Sector of Zagreb Control.

The Upper Sector Controller did not inform the crew of BE 476 about the DC-9 aircraft in vicinity of ZAG VOR. During the control of RTF frequency it was established that the crew of BE 476 may have heard JP 550 in vicinity ZAG VOR about 50 seconds before the collision, when the crew of JP 550 reported, in the English language, its flight level in climb (325) and arrival at ZAG VOR at 14th minute. (The same time as Trident's above ZAG VOR).

It has not been established whether the crew of Trident heard this message, but probably did not recognize any conflict situation.

From the evidence of the cockpit voice recorder it is clear that nothing distracted the crew during the last few minutes before the accident. However, the aircraft were approaching at a very high closing speed (about 380 meters per second), about 2 NM every 10 sec.

The aircraft was flying at the cleared flight level on the airway UB 5 and when above ZAG VOR collided with the DC-9 aircraft.

(b) The DC-9 aircraft

The aircraft operated a charter flight JP 550 and the flight proceeded normally from the take-off to the region of ZAG VOR. After the take-off from Split the aircraft climbed over Split VOR on the airway B9 and then proceeded in the direction of Kostajnica NDB.

The crew used the Long Range Climb regime (economical climb regime).

According to the instructions of Zagreb ACC the aircraft was in level flight at FL 260 for a period of 1 minute 48 seconds (from 10.05'57" until 10.07'45") when it obtained a clearance from the Middle Sector Controller to climb to FL 350.

In climbing it passed Kostajnica NDB on the airway UB9 and assumed a heading in the direction of ZAG VOR.

At 10.14'10" the aircraft passed FL 325 and reported to the Air Traffic Control crossing ZAG VOR at 14 (10.14'). It is possible that the flight deck time in both aircraft differed from the ATC time by 1 minute. (They reported passing ZAG VOR at 10.14' while actually they were overhead VOR at 10.15).

At the time when BE 476 established radio contact with Zagreb ACC on the Upper Sector frequency, the DC-9 was flying in the Middle Sector maintaining radio communication on the Middle Sector frequency. Due to that the crew of the DC-9 could not hear the message of the BE 476 crew.

On passing FL 325 in a critical phase of the flight, in relation to the position of the Trident-3, the DC-9 aircraft continued climbing to FL 350 in accordance with the ATC clearance.

Following a report from the DC-9 that they were "passing FL 327" the controller required the aircraft to maintain its present level. Due to momentary misunderstanding as to which flight level to maintain, the crew of JP 550 asked again "what level". In this period the DC-9 aircraft continued to gain altitude until 10.14'38" when the crew reported "OK, maintain precisely 330".

Immediately before the collision the crew of the DC-9 were incorrectly informed that the Trident was flying on FL 335.

At this level, 9 seconds after it had levelled at FL 330, according to the flight recorder readout (altitude parameter) the DC-9 collided with the Trident-3 over ZAG VOR.

It was established that the collision occurred exactly at 10.15'(10.14'38" + 22). With the left wing in the length of 5 meters, the DC-9 struck the Trident-3 cockpit and the crew were not able to control the aircraft though they were alive shortly afterwards. The aircraft fell on the ground.

(c) Other factors relevant to the accident

It was established that before the accident there was no fire, explosion, attempted diversion or unlawful interference on board either aircraft.

The crew of both aircraft were properly certificated and qualified for the performance of their duties. They were also medically fit, rested and fully trained for the respective types of aircraft on which they were flying; there was also no influence of alcohol, drugs or narcotics. There was no engine malfunction on either aircraft during the previous flight.

The aircraft were loaded within the approved limits.

The weather situation and visibility were favourable enabling the possibility of a good look-out.

The azimuth angle of the sun was 166° with an angle in relation to the horizon of 48° . The angle of the sun as seen from either cockpit could not have restricted visibility.

All ground radio navigation aids on the airways UB9 and UB5 were technically serviceable without interruptions in operation.

