

AGENZIA NAZIONALE PER LA SICUREZZA DEL VOLO

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FINAL REPORT

(As approved by ANSV Board on the 20th of January 2004)

**ACCIDENT INVOLVED AIRCRAFT
BOEING MD-87, registration SE-DMA
and CESSNA 525-A, registration D-IEVX
Milano Linate airport
October 8, 2001**

N. A/1/04

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PURPOSE OF THE TECHNICAL INVESTIGATION

The investigation of this accident, as required by Article 827 of the Italian Navigation Code, was conducted following the requirements of ICAO ANNEX 13 to the Chicago Convention, December the 7th 1944, approved and made executive in Italy by Legislative Decree of March 6th 1948, n. 616, and ratified with Law of April 17th 1956, n. 561.

The Agenzia Nazionale per la Sicurezza del Volo (ANSV) performs its investigations *with the only purpose of accident and serious incidents prevention, excluding any appraisal of blame or responsibility* (art. 3, paragraph 1, Legislative Decree of February the 25th 1999, n. 66).

ANSV issues a report upon completing the accident investigation or the incident investigation; such reports may include Safety recommendations with the purpose of preventing accidents and incidents (art. 12, paragraph 1 and 2, Legislative Decree of February the 25th 1999, n. 66).

In all reports ANSV will safeguard the privacy of all persons involved in the event and of those that contributed information during the investigation. Anonymity will be granted to all persons involved in the events (art. 12, paragraph 3, Legislative Decree of February the 25th 1999, n. 66).

Reports and associated Safety recommendations are never intended to apportion blame or responsibility (art. 12, paragraph 4, Legislative Decree of February the 25th 1999, n. 66).

This document is released in accordance with and under the provisions of Legislative Decree n. 66 of February 25, 1999 institutive of ANSV.

Copying, distribution or the use of this document (totally or partially) for commercial purposes is forbidden.

This report has been translated and published by the AGENZIA NAZIONALE PER LA SICUREZZA DEL VOLO for the English-speaking concerned public. The intent was not to produce a factual translation and as accurate as the translation may be, the original text in Italian is the work of reference.

Questa Relazione d'inchiesta è stata tradotta ed è disponibile in lingua Inglese a cura dell' AGENZIA NAZIONALE PER LA SICUREZZA DEL VOLO a beneficio delle persone interessate. Benché grande attenzione sia stata usata allo scopo di offrire una traduzione accurata, il testo di riferimento rimane quello in lingua Italiana.

SYNOPSIS

The accident occurred on the 8th of October 2001 at 06.10 UTC (08.10 local time) at Milano Linate airport. Two aircraft were involved in the event, a Boeing MD-87, registration marks SE-DMA radio call sign SK 686 and a Cessna Citation 525-A, registration marks and radio call sign D-IEVX.

The MD-87 on a scheduled flight from Milano Linate airport to Copenhagen Kastrup airport was manned by a crew of two pilots and four cabin attendants and had a load of 104 passengers. The Cessna 525-A was on a flight from Milano Linate airport to Paris Le Bourget airport and it was manned by a crew of two pilots with a load of two passengers.

The Agenzia Nazionale per la Sicurezza del Volo has immediately opened the investigation upon receiving notice of the accident and sent an investigating team on site which arrived at around 10.00 UTC (12.00 local time) of the same day.

The Agenzia Nazionale per la Sicurezza del Volo, pursuant to the Legislative Decree 66/1999, has conducted the technical investigation in accordance with Annex 13 of the Convention on international civil aviation (Chicago, 1944).

This investigation has been conducted with the valuable assistance of accredited representatives of the following States:

- Denmark, represented by AAIB-Danish Aircraft Accident Investigation Board,
- Germany, represented by BFU-German Accident Investigation Board,
- Norway, represented by HSLB-Norway Aircraft Accident Investigation Board,
- Sweden, represented by SHK-Swedish Accident Investigation Board,
- United States of America, represented by NTSB-National Transportation Safety Board,
- other advisers in accordance with Annex 13.

This Final Report updates the progress made on the investigation as of this date, adding to the Preliminary Report, the first Interim Factual Report published on December 27, 2001 and the second Interim Factual Report published on July 9, 2002.

Certain information and evidence, not relevant to the dynamics of the accident or to its causes, have been seized and kept in custody by the Magistrate conducting the criminal inquiry and could not be used for the investigation; such information has been requested by this Agency but to the date of publication of this Final Report, it has not been obtained.

GLOSSARY

AAAVTAG: “Azienda Autonoma Assistenza al Volo per il Traffico Aereo Generale”, actually ENAV SpA

ACARS: Aircraft Communications Addressing and Reporting System

ACC: Area Control Centre, Area Control

ACFT: Aircraft

ACI: Airports Council International

AEA: Association of European Airlines

AEP: Airport Emergency Plan

AFIS: Aerodrome Flight Information Service

AGA: Aerodromes, air routes and Ground Aids

AIC: Aeronautical Information Circular

AIP: Aeronautical Information Publication

AIS: Aeronautical Information Services

AMSL: Above Mean Sea Level

ANSP: Air Navigation Service Provider

AOC: Air Operator Certificate

APN: Apron

APS: Fire brigade water pumping vehicle

ARO: Air traffic services Reporting Office

ASA: Fire brigade rescue vehicle

ASDA: Accelerate-Stop Distance Available

ASMI: Aerodrome Surface Movement Indicator

ATA: “Ali Trasporti Aerei”, Airport handling and service provider

ATC: Air Traffic Control

ATIS: Automatic Terminal Information Service

ATM: Air Traffic Management

ATOW: Actual take Off Weight

ATPL: Airline Transport Pilot License

BCFG: Fog patches

BECMG: Becoming

BFU: Bundesstelle für Flugunfalluntersuchung, German Federal Bureau of Accident Investigation

BR: Mist

BKN: Broken, cloud coverage

CA: Cabin Attendant

CAT I, CAT II, CAT III: Instrument approach categories

CAT: Category

CAV: “Centro Assistenza al Volo”, Flight assistance center

CB: Cumulonimbus cloud

CHD: Child

CIT: Company Investigation Team

CPL: Commercial Pilot License

CRASH RECORDER: see DFDR, FDR

CRI: Class Rating Instructor

CSO: “Capo Sala Operativo”, team manager controller of TWR operation

CTA: Control Area

CTA: Air traffic controller (denomination used in IPI)

CTR: Control zone

CVR: Cockpit Voice Recorder

CWY: Clear way

DCA: “Direzione di Circostrizione Aeroportuale”, jurisdictional aerodrome authority

DEW POINT: The temperature at which air moisture starts condensing

DFDR: Digital Flight Data Recorder

DGAC: “Direzione Generale dell’Aviazione Civile”, national authority for Air Transport, now substituted by ENAC

DH: Decision Height

DOC: Document

DOP: “Disposizioni Operative Permanenti”, permanent operational instructions

EAP: European Action Plan, on runway incursion prevention

ECA: European Cockpit Association

ECAC: European Civil Aviation Conference

EFIS: Electronic Flight Instrument System

EGT: Exhaust Gas Temperature

ELT: Emergency Locator Transmitter

ENAC: “Ente Nazionale per l’Aviazione Civile”, civil aviation authority

ENAV: “Ente Nazionale di Assistenza al Volo SpA” (previously AAAVTAG), civil aviation ANSP