After the accident both Primary and Secondary radar-SSR systems in operation at Zagreb ACC were found technically and operationally in order, with clear video maps and without interference. No defects had been reported.

Radio equipment for ground-air communications on the frequency 124.6 MHz, 135.8 MHz and 134.45 MHz was operationally serviceable; radio communications with both aircraft was maintained without interference.

Zagreb airport was equipped with all aids necessary for safe flying.

The flight recorders recorded all flight parameters from the take-off until the collision. They were used during the reconstruction of the flight. The quick access recorder from the Trident-3 aircraft was not found.

The flight parameters revealed that both crews complied with their flight plans and that there was no deviation from the flight plan. The flight level 310 was indicated in the flight plan of JP 550, but as this flight level was not available, it was changed to FL 350 (according to Zagreb ATC clearance).

Radio-navigation aids of both aircraft were selected for the flight to ZAG VOR, except for the Nav 1. receiver of the BE 476 which was still selected to Klagenfurt VOR.

It is probable that both aircraft were flying under control of the autopilot.

As no avoiding action was taken it could be concluded that the crews did not see each other.

The collision occurred on the intersection of the headings 116° and 353° overhead ZAG VOR, at FL 330.

Parts of the aircraft, equipment and baggage were scattered over large area (32 x 10 km) which caused difficulties in searching, gathering and identification of the wreckage of the aircraft and equipment. During the identification of the aircraft parts and during the reconstruction of the accident, great assistance was rendered by the aviation experts from Great Britain.

The evacuation of dead passengers and crews was made difficult due to swampy terrain and the fact that both aircraft and bodies were scattered over large area.

A great assistance during fire fighting, searching of terrain and evacuation of dead passengers was rendered by: Fire Fighting Brigades from Zagreb and Vrbovec, Agricultural-industrial Cooperative "Vrbovec", police units, medical teams, soldiers and people from the neighbouring villages.

2.2 Analysis of the Air Traffic Control Operation

The documentation and analysis show that certain departures from the Air Traffic Control Instructions and ATC Rules preceded the accident of the JP 550 and BE 476 aircraft.

The situation shortly before the accident began at the moment the clearance was given to the crew of JP 550 to climb from FL 260 to FL 350.

There is a conflict of evidence as to whether and to what extent, the coordination was effected between the Middle Sector Assistant Controller and the Upper Sector Controller. It has not been possible to establish definitively whether the Upper Sector Controller was informed that JP 550 would climb to FL 350 estimating crossing Zagreb at 10.16'.* However, other facts show that the Upper Sector Controller issued the clearance to JP 550 to climb to FL 350 and that he probably did so believing that the aircraft would reach that level prior Zagreb VOR.

The clearance to climb to FL 350 resulted in a situation, considering the climb speed characteristics, that JP 550 in vicinity of Zagreb VOR was crossing the altitude of BE 476 which was flying at FL 330. Thus, there was no possibility for the Upper Sector Controller to separate the aircraft by procedural method (on the basis of time).

Had the regulations for strip production and distribution to the Upper Sector been followed at the moment when JP 550 received the clearance to climb to FL 350 (10.07'04'') it is considered that the Upper Sector Controller, with the strip in front of him at the procedural console, would have been informed about the proceeding of JP 550 and that he would have had a possibility to perform timely radar separation with the aircraft BE 476.

* The data extracted from the flight progress strip

When JP 550 reported passing FL 310, during the transfer of communication to the Upper Sector, the Middle Sector Controller instructed the aircraft to SQUAWK STAND BY temporarily.

Had this instruction not been given, the code and altitude of the aircraft, which it has had in the Middle Sector after passing FL 310, would have been presented on the Upper Sector radar display together with a symbol of aircraft position which was constantly displayed, while the altitudes would vary according to climb of the aircraft.

Had the data on code and altitude of the aircraft remained on the Upper Sector radar display, the Upper Sector Controller could have not provided adequate separation between JP 550 and BE 476 due to very short time.