EPR: Engine Pressure Ratio

ERA: European Region Airlines’ Association

ESARR: Eurocontrol Safety Regulatory Requirement

EUROCONTROL: European Organization for the Safety of Air Navigation

FAA: Federal Aviation Administration

FDR: Flight Data Recorder

FF: Fuel Flow

FG: Fog

FI: Flight Instructor

FIC: Flight Information Center

FIR: Flight Information Region

FIS: Flight Information Service

FL: Flight Level

FLEX: Takeoff thrust setting procedure

FLUSSO: ATC service office for coordination between ACC and Eurocontrol

FSCC: Fire station control center

FT: Foot, feet

GASR: Group of Aerodrome Safety Regulators

GND: Ground control

GND: Ground, terrain

GS: Ground Speed

HDG: Heading

hPa: HectoPascal

IAS: Indicated Air Speed

IAOPA: International Aircraft Owners and Pilots' Association
IATA: International Air Transport Association
ICAO: International Civil Aviation Organization
IDENT: Transponder identification message (selectable)
IDLE: Throttle position that delivers the minimum thrust
IFALPA: International Federation of Air Line Pilots' Association
IFATCA: International Federation of Air Traffic Controllers' Association
IFR: Instrument Flight Rules
ILS: Instrument Landing System
IMC: Instrumental Meteorological Condition
IPI: "Istruzioni Permanenti Interne", permanent instructions to ATC controllers
IRI: Instrument Rating Instructor
JAA: Joint Aviation Authorities
JAR: Joint Aviation Requirement
Kt/kts: knot/s, speed unit, nautical mile/s per hour
LBA: Luftfahrt Bundesamt Abgesandt, German civil aviation authority
LDA: Landing Distance Available
LVO: Low Visibility Operation
LVP: Low Visibility Procedure
LVTO: Low visibility Takeoff Procedure
MAC: Mean Aerodynamic Cord
MET: Meteorological, meteorology
METAR: Aviation routine weather report
MHz: Megahertz
MID: Runway mid point (for RVR reading)
MIFG: Shallow fog
MLG: Main Landing Gear
NLG: Nose Landing Gear
NM: Nautical Mile
NOSIG: No Significant Change

NOTAM: Notices To Air Men

NTSB: National Transportation Safety Board (Accident Investigation Board of the USA)

OdS: “Ordine di Servizio”, service order, regulation

OVC: Overcast, cloud coverage

PF: Pilot Flying

PIC: Pilot-in-command

PLA: Power Lever Angle

PLN: Flight Plan

PNF: Pilot Not Flying

QAR: Quick Access Recorder

QNH: Atmospheric pressure referred to sea level measured in hPA

RA: Radio Altimeter

RADOME: Forward portion of the fuselage where weather radar is normally located

RCL: Runway Center Line

READ BACK: The correct, accurate and complete repetition of a received ATC message

REVERSE: Position of engine thrust levers to obtain reverse engine thrust, used to improve aircraft braking capability

ROGER: Conventional aeronautical word of acknowledgement

R/T: Radio telephony (radio communications)

RVR: Runway Visual Range

RWY: Runway

SARPs: Standards and Recommended Practices (ICAO)

SAS: Scandinavian Airlines System

SAAV: “Sistema Aeroportuale di Assistenza al Volo”, ENAV’s airport organization unit

SCT: Scattered, cloud coverage

SEA: “Società Esercizi Aeroportuali”, a corporation delivering handling and other assistance to Malpensa and Linate airports

SHK: Statens Haveri Kommissions; Accident Investigation Board of Sweden

SID: Standard Instrument Departure

SIGMET: Information concerning en route weather phenomenon which may affect the safety of aircraft operation

SLAT: High-lift structural part of aircraft wing

SLOT: Assigned takeoff time

SMGC: Surface Movement Guidance and Control System

SSCVR: Solid State Cockpit Voice Recorder

SSR: Secondary Surveillance Radar

STOP END: Runway end point (for RVR reading)

STW: Stop way

TA: Traffic Advisory, TCAS generated advisory to the pilot

TA: Transition Altitude

T/B/T: “Terra/Bordo/Terra”, Air-ground radio communications

TAF: Terminal Aerodrome Forecast

TDZ: Touch Down Zone, Runway initial point (for RVR reading)

THR: Runway threshold

TMA: Terminal Control Area

TODA: Takeoff Distance Available

TORA: Takeoff Run Available

TRANSPONDER: Airborne equipment allowing secondary radar on ground to identify the specific code of an aircraft

TRI: Type Rating Instructor

TWR: Control Tower

TWY: Taxiway

UCT: “Ufficio Controllo del Traffico”, a section of DCA responsible for traffic documentation, traffic office

UMA: Airport Meteorological Office

UOC: Area ATS control unit

UOP: Peripheral ATS control unit

UTC: Universal Time Coordinated

VRB: Variable

VICTOR: Radio code name for firemen units

VHF: Very High Frequency

VVF: Firemen

Comment

- All times 00.00:00 (hh.mm:ss) reported in this report are UTC (Universal Time Coordinated); event local time, minus two hours.
- Times reported between brackets (00.00:00) indicates elapsed time (hh.mm:ss) starting from aircraft collision time.
- Times reported between square brackets [00.00:00] indicates elapsed time [hh.mm:ss] from notification time to TWR by UCT officer (inspecting the runway) of discovery of the Cessna wreckage.
- In this Report, radio communications transcription are shown in ***Bold and Italics*** character when they refer to the original language used; communications transcription originally in Italian, translated in English will be in *Italics* character only.
- Text that are in ***Bold and Italics*** character represent the actual text reproduction of an original document referenced; text from documents originally in Italian, translated in English will be in *Italics* character only.
- Certain hour reference (time) and text of particular significance will be shown in **Bold** character.
- For an easier understanding of the sequence of events, when radio communications are referenced, the aircraft will be identified by their radio call signs, as follows: the Boeing MD-87, registration marks SE-DMA, will be identified as **SK 686**, while the Cessna will be identified as **D-IEVX**; elsewhere the aircraft will be identified by their make or model type, respectively **Boeing MD-87** (or **MD-87**) and **Cessna 525-A** (or **Cessna**).

CHAPTER I

GENERAL INFORMATION

1. GENERAL INFORMATION

On the 8th of October 2001, at 06.10 UTC, a Boeing MD-87, registration marks SE-DMA operated by SAS, while on takeoff run on runway 36R of Milano Linate airport, **collided** with a Cessna 525-A, registration marks D-IEVX which taxied into the active runway. After the collision the MD-87 continued traveling down the runway, the aircraft was airborne for a short while, and came to a stop **impacting** a baggage handling building. The Cessna 525-A, which was coming from West apron (General Aviation), remained on the runway and was destroyed by post-impact fire.

All occupants of the two aircraft and four ground staff working inside the building suffered fatal injuries. Four more ground staff suffered injuries and burns of various entity.

1.1. HISTORY OF THE EVENT

1.1.1. Aircraft involved

Arrival of the Cessna at Milano Linate.

At 04.54:37 hrs of October 8, 2001, the Cessna, who had originated its flight in Köln (Germany), was approaching Milano Linate airport.

The pilot was in contact with Milano Approach controller on frequency 126.75 MHz and received the following meteorological information: visibility 100 meters, RVR on points A and B 200 meters.

The controller asked the Cessna pilot if he intended to perform an approach to Milano Linate and he was given a positive answer.

At 04.56:15 hrs the pilot of the D-IEVX contacted Linate TWR on frequency 118.1 MHz and reported to be established for final approach on RWY 36R. The controller cleared the pilot for landing and restated the meteorological conditions: *wind calm, general visibility 100 meters with fog, overcast at 100 feet, RVR 175, 200, 225 meters.*

At time 04.59:34 hrs the Cessna landed on RWY 36R at Milano Linate.

The landing run took the aircraft beyond TWY R6 (see attachment A) intersecting with the runway and the crew then requested and obtained permission to backtrack and to taxi on that TWY then to proceed towards the West apron (General Aviation apron).

D-IEVX: *EcoVictorXray on the ground, we could do a short back-track, to turn off to General Aviation.*

The apron for General Aviation is denominated West apron both on AIP Italy and Jeppesen charts. The TWR accepted the request and cleared the aircraft accordingly, instructing the pilot to report runway vacated and when entering TWY R6.

TWR: *DeltaVictor Xray roger, on the ground on the hour, report runway vacated on Romeo 6.*

D-IEVX: *I'll call you on Romeo 6.*

At time 05.01:09 the pilot of the Cessna reported to be entering TWY R6.

D-IEVX: *DeltaVictorXray is entering Romeo 6, now.*

Before his departure from Köln, the crew of the Cessna D-IEVX had forwarded via fax, a flight plan to operate his next flight from Milano Linate to Paris Le Bourget with two passengers on board, for a departure at 05.45 hrs (see attachment B).

One passenger was a Cessna Aircraft employee and the other was a current Cessna Citation owner and a prospective Cessna 525-A customer.

The flight plan filed from the incoming flight reported the instrument (IFR) rating of the crew; allowing ILS CAT I approach down to a minimum visibility of 550 meters.

The MD-87 operating flight SK 686, was scheduled to depart from Milano Linate at 05.35 hrs with destination Copenhagen.

At 05.41:39 hrs, the pilot of the Boeing MD-87 parked on North apron, requested Linate GND on frequency 121.8 MHz for his engine start clearance, as the boarding of 104 passengers had been completed.

The GND cleared the pilot to start engines and advised that the slot time for takeoff of the flight was at 06.16 hrs.

At 05.54:23 hrs, after completing their ground operations, the crew requested taxi clearance.

The GND controller instructed the pilot of flight SK 686 to taxi to RWY 36 ILS CAT III holding position and asked to be advised when the aircraft would enter the main taxiway:

GND: *Scandinavian 686 taxi to the holding position Cat III, QNH 1013 and please call me back entering the main taxiway.*

At 05.58:23 hrs, the Cessna pilot requested start-up clearance to Linate GND on frequency 121.8 MHz, for his programmed flight: Milano Linate – Paris Le Bourget.

The GND cleared the pilot to start engines and informed that the slot time for the flight takeoff was at 06.19 hrs.

D-IEVX: *Linate buongiorno, DeltaIndiaEcoVictorXray, request start up with information Charlie.*

GND: *DeltaIndiaVictorEcoXray...buongiorno. Please speak a bit louder thank you. You are cleared to destination via Saronno 5 Alpha, Arles 8, Alpha transition, 6.000 feet initial climb.*

D-IEVX: *DeltaIndiaEcoVictorXray is cleared to destination, Saronno 5 Alpha, after Argon on 8 Alpha departure, climb initially 6.000...DeltaVictorXray*

GND: *OK Arles 8 Alpha the transition, start up is approved according to the slot 06.19.*

D-IEVX: *Start up is approved according to the slot and confirm Arles 8 Alpha.*

GND: *OK.*

At 05.59:41 hrs GND instructed the pilot of flight SK 686 to contact TWR on frequency 118.1 MHz, when taxiing abeam the fire station.

GND: *...passing the fire station, call TWR 18.1 bye.*

SK 686: *Scandinavian 686, good bye.*

The fire station appearing in the AIP Italy charts was shown on the Jeppesen 20-9 chart as a building (but not labeled “FIRE STATION”) and it was not shown or labeled on the SAS Flight Support charts.

At 06.01:24 hrs the pilot of SK 686 switched frequency to 118.1 MHz and contacted TWR.

Starting from this moment the crew of the Boeing MD-87 and the crew of the Cessna 525-A were tuned on two different assigned VHF radio frequencies.

1.1.2. ATC situation

At the time of the accident the visibility at the airport ranged from 50 to 100 meters.

The Runway Visual Range (RVR) for RWY 36R was about 200 meters with a registered minimum value of 175 meters. The aerodrome operated formally under Category III from time 05.24. During the time interval from 05.10:47 and 06.10:21 (accident time), controllers had assisted 24 aircraft: 21 that taxied out coming from North apron and West apron and 3 more aircraft that had landed. Both English and Italian language were used during these communications.

Considering that each aircraft called more than one time during that time interval just prior to the accident and given the existing meteorological conditions, the workload on both controllers was demanding. They had no possibility to confirm (check) the position reported by aircraft by means of technical aids.

ICAO DOC 9476 defines MEDIUM traffic when up to 25 movements and HEAVY traffic when more than 26 are involved.

When SK 686 passed the fire station and contact with TWR controller was established, SK 686 was number four in the departure sequence.

1.1.3. Aircraft movement on the ground

At 06.05:44 hrs the pilots of the Cessna received the following taxi clearance:

GND: *DeltaVictorXray taxi north via Romeo 5, QNH 1013, call me back at the stop bar of the ... main runway extension.*

The pilot acknowledged by saying:

D-IEVX: *Roger via Romeo 5 and ... 1013, and call you back before reaching main runway.*

Some thirty seconds after this call, at 06.06:23 hrs, the GND controller cleared the aircraft LX-PRA for taxi following the request from the pilot; LX-PRA was also parked on West apron.

GND: *OK RomeoAlpha taxi north Romeo 5, QNH 1013, you must follow a Citation marks DeltaIndiaEcoVictorXray who is also taxiing on Romeo 5. Obviously he is not in sight, and the clearance limit for you is the stop bar of the extension of the main runway on Romeo 5.*

LX-PRA: *We follow the German and the stop of the... on Romeo 5.*

That exchange was spoken in the Italian language and the (German) Cessna pilots may have missed its significance.

An ATA foreman has declared that the Cessna exited from the parking stand following the instructions received from the marshal. There was no recollection among the persons witnessing the taxi out if the Cessna had taxi lights switched on (see attachment C).

Nevertheless it is reasonable to assume that the aircraft had its collision lights ON as required for engine start.

The Cessna started to taxi from the General Aviation parking position; he followed the yellow taxi line and turned to the left passing in front of the ATA terminal building. The aircraft turned again to the left reaching the position where the yellow taxi line splits into two diverging directions: one large radius trajectory to the left, Northwards and one smaller radius to the right, leading South-East.

The Cessna followed the latter (South-East bound) and entered TWY R6. He went by a side stopping area and crossed a runway-holding position marking, ICAO pattern B, that followed a yellow marking indicating **S5** that was clearly visible and oriented towards the approaching aircraft; this marking was located before the intersection of TWY R6 and the southern extension of RWY 18R. After passing that runway extension intersection he continued in the same direction, passing by another side stopping area and another runway-holding position marking, ICAO pattern B, immediately followed by a yellow marking indicating **S4** also easily readable but oriented opposite to the aircraft movement direction.

At 06.08:23 hrs, the pilot of the Cessna, made the following unsolicited position report:

D-IEVX: *DeltaIndiaEchoVictorXray, is approaching Sierra 4.*

At 06.08:28 hrs, GND asked confirmation about the position report:

GND: DeltaIndiaEchoVictorXray confirm your position?

At 06.08:32 hrs, the pilot answered:

D-IEVX: *Approaching the runway ... Sierra 4.*

At 06.08:36 hrs, GND issued the following instruction:

GND: *DeltaVictorXray, Roger maintain the stop bar, I'll call you back.*

To which, at 06.08:40 hrs, the pilot answered:

D-IEVX: *Roger Hold position.*

After about 15 seconds from the end of this last communication, the GND controller asked another aircraft, Air One 937, details about its position using the Italian language:

GND: *AirOne 937 where are you?*

AP 937: *Hmm...we are...on...between the 18 and the Delta.*

GND: *Therefore you are practically in front of the TWR, right?*

AP 937: *Hmm...yes slightly before, slightly before that.*

At 06.09:19 hrs, upon receiving confirmation that the Air One aircraft was on North apron near the beginning of the taxiway parallel to the runway and almost abeam the TWR, the GND controller cleared the Cessna to continue its taxi on the North apron - using the words *main apron* - and to follow the Alpha line (see attachment A).

GND: *DeltaVictorXray continue your taxi on the main apron, follow the Alpha Line.*

At 06.09:28 hrs the pilot answered:

D-IEVX: *Roger continue the taxi in main apron, Alpha Line the...DeltaVictorXray.*

At 06.09:37 hrs the controller replied:

GND: *That is correct and please call me back entering the main taxiway.*

The pilot confirmed, at 06.09:38 hrs:

D-IEVX: *I'll call you on the main taxiway.*

The Cessna continued to taxi on TWY R6. About 180 meters before RWY 18L/36R, there was a third side stopping area, where the aircraft crossed a **STOP** marking white painted on the black asphalt (see attachment D), then crossed the next ICAO pattern B runway-holding marking, yellow painted on the asphalt, (see attachment E), then crossed a unidirectional lighted red lights bar. To the left of this red lights bar a lighted vertical sign was posting the inscription **CAT III**, white painted on red background (see attachment F).