The transfer of radar identity of JP 550 from the Middle to the Upper Sector was made physically as the target was shown by finger, and not by comparison of codes on the radar displays of both sectors. As the code and altitude were not presented on the Upper Sector display at the time when the aircraft was under the control of the Middle Sector (height filtering), switching of the JP 550 transponder to "Stand by" during the transfer to the Upper Sector, did not cause changes in presentation of the aircraft target on the Upper Sector display.

The use of "Julia" system enables each sector to select a layer by height filtering system, presenting all data available (position, discrete code and flight level) while for the rest of the airspace only aircraft positions are displayed.

Each sector selects a layer, by height filtering system, which covers a part of the airspace under its responsibility, in order to avoid gathering and overlapping of codes and altitudes of its aircraft with those operating in other sectors.

Thus, all aircraft at FL 310 and higher were presented on the Upper Sector radar display with the codes, altitudes and position symbols. The aircraft operating below FL 330 were presented only with the position symbols.

In accordance with the above, all aircraft operating at flight levels between 250 and 310 were presented on the Middle Sector radar display with the codes, altitude and position symbols while all, other aircraft, higher and lower, were presented only with the position symbols.

A controller in each sector may, if necessary, have on his radar display, the codes and altitudes of some aircraft operating out of the selected layer. He can achieve this in the following way:

- (a) feeding into a computer the code already transmitted by the aircraft operating in another sector;
- (b) requesting another sector to instruct the aircraft to transmit the code already fed into the computer;
- (c) using the "Pointer" facility which provides readout of codes and altitudes of any aircraft in duration of 30 seconds.

The Upper Sector Controller did not use any of these possibilities, probably because he thought that the aircraft climb was safe and that JP 550 would reach FL 350 before crossing Zagreb VOR.

The Upper Sector Controller was again aware of the presence of JP 550 when the flight progress strip was passed to him by the Middle Sector Assistant Controller. This could have been shortly before JP 550 made first contact on the Upper Sector frequency.

This first call of JP 550 was in any case delayed due to volume of RTF traffic on the Upper Sector frequency which was continuous from 10.12'12" until 10.14'04".

From 10.05'10" until 10.10'00" and probably until 10.13'00", during the critical phase, the Upper Sector Controller was working alone without an Assistant Controller who should have been at his post. This considerable additional workload resulted in the Upper Sector Controller being overloaded.

At 10.14'10" when JP 550 reported passing FL 325 the controller probably did not understand or believe the reported flight level. Most probably that the controller did not realise a critical situation existed with BE 476 until 10.14'17" when JP 550, upon his request, reported passing FL 327.

At 10.14'17" the Upper Sector Controller broke into Serbocroatian language in an attempt to stop the climb of JP 550 at the last reported level (327). Had the controller continued to use the English language in this critical stage of the flight, the crew of BE 476 would probably have heard and understood the critical situation and might have attempted to take avoiding action. However, even if the controller had warned BE 476 in the English language, it is uncertain whether any avoiding action would have been successful, due to very short time available before the collision.

In respect of the Upper Sector Controller's statement about the flight level of BE 476, it has been impossible to substantiate or deny his statement that the level readout before the collision was 332 or 335.

The flight level readout for the operation of the aircraft above German and Austrian territory was, according to the official report from Munich and Vienna, 330.

The instruction of the Upper Sector Controller issued to JP 550 to maintain its present level (while the aircraft was passing FL 327) suggests that he hoped to achieve a vertical clearance of about 300 feet. However, the request was placed late and was not sufficiently precise.

Due to the time necessary to bring the aircraft into horizontal flight, the aircraft levelled no sooner than FL 330.

An important factor in the build up of the critical situation leading to the collision was the absence from his post of the Upper Sector Assistant Controller. There is a conflict of evidence as to what the Chief of the Shift was doing during this critical time and as to whether he was aware of the absence of the Upper Sector Assistant Controller. He took no action to intervene or to help. He should have noticed the absence of the Assistant Controller and the work-load of the Controller who was alone.