Continuing along his path, immediately before entering the runway, the Cessna crossed another and last runway-holding marking ICAO pattern A, yellow painted on the taxiway asphalt (see attachment E).

The Cessna crossed the runway-holding sign, then entered the active runway 18L/36R following the green lights present on TWY R6 and leading towards the runway centerline.

At 06.09:28 hrs, at the same time of the previous communication from the GND controller to the Cessna on frequency 121.8 MHz, the TWR controller, on frequency 118.1 MHz, while answering a call in Italian from Meridiana 683, added the takeoff clearance to the Boeing MD-87:

TWR: *Meridiana 683, good morning, stand by one. Break-break. Scandinavian 686*

Linate, clear for take off 36, the wind is calm report rolling, when airborne squawk ident.

SK 686 acknowledged promptly and then complied.

SK 686: *Clear for takeoff 36 at when...airborne squawk ident and we are rolling, Scandinavian 686.*

At 06.09:59 hrs the TWR controller replied to a request from another Meridiana flight (IG 893), using the Italian language:

IG 893: *Yes, Meridiana 893, we kindly wanted to know the RVR.*

TWR: *Yes, at the moment we have 225, 200, 175 Alpha, Bravo, Charlie respectively.*

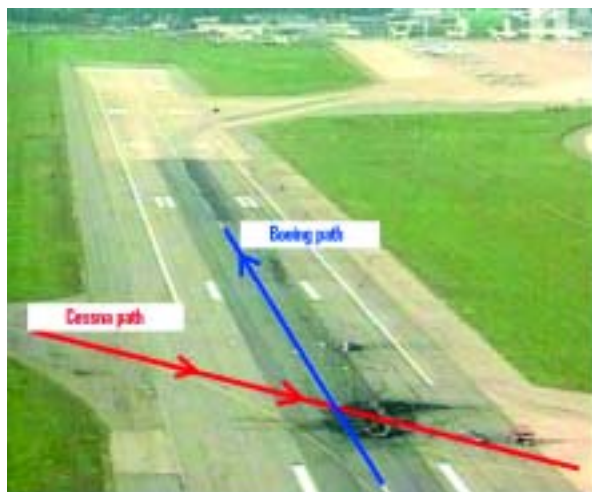
Point Bravo (MID) is at 1.100 meters from runway 36R head.

At the same time, the Cessna entered runway 18L/36R, while, coming from his right hand, the MD-87 was on the takeoff run.

1.1.4. Collision

At **06.10:18** hrs, the ACARS receiving installation, in Copenhagen-Denmark, registered the ACARS takeoff signal transmitted by the equipment installed on the Boeing MD-87.

At **06.10:21** hrs the two aircraft collided.



Photograph 1 - Aircraft trajectories.



Photograph 2 - Boeing MD-87 path after the collision.

At collision time the Cessna was crossing RWY 18L/36R with an estimated heading of 135° ($\pm 10^{\circ}$), while the MD-87, keeping the runway heading, was performing a normal takeoff rotation (see photograph 1).

Approximately one second prior to the collision an additional large elevator nose-up command was registered by the MD-87 DFDR.

It is probable that the flight crew of the MD-87 had a glimpse of the Cessna just prior (0,5 seconds) of the collision; this is suggested by an (unintelligible) exclamation recorded on the CVR. Collision occurred and the NLG of the MD-87 had left the ground and MLG were extending the shock absorbers but the main wheels were still on the ground; IAS was 146 kts (270,5 km/h).

At **06.10:21 hrs (00.00:00)**, an ELT signal lasting 18,6 seconds was recorded at the TWR recording facility.

During less than one second, the two aircraft had a number of contacts before breaking up.

The Cessna was split in three major sections resting 10 to 15 meters apart, which remained on the runway near TWY R2 intersection. The front and mid section were destroyed by after impact fire; the tail portion was not significantly attacked by flames.

At collision the Boeing MD-87 RH MLG leg and the RH engine separated from the fuselage. The pilot of the Boeing MD-87 gradually advanced the throttles and then the aircraft was airborne for a total of 12 seconds, reaching an estimated height of about 35 feet (10,67 meters). The LH engine suffered a noticeable thrust reduction (debris ingestion), instead of the increased power requested by the action of the pilot flying, which became insufficient to sustain flight.

The IAS increased up to (a calculated) 166 kts (307,6 km/h), but the MD-87 descended abruptly making contact with the runway with the LH MLG, the truncated RH MLG leg and the tip of the RH wing. Prior to touch down the pilot reduced engine thrust and after ground contact the engine reverse levers were activated and deployed (on the LH engine only). Maximum available reverse thrust was selected, directional control of the aircraft was attempted and the brakes applied. Such attempts were only partially successful due to the altered geometry and balance of the aircraft and the residual effectiveness of flight controls in combination with the RH wingtip dragging the grass.

1.1.5. MD-87 impact with the baggage building

The aircraft slid over the runway end and sideways to the right, coming to an abrupt stop only 460 meters away from, then came to an impact with the airport baggage building, a baggage sorting and handling area (see photograph 2).

The calculated residual speed at impact was of 139 kts (257,6 km/h).

After the impact, fire was destructive for the building and its contents and part of the MD-87 wreckage.

A few seconds later UCT called TWR on phone number 2730 and informed that they heard a number of bangs; a lengthy exchange but the call was not sufficient to worry the controller. The UCT office was located at about 450 meters and North-East of the baggage building.

06.11:00 (00.00:39)

TWR: *Hello this is TWR.*

UCT: *Yes, hello, listen this is UCT. We heard a number of bangs like an engine that...*

TWR: *Hmm...we heard them too, but we do not know what it was ...*

UCT: *Hmm ... here... now...everything is quiet...*

TWR: *Because here it looks like...it seemed as if somebody was climbing the steps... we did not...*

UCT: *No here it was like an engine increasing... misfiring... but with some energy...*

TWR: *I don't know here it has been as if someone... no, it was as if someone was shaking the head of one of our supervisors against the window. It was a similar sound, a hollow sound, understood... a resounding sound...*

UCT: *that's right... , that is it could have been some...*

TWR: *In fact... useful... however I don't know...*

UCT: *...you don't have ...anything abnormal?*

TWR: *No, nothing.*

UCT: *No because, here, I mean the visibility is zero, I cannot see anything...*

TWR: *Hmm...that's it, here too.*

1.1.6. First alert

Police officer and Customs officer servicing at airport gate known as gate n. 5, at the northern boundary behind the airport baggage handling area, heard an explosion and immediately after, they saw a SEA workman covered with severe burns and many of them still blazing. They immediately tried to assist him and the Police officer used his service radio to inform the airport Police Control Center. The Police operator receiving the call immediately informed the firemen on a phone line that was not recorded.

The Fire Station Control Center - FSCC, has reported that they received the call at around 06.12 hrs, reporting about a rapidly expanding generic fire at the airport baggage handling building,

near gate n. 5.

Two fire fighting vehicles were immediately dispatched from the airport fire station (located inside the airport perimeter); they arrived on the fire scene after having followed an airport peripheral service road (see attachment G).

Subsequently, after another phone call to the FSCC (again no time is available since it was not recorded), which signaled that there was an aircraft involved, four more rescue and fire-fighting vehicles were dispatched. They followed the same airport peripheral service road used by the others.

While the events were unfolding, the TWR controller, who had no knowledge of the events just described, did not identify the MD-87 taking off on the radar screen as he expect (a radar used for take off and landing traffic monitoring by TWR). Consequently he called the ACC to obtain confirmation of the aircraft departure.

06.11:58 (00.01:37)

ACC: *Yes?*

TWR: *Listen, report if the Scandinavian has called.*

ACC: *Which Scandinavian?*

TWR: *686 taking off.*

ACC: *686 Scandinavian, I do not see him.*

TWR: *Neither do we, he disappeared and he does not answer any more.*

ACC: *Really?*

TWR: *Yes.*

ACC: *(...altercation...)...OK.*

TWR: *No. Milano does not have it, not even on radar.*

ACC: *Hmm...(...) (...) (he speaks with someone else there).*

TWR: *I will let you know.*

ACC: *OK thank you.*

The call ended at 06.12:22 hrs (00.02:01).

A few seconds after this call, the pilot of AZ 2023, parked at North apron, gate A15 near the baggage handling building, called GND to report an information received from a ramp agent at 06.12:40 hrs (00.02:19):

AZ 2023: *Listen we are at Alpha 15, behind us we heard a couple of minutes ago three bangs*

sequenced...and...the ramp agent reports that she has seen behind us, at the runway end, a red streak of fire of...some...something...towards...the localizer antenna.

After this communication the alarm signal was activated by TWR. The time of issuance of the alarm is not known since it was not recorded.

The phases that followed are described in paragraph **1.15. SURVIVAL ASPECTS**.

At 07.52:00 hrs (01.42:00), Milano Linate DCA requested ENAV SpA to issue a NOTAM for the closure of the airport to all traffic. The NOTAM was issued at time 07.53:00 (see attachment H).

1.2. INJURIES TO PERSONS

Injuries	Crew	Passengers	Other
Fatal	8	106	4
Serious	0	0	1
Minor/None	0	0	3

1.3. DAMAGE TO AIRCRAFT

Both aircraft were destroyed in the accident.

Remaining wreckages were partially reassembled and kept in a hangar at the Milano Linate airport and have since been seized by judicial Authority.

1.3.1. Boeing MD-87

The MD-87 ended its run hitting the baggage handling building of the air terminal at an estimated speed of 139 kts (257,6 km/h) and was destroyed when it crashed, coming to an instantaneous stop (see photograph 3).

Due to the high speed, estimated at 139 kts (257,6 km/h), the high energy impact of the LH side of the fuselage demolished two pillars of the concrete structure of the building, causing the lintel they were sustaining and part of the roof to collapse on the wreckage that had penetrated the building.

The empennage broke off forward of aft pressure bulkhead when hitting a corner and was stopped outside the building.

The fuselage stopped instantly and the complete wing assembly detached from the fuselage and continued into the building. The fuel contained in the central section and the wings spread and burst into fire. The tip of LH wing broke and slid beyond the left corner of the building without being ingested by fire. The horizontal stabilizer continued to travel further away and finally came to rest on top of the building. LH engine heavily damaged, was located close to the fuselage with the reverse thrust buckets deployed.



Photograph 3 – MD-87 fuselage.

1.3.2. Cessna 525-A

Collision forces split the Cessna into three main sections, 10 to 15 meters apart: wing, empennage/tail cone and cockpit/cabin (see photograph 4).

The empennage/tail cone section, including the fin, was the only one not to sustain significant fire damage. The right engine was in two pieces and was approximately 400 meters North of the main wreckage and laying on the right side of the runway. The wing and cockpit/cabin sections were mostly consumed in the post-collision fire.

The radome and the baggage area of the cockpit/cabin section were totally destroyed by fire but showed no sign of collision damage.

The rear seats of the cabin were consumed by fire.

Both horizontal stabilizers were separated from the empennage



Photograph 4 – The Cessna wreckage on the runway.

and were lying on the runway. The major part of the RH elevator remained connected to the RH stabilizer. The LH stabilizer and elevator showed signs of collision on their lower side.

The LH wing did not show collision damage but it was heavily damaged by fire. Control surfaces of the LH wing were not found.

1.4. OTHER DAMAGE

The surface of runway 36R was carved and scraped by the Boeing MD-87.

The runway surface had scrape marks from the RH MLG piston and other parts of the MD-87 hitting and then skidding towards the airport building.

The Boeing MD-87 RH engine, which separated during the collision, damaged the runway 180 meters beyond collision point and tumbled further away on the RWY.

Other damage to the runway was caused by the post-collision fire of part of the Cessna in proximity of TWY R2.

Impact of the Boeing MD-87 and the post impact fire caused the total destruction of the airport baggage building. Two main pillars were destroyed causing the rafter they sustained to fall over the aircraft wreckage. The airport baggage building, its equipment and all the baggage it contained, were virtually destroyed at impact with the Boeing MD-87 and post impact fire.

1.5. PERSONNEL INFORMATION

The following information is pertinent to the personnel involved.

1.5.1. Pilots

Both aircraft were manned by a two pilot crew.

1.5.1.1. Pilots of the Boeing MD-87

The PIC had been hired by SAS in 1990, ATPL licensed, Captain qualification at SAS since January 1999. His flying experience was matured on DC9-21/41 and in April 2001 he had completed the training and was qualified on Boeing MD-80/88 (which comprises MD-87). He had totaled approximately 6.000 flying hours.

Personal details: male, age 36, Swedish nationality

License:	ATPL		
Type rating:	DC9, DC9-80, MD-88, MD-90 Certificate of radio operator		
Medical:	Class I, expiry date May 02, 2002		
Proficiency check:	May 3, 2001, flight simulator, comment: very high standard		
Flight experience:	5.842 h	on type:	232 h
Last 90 days:	121 h	on type:	121 h
Last 30 days:	52 h	on type:	52 h
Last 24 hrs:	02.46 h	on type:	02.46 h
Pre-accident duty time			
Rest before duty start:	9 hours from arrival of previous flight		
Duty start:	at 04.50 of October 8, 2001		

The co-pilot had been hired by SAS in 1997 with a previous experience of 2.400 flying hours of commercial activity with other Operators and as a flight instructor (basic flight and IFR) with various Flight Schools. He had accumulated about 2.000 flying hours with SAS on type (MD-87).

Personal details:	male, age 36, Swedish nationality		
License:	CPL		
Type rating:	as co-pilot DC9-80, MD-90, Boeing 737, Boeing 727,		
Medical:	Class I, expiry date July 19, 2002		
Proficiency check:	September 4, 2001, flight simulator, comment: above average		
Flight experience:	4.355 h	on type:	1.978 h
Last 90 days:	148 h	on type:	148 h
Last 30 days:	53 h	on type:	53 h
Last 24 hrs:	02.46 h	on type:	02.46 h
Pre-accident duty time			
Rest before duty start:	9 hours from last flight		
Duty time start:	04.50 of October 8, 2001		

1.5.1.2. Pilots of the Cessna 525-A

The PIC had a flight experience of about 5.000 flight hours; most of which flown with private organizations. He had IFR qualification for operations down to ILS CAT I landing minima (minimum visibility/RVR 550 meters and 200 feet DH). No records were found of any specific

training for operations with lower weather minima (takeoff in RVR less than 400 meters). Records show that he had landed five times at Milano-Linate since 1998 (twice on 26.6.1998, then on 30.12.1999, 30.03.2000, 28.08.2000).

Personal details: male, age 36, German nationality
License: CPL
Type rating: Cessna 525 (includes 525-A), PIC, IFR Rating ILS CAT I
Medical: Class II, expiry date 23.04.2003
Proficiency check: June 2, 2001, flight test, Cessna 525 for CAT I
Flight experience: 5.000 h on type: 2.400 h
Last 90 days: 74 h on type: 71h
Last 30 days: 26 h on type: 24 h
Last 24 hrs: 01.10 h on type: 01.10 h
Pre-accident duty time
Rest before duty start: 5 days from last flight
Duty time start: 02.30 of October 8, 2001 (presumed)

The other pilot had totaled 12.000 hours of flight experience, most of it on “executive” aircraft. He had been employed for 10 years as a Captain by Air Evex GmbH of Dusseldorf, a company which operated on demand “executive” air transportation.

His instrument rating qualified him for IFR and ILS CAT I landing operations (minimum visibility/RVR 550 meters and 200 feet DH). No records were found of any specific training for operations with lower weather minima (takeoff in RVR less than 400 meters).

Records show that he had landed seven times at Milano Linate since 1999 (7.1.1999, 11.4.1999, 14.7.1999, 6.2.2000, 10.10.2000, 21.6.2001, 22.6.2001).