The cumulative effect of circumstances and departure from published ATC rules and regulations combined with the overloading of the Upper Sector Controller led to the aircraft collision.

3. Conclusions

- 3.1 On the basis of the data and analysis it is possible to eliminate the following as the cause of the accident:

Fire on board aircraft and unlawful interference

Medical condition and qualifications of the crews of both aircraft and the controllers

Operation of the crews of both aircraft in respect of compliance with regulations and instructions

Technical serviceability of the aircraft, engines and equipment of both aircraft

Operation of ground radio-navigation aids

Current meteorological situation.

3.2 Contributory factors to the accident chronologically listed were:

3.2.1 Contrary to ATC instructions, a flight progress strip was not produced for JP 550 for a part of the flight within the Upper Sector of Zagreb ACC. This resulted in the Sector's overlooking of the previous information about this flight and untimely planning and safe control.

3.2.2 The Upper Sector Assistant Controller was absent from his duty post from 10.05'10" until 10.10' and probably until 10.13' hours during a period when the Sector Controller's workload was high.

3.2.3 The Chief of the Shift should have noticed the absence of the Upper Sector Assistant Controller and taken the appropriate measures. However, he did not do so.

3.2.4 The Upper Sector Controller was overloaded and this with the absence of the appropriate flight progress strip, led to the overlooking and late recognition of conflict situation.

3.2.5 The Upper Sector Controller accepted the coordination on JP 550 to climb to FL 350 without providing adequate procedural separation against BE 476.

3.2.6 The use of Secondary Radar Height Filtering System and non usage of its specific possibilities for tracking of aircraft in other sectors as well, prevented the Upper Sector Controller to sight in time and follow vertical movement of JP 550 and to carry out the separation procedure.

3.2.7 There was a critical delay prior to the first call from JP 550 to the Upper Sector Controller due to the volume of RTF traffic on the Upper Sector frequency.

3.2.8 Shortly before the collision (about 30 seconds) the crew of JP 550 was warned that they had an aircraft from left to right at FL 335. However, the instructions of the Upper Sector Controller for the purpose of achieving any vertical separation between the two aircraft were not sufficiently precise and accurate.

3.2.9 Occasional use of the Serbocroatian language by the Upper Sector Controller in the critical situation, prevented the crew of BE 476 from monitoring the RTF conversation between the Upper Sector Controller and JP 550. However, the crew of BE 476 must have heard at 10.14'10" and 10.14'17" the conversation in the English language between the ATC and the crew that JP 550 had passed FL 325 and 327 respectively, in immediate vicinity of Zagreb VOR, i.e. that it estimated to cross Zagreb VOR in the current minute.

3.3 Causes of the Accident

3.3.1 This collision was caused by a failure:

to provide the prescribed separation between the aircraft

untimely recognition of conflict situation

application of unprecise measures for prevention of the collision

This resulted from the following:

- (a) non-application of rules and regulations by the competent air traffic controllers
- (b) the overloading of the Upper Sector Controller in a critical situation due to the absence from his post of the Upper Sector Assistant Controller.

3.3.2 Besides the failure attributable to the air traffic controllers, a series of circumstances contributed to the collision of the aircraft which were flying in the conditions of great visibility.

4. Recommendations

1. The regulations should specify that an individual secondary radar identity code is retained by each aircraft throughout its entire flight within a Control Area where the radar coverage is provided.
2. To prohibit switching off of the transponder during the transfer of aircraft between the adjacent sectors.
3. Radar height filtering system should be used in such a way that it includes the layers between the adjacent sectors thus providing the automatic tracking of aircraft during climbing or descending and their observance before they enter the airspace of the specific sector.
4. For air-ground radio-telephony communications a standard phraseology in the English language to be used by Air Traffic Control Units and aircraft during the flight along the airways and in the zones used for international air services.
5. The duties of the crews should be defined more precisely in respect of the look-out for the purpose of avoidance of air collision, when the conditions permit.