Personal details: male, age 64, German nationality
License: ATPL
Type rating: Cessna 500/501, 525 (includes the 525-A), 550/551, 560, LearJet 45
IFR Rating – ILS CAT I
Instructor (FI, IRI, CRI, TRI)
Medical: Class 1, valid with waivers (lenses), expiry date November 28, 2001
Proficiency check: May 30, 2001, flight test, Cessna 525 for ILS CAT I
Flight experience: 12.000 h on type: 2.000 h

Last 90 days:	100 h	on type:	N.A.
Last 30 days:	43 h	on type:	N.A.
Last 24 hrs:	01.10 h	on type:	01.10 h
Pre-accident duty time			
Rest before duty start:	5 days from last flight		
Duty time start:	02.30 of October 8, 2001 (presumed)		

Comment: the operator of the aircraft, Air Evex, was not certified to operate in weather condition lower than CAT I and his crews were not trained to perform landing and take-off below ILS CAT I weather minima.

1.5.1.3. The status of the Milano Linate to Paris Le Bourget flight

The information gathered while conducting the investigation, somehow conflicting, has suggested that a thorough analysis be conducted on the juridical status of the flight operated by the Cessna D-IEVX on the morning of October 8, 2001.

The relevance of that in depth investigation is essential to identify correctly the nature of the flight, either as **private** or as **commercial**; additionally, to ascertain the professional licenses required to operate the flight according to existing regulations.

The documentation found shows that:

- the owner of the aircraft was a private citizen;
- the operator of the aircraft was a company controlled by the same owner of the aircraft;
- the LBA had authorized the company to operate commercial flights with that aircraft, pending issuance of the requested AOC;
- the owner of the aircraft had issued a statement to BFU in which he qualified the above mentioned flight as **private** for the transportation of **business friends**;
- according to the owner, the pilots, who were normally employed by the company he owned, were operating that flight outside their normal duty assignment;
- the aircraft (D-IEVX) and the two pilots were not qualified to conduct ILS CAT II/III approaches and low visibility take off;
- the Cessna 525-A aircraft could be operated by a single pilot, but only for **private** flight;

- one of the two pilots was 36 years old, he was CPL licensed with a class II medical and qualified as PIC of Cessna aircraft series 525; the other pilot was 64 years old, he was ATPL licensed with a class I medical;
- the DCA prescribed that a *Foglio di controllo Control form* should be filed by all departing General Aviation aircraft; at the Milano Linate UCT, the form concerning the flight of the Cessna D-IEVX indicated that the company of the owner of the aircraft was the operator of the flight; the flight was qualified as **private**; the pilot designated as PIC was the younger, while the other pilot (the elder) was designated as co-pilot;
- the flight plan form filed for the flight from Milano Linate to Paris Le Bourget shows that at item 8, the *type of flight* is indicated to be **N**, which defines a *non-scheduled air transport operation*; while for the flight from Köln to Milano Linate the record shows that the *type of flight* is indicated to be **G**, which defines a **general aviation** flight;
- a letter from Cessna Aircraft Company, signed by their sales manager, one of the victims of the accident of October 8, 2001, gives confirmation to the company of the owner of the aircraft Cessna 525-A, D-IEVX, for their need to operate two flights, from Milano Linate to Paris Le Bourget and back to Milano Linate, at an agreed cost to be invoiced to Cessna Aircraft Company (see attachment I).

1.5.2. Cabin crew

The MD-87 had a cabin crew complement of four members. The cabin crew members were qualified and trained in accordance with existing Joint Aviation Authorities (JAA) regulatory requirements.

The Cessna had no cabin crew.

1.5.3. Air Traffic Controllers

At the time of the accident, regulations required the presence of five controllers inside the Control TWR.

- a) Tower shift supervisor controller, CSO;
- b) assistant controller, CA;

- c) reserve controller, Stand-by;
- d) arrival and departure controller, TWR;
- e) Ground controller, GND.

Professional details of the controllers are summarized as follows.

- a) The CSO controller, acting TWR shift supervisor, professional record shows that he became a civil air traffic controller about twenty years ago after having performed the same duties in the Air Force. He had worked about twenty-seven years at the TWR of Milano Linate. In his record there is no indication of any recurrent training taken for the past twenty years.

Personal details:	male, age 53, Italian nationality
License:	air traffic controller TWR controller approach controller TWR shift supervisor controller
Medical:	valid, expiry date May 5, 2002
Professional experience:	27 years at Milano Linate airport
Duty time	
Rest before duty start:	72 h
Duty time start:	06.00 of October 8, 2001

- b) The CA controller professional record shows that he became a civil air traffic controller about twenty years ago after having performed the same duties in the Air Force. He had always worked at the TWR of Milano Linate. He was also qualified as CSO. In his record there is no indication of any recurrent training taken for the past twenty years.

Personal details:	male, age 54, Italian nationality
License:	air traffic controller TWR controller approach controller TWR shift supervisor controller
Medical:	valid, expiry date June 11, 2002
Professional experience:	last 20 years at Milano Linate airport
Duty time	
Rest before duty start:	16 h
Duty time start:	05.00 of October 8, 2001

- c) The Stand-by controller personal professional record shows that he had worked as controller at Lamezia airport for about 2 years and that he had been transferred to Milano Linate in May 1998. He last attended a course for “approach radar area controller” (from March 12, 2001 to April 13, 2001).

Personal details: male, age 34, Italian nationality
License: air traffic controller
aerodrome controller
approach controller
approach area radar controller
Medical: valid, expiry date January 29, 2003
Professional experience: at Milano Linate airport since May 1998
Duty time
Rest before duty start: 10 h
Duty time start: 06.00 of October 8, 2001

- d) The TWR controller professional record shows that he had worked at Milano Linate airport during the previous eleven years. He last attended a course for “aerodrome radar controller” (from Feb 05, 2001 to Mar 03, 2001).

Personal details: male, age 34, Italian nationality
License: air traffic controller
aerodrome controller
approach controller
aerodrome approach radar controller
instructor (theory and practice)
Medical: valid, expiry date March 19, 2003
Professional experience: last 11 years at Milano Linate airport
Duty time
Rest before duty start: 10 h
Duty time start: 06.00 of October 8, 2001

- e) The GND controller professional record shows that he had initially operated for 18 months as TWR controller at Pantelleria airport. From April 1998 he had been transferred to Milano Linate. He had attended a course for “Tower and procedural approach controller” at Milano Linate (from November 22, 1998 to February 02, 1999).

Personal details:	male, age 36, Italian nationality
License:	air traffic controller, aerodrome controller, approach controller
Medical:	valid, expiry date January 24, 2002
Professional experience:	at Milano Linate airport since April 1998
Duty time	
Rest before duty start:	16 h
Duty time start:	05.00 of October 8, 2001

1.5.4. Fire brigade personnel

The fire brigade team on duty was manned as follows:

1 coordinator (head of department)

1 switchboard operator

6 squad leaders

9 firemen

Duty time

Rest before duty start: 48 h

Duty time start: 06.00 of October 8, 2001

The fire brigade working shifts lasted 12 hours and they were organized as follows:

Morning shift: from 06.00 to 18.00 hrs

Rest: 24 h

Next working shift: from 18.00 to 06.00 hrs

Night shift: from 18.00 to 06.00 hrs

Rest: 48 h

Next working shift: from 06.00 to 18.00 hrs

The team that started the working shift at 06.00 on the day of the accident had enjoyed a 48 hours rest time.

1.5.5. Airport Civil Aviation Authority personnel (UCT-DCA)

The DCA officers working shifts were organized in four shifts of duty, as follows:

Morning shift:	06.00 - 11.30	(two officers)
Afternoon shift:	11.15 - 17.30	(two officers)
Late afternoon shift:	17.15 – 22.15	(one or two officers)
Late night shift:	22.15 – 06.15	(one officer)

At accident time, on October 8, 2001, office duties were discharged by one officer (DCA officer 1); she started her working shift at 17.15 hrs the previous day, October 7, and should have terminated duty at 06.15 hrs after having covered two consecutive scheduled duty shifts for 13 hours of continuous duty time. Before this duty time, the rest time from the previous duty had been of 5 hours and 45 minutes. DCA officer 2 was taking charge of the office at 06.00 hrs.

On October 8, 2001, normal duty roster provided for two officers on duty from 06.00 hrs to 11.30 hrs, for that morning shift, but only one of the two officers was present at the start of the shift, and he had enjoyed a rest period of 12 hours and 30 minutes from his previous working shift; the second DCA officer had reported ill and had not been substituted.

At accident time there were two DCA officers present; one of them, having been on duty for 13 hours, was about to end his double shift service, the other was starting his scheduled working shift.

Duty time of DCA officer 1

Rest period before duty time start:	5 h 45'
Duty time start:	17.15 of October 7, 2001

Duty time of DCA officer 2

Rest period before duty time start:	12 h 30'
Duty time start:	06.00 of October 8, 2001

1.5.6. SEA station manager

Rest period before duty time start:	12 h
Duty time start:	04.00 of October 8, 2001

1.5.7. SAS station manager

Rest period before duty time start: leave period

Duty time start: 03.30 October 8, 2001

1.6. AIRCRAFT INFORMATION

1.6.1. The Boeing MD-87

The Boeing MD-87 version 87H, manufactured by McDonnell-Douglas in Long Beach, California USA, was owned by Orbit Leasing International Co. Ltd on lease to Scandinavian Airlines System. The aircraft was certified for a maximum approved passenger seating configuration of 110.

The aircraft was equipped and certified for ILS CAT III-A minima.

1.6.1.1. Administrative information

Registration marks	SE-DMA	
Registration certificate	n. 6082	
Airworthiness certificate	n. 53009	expiry date December 31, 2001
Environmental certificate	n. 53009	
Radio license	n. 685173	expiry date December 31, 2014
Fuselage	n. 1916	
Serial	n. 53009	

1.6.1.2. Technical information

Engines	Engine 1	Engine 2
Pratt&Whitney JT8D 217 C		
Serial number	708149	726036
Total time (hours)	43.219	21.002
Cycles	33.793	17.333
Fuselage		
Total flight time (hours):	25.573	
Total cycles:	16.562	

1.6.1.3. Loading

The following mass distribution was described in available documentation.

The aircraft had a BOW of 36.904 kg and a MTOW of 63.503 kg, with a load of 104 PAX (including 4 CHD) and 1.237 kg of baggage and mail, for a total payload of 10.181 kg. SAS had approval from the Scandinavian CAA's to use other than standard weights. This means that infants weigh 0 kg, children (2 – 12 years) and adults 86 kg for flights within Europe.

The aircraft had been refueled with 10.400 kg for the trip (200 kg were for taxi). Calculated ramp weight was 57.285 kg + 200 kg (see attachment J).

This weight was well below the maximum certified limit of 63.503 kg.

The load distribution had been handled correctly and the MAC, reported on the weight and balance sheet, was 13%, within allowed limits.

1.6.1.4. Performance

The ATOW, runway condition and other weather conditions allowed for a reduced thrust take off technique adoption.

Take-off flap setting was 11°, calculated take off speeds were V1=132 kts, VR=135 kts, V2=144 kts.

1.6.1.5. Maintenance

Maintenance on the aircraft has been documented by the operator as having been carried out at their Maintenance Division in accordance with their JAR 145 approval.

The last programmed periodic maintenance had been performed on September 3, 2001; since then, the aircraft had flown 241 hours. During that period, no maintenance call had been reported that might have had an influence on the events described here.

The last MSC (Maintenance Service Check) had been performed at Oslo (Norway) on Oct 7, 2001. That same day, upon arrival at Milano Linate, the prescribed PFC (Pre Flight Check) had been performed.

1.6.2. The Cessna 525-A

The Cessna, Citation Jet 2, manufactured by Cessna Aircrafts at Wichita, Kansas, USA had been registered in Germany on September 5, 2001 by Air Evex GmbH, Düsseldorf, Germany, with registration marks D-IEVX. Air Evex GmbH, Düsseldorf had requested LBA Germany to regis-

ter the aircraft on its AOC but the formality had not yet been completed.

The aircraft was owned by a German citizen who also owned Air Evex, the operator of the aircraft. The MTOW was 5.613 kg (max ramp weight 5.670 kg) and the maximum passenger carrying capacity 6/7 PAX, plus crew (one or two) and it was certified for ILS CAT I operation.

There were no flight recorders (CVR/FDR) on board; such equipment is not required for aircraft with a MTOW of less than 5.700 kg.

1.6.2.1. Administrative information

Registration marks	D-IEVX	
Registration certificate	n. L 25699	released on September 5, 2001
Airworthiness certificate	n. L 25699	released on September 5, 2001
Noise certificate	n. 15638	released on September 5, 2001
Radio license	n. 12450399	released on September 10, 2001
Insurance certificate	n. ILU 30/570/0810326/240	expiry date May 1st, 2002

1.6.2.2. Technical information

Engines	Engine 1	Engine 2
Williams-Rolls FJ44 2-C		
Serial number	1075	1076
Total time (hours) (*)	28	28
Cycles (*)	20	20

Fuselage	Serial n. 525-A-0036
Total flight time (hours) (*)	28
Total cycles (*)	20

(*) approximate figures

Due to lack of information, flight time, cycles and engines total flight time has been calculated by adding to the time of the CESCO (Aircraft Flight Log) of Oct 2, 2001 the presumed flight time of the flights from Düsseldorf to Köln and from there to Milano Linate (see attachment K).

1.6.2.3. Loading

The ATOW and balance of the aircraft are not known since no specific documentation was found. It is possible to presume that the fuel on board was the amount required for the flight from Milano Linate to Paris Le Bourget; the required fuel quantity, according to the flight plan, would have been at least 2.000 lbs (about 900 Kg).

1.6.2.4. Performance

Not relevant.

1.6.2.5. Maintenance

The aircraft had undergone acceptance checks on August 6, 2001 and subsequent minor maintenance operations are not deemed significant for the events described in this report.

1.7. METEOROLOGICAL INFORMATION

During the time span ranging from 00.20 of October 7, 2001 to 01.50 of the next day, October 8, the meteorological situation for the area considered had been that of a low intensity occlusion and scattered low clouds, moving slowly. From October 7 early morning the weather system coming from North-East at a speed of 4-5 kts, then rotating slowly southwards, so that at 17.20 hrs it was coming from South-East with speeds ranging between 7 and 4 kts.

From time 17.50 hrs onwards, METAR indicated a surface wind variable at 1-2 kts, or nil.

GND temperatures had ranged between 19°C and 17°C, while difference between dew point and actual air temperature had been consistently 1°C, except in seven messages when it had been 2°C.

Until October 7, 2001 at 20.50 hrs the visibility at Linate airport had ranged from a minimum of 1.800 meters to a maximum of 3.500 meters, then stabilizing at this latter value; the next day October 8, (the day of the accident) at 01.50 hrs when a misty condition started to prevail (MIFG was reported at 02.20 hrs), then fog patches appeared (BCFG was reported at 03.20 hrs), then becoming foggy (FG was reported at 04.50 hrs).

Barometric pressure had been close to standard (varying from 1010 to 1013 hPa) then consistently stabilizing at 1013 hPa for the last four reports analyzed.

1.7.1. Terminal Area Forecast - TAF

The weather conditions had been coherent with the forecast.

The TAF for the Milano Linate airport, issued by ENAV SpA valid from 03.00 to 12.00 hrs of October 8, 2001 reported (see attachment L):

080312 VRB 05 KT 2000 BR SCT010 BKN025 TEMPO 0307 0600 -RA FG

The forecast valid from 06.00 to 15.00 hrs of the same day reported:

080615 VRB 05 KT 0200 BCFG BKN 001 BECMG 0710 2000 BKN 010

1.7.2. Meteorological Actual Report - METAR

The METAR for Milano Linate airport the day of the accident had been the following (see attachment L):

The 03.50 hrs METAR reported:

VRB 01KT 0400 R36R/M0900 BCF SCT008 18/1 Q 1012 NOSIG

The 04.20 hrs METAR reported:

0000KT 0200 R36R/0400 VM0650N BCFG BKN001 17/16 Q 1012 NOSIG

The 04.50 hrs METAR reported:

VRB 02KT 0100 R36R/0175N FG OVC001 17/16 Q1013 NOSIG

The 05.20 hrs METAR reported:

0000KT 0050 R36R/0175N FG OVC001 17/16 Q1013 NOSIG

The 05.50 hrs METAR reported:

VRB01KT 0050 R36R/250V0600U FG OVC001 17/16 Q1013 NOSIG

The 06.20 hrs METAR reported:

0000KT 0100 R36R/0225N FG OVC001 17/16 Q1013 NOSIG

Twenty two seconds before aircraft collision, the TWR controller read the following RVR at the request of another aircraft, Meridiana 683:

Yes, at the moment we have 225, 200, 175 respectively at Alpha, Bravo and Charlie.

Comment:

point A (TDZ) is positioned at 300 meters from RWY 36R threshold;

point B (MID) is positioned at 1.100 meters from RWY 36R threshold;

point C (STOP-END) is positioned at 2.010 meters from RWY 36R threshold.

All RVR sensors are located on the right hand side of runway 36R.

The intersection of the centerline of RWY 18L/36R (collision point) and the joining line of TWY R6 and TWY R2 and is at approximately 1.500 meters from RWY 36R threshold.

1.7.3. Automatic Terminal Information Service - ATIS

The ATIS (see attachment L) are normally based on observations (met reports) carried out at half hour intervals and they are broadcasted a few minutes later; occasionally other special observations are carried out and determine a new ATIS broadcast.

The ATIS broadcast of 04.50 hrs reported the observation of time 04.42 hrs, it read:

Info Zulu, wind var 02 KTS, visibility 0100 meters, present weather fog overcast 100 ft, temperatures 17/16, QNH 1013, trend NOSIG, runway in use 36 Right. Thunderstorm activity forecast between SRN-LIME-COD-VOG-SRN, top of CB 7500 meters, moderate to severe turbulence.

The ATIS issued at 05.20 hrs reported the observation of time 05.12 hrs, it read:

Info Alpha, no wind, visibility 0050 meters, present weather fog, overcast 100 ft, temperatures 17/16, QNH 1013, trend NOSIG, runway in use 36 Right. Thunderstorm activity forecast between SRN-LIME-COD-VOG-SRN, top of CB 7500 meters, moderate to severe turbulence. ATC CAT III procedure in operation. Report to Milano Arrival category of approach.

At time 05.24 hrs another ATIS *Information Alpha* and at 05.25 hrs an *Information Bravo* were broadcasted, containing the same information of the broadcast issued at time 05.20 hrs.

The ATIS issued at 05.50 hrs reported the observation of time 05.43 hrs, it read:

Info Charlie, wind var/01 KT, visibility 0050 meters, present weather fog overcast 100 ft, temperatures 17/16, QNH 1013, trend NOSIG, runway in use 36 Right. Thunderstorm activity forecast between SRN-LIME-COD-VOG-SRN, top of CB 7500 meters, moderate to severe turbulence. ATC CAT III procedure in operation. Report to Milano Arrival category of approach.

The ATIS issued at 06.20 hrs, *Information Delta* reported the observation of time 06.12 hrs, it read:

Info Delta, no wind, visibility 0100 meters, present weather fog overcast 100 ft, temperatures 17/16, QNH 1013, trend NOSIG, runway in use 36 Right. Thunderstorm activity forecast between SRN-LIME-COD-VOG-SRN, top of CB 7500 meters, moderate to severe turbulence. ATC CAT III procedure in operation. Report to Milano Arrival category of approach.

1.7.4. RVR readings for RWY 36R

RVR readings were recorded every five minutes. The recorded data of TDZ point RVR of time 06.10 shows an increase to 2.000 meters, from the 220 meters value recorded at 06.05 hrs, presumably due to the jet blast of the MD-87 engines taking-off, then drops again to 250 meters at the 06.20 hrs reading value.

At MID point, the recorded data shows an increase in the RVR to 700 meters at time 06.15 hrs, from the 200 meters reading of 06.10 hrs, the collision time, presumably due to the fire developing on the Cessna wreckage (see attachment L).

1.8. AIDS TO NAVIGATION

For information on markings, signs and visual aids, see paragraph **1.10. AERODROME INFORMATION.**

1.9. COMMUNICATIONS

The GND controller (121.8 MHz) had been in contact with eleven aircraft during the time interval from 05.54:23 hrs, when the MD-87 requested taxi clearance from gate number 13, to 06.10:21 hrs, collision time: SK 686, LX-PRA, I-DEAS, I-LUBI, D-IEVX, AP 937, AZ 2021, OS 222, Sirio 0051, AZ 1278, AZ 2010.

During those 15 minutes and 58 seconds he managed 126 radio communications.

The TWR controller (181.1 MHz), had been in contact with the following six aircraft, from 05.58:43 to 06.10:21 hrs (collision time): AZ 226, AZ 2019, AZ 410, SK 686, I-LUBI, AZ 2010 and with another aircraft IG 683 who was inquiring about the runway visibility conditions.

During those 11 minutes and 38 seconds he managed 73 radio communications.

Significant communications contained in this report is either in their original language (***Bold and Italics text***) or they have been translated in English (*Italics text*).

1.9.1. ATC-GND communications, frequency 121.8 MHz

Transcripts of RT communications that took place on GND frequency from time 05.00:55 to 06.12:27 of October 8, 2001, are attached to this report (see attachment M).

The transcription of RT communications recorded on GND on October 7, 2001, from time

08.15:15 to 19.19:35 hrs and on October 8, 2001, from time 03.46:09 and 06.06:20 hrs, are also attached to this report have been grouped by call sign, to allow an easier understanding and analysis of the phraseology used by the controllers.

Other, selected communications containing mainly taxi instructions and issued on GND frequency to aircraft cleared to taxi via TWY R5 and TWY R6, are contained in a separate attachment (see attachment O).

1.9.2. ATC-TWR communications, frequency 118.1 MHz

A copy of the entire RT communications transcripts that took place on TWR frequency from time 04.56:15 to 06.10:33 on October 8, 2001, is attached to this report.

(see attachment P)

1.9.3. Telephone communications

Similarly, transcripts of telephone communications are made available in this report, (see attachment Q). These are phone calls exchanged to/from ENAV telephone at extensions 230, 231, 2282; SEA telephone at extension 2730; direct line telephone communications from TWR to/from ARO, ACC, FIC, FLUSSO, VVF, DCA.

All phone calls to/from TWR were recorded and time stamped.

Phone calls to/from FSCC were not recorded, therefore not available, except those to/from TWR.

1.9.4. Service radio communications, frequency 440.450 MHz

Transcripts of service radio communications, from time 05.10:57 to time 06.51:00 hrs on October 8, 2001 are also made available in this report (See attachment R).

The airport emergency plan made provision for a dedicated radio frequency (440.450 MHz) for usage by selected users who were identified and listed in the plan; these communications were recorded at the TWR. The firemen and their field units made use of a different dedicated frequency (73.950 MHz – channel 20); such communications were not subject to recording.

TWR did not have access to that dedicated frequency and could not receive or transmit through that channel.

1.9.5. Communications comparison

Transcripts of all communications in their chronological order are made available in this report; from time 06.02:34 to time 06.59:15 on October 8, 2001 (see attachment S).

1.10. AERODROME INFORMATION

Following World War II, Linate airport was adequate to handle the air traffic volume of that time. Aircraft movement of Commercial and General Aviation was handled separately using two runways. In the mid-sixties the section of TWY R6 that presently joins the threshold of runway 36L with runway 18L/36R did not exist (see attachment T).

Later on, when TWY R6 was completed and it became usable, General Aviation, which had been confined to the usage of RWY 18R/36L, taxiways R5 and R6 and West apron, started to use RWY 18L/36R, the taxiway East of (and parallel to) that runway and the North apron which had so far been in use mainly by Commercial traffic. Initially only few aircraft used both areas and their movement was easily controllable.

General Aviation traffic was mainly regional and domestic; over the time, this may have created a culture of familiarity between the local air traffic controllers and the pilots.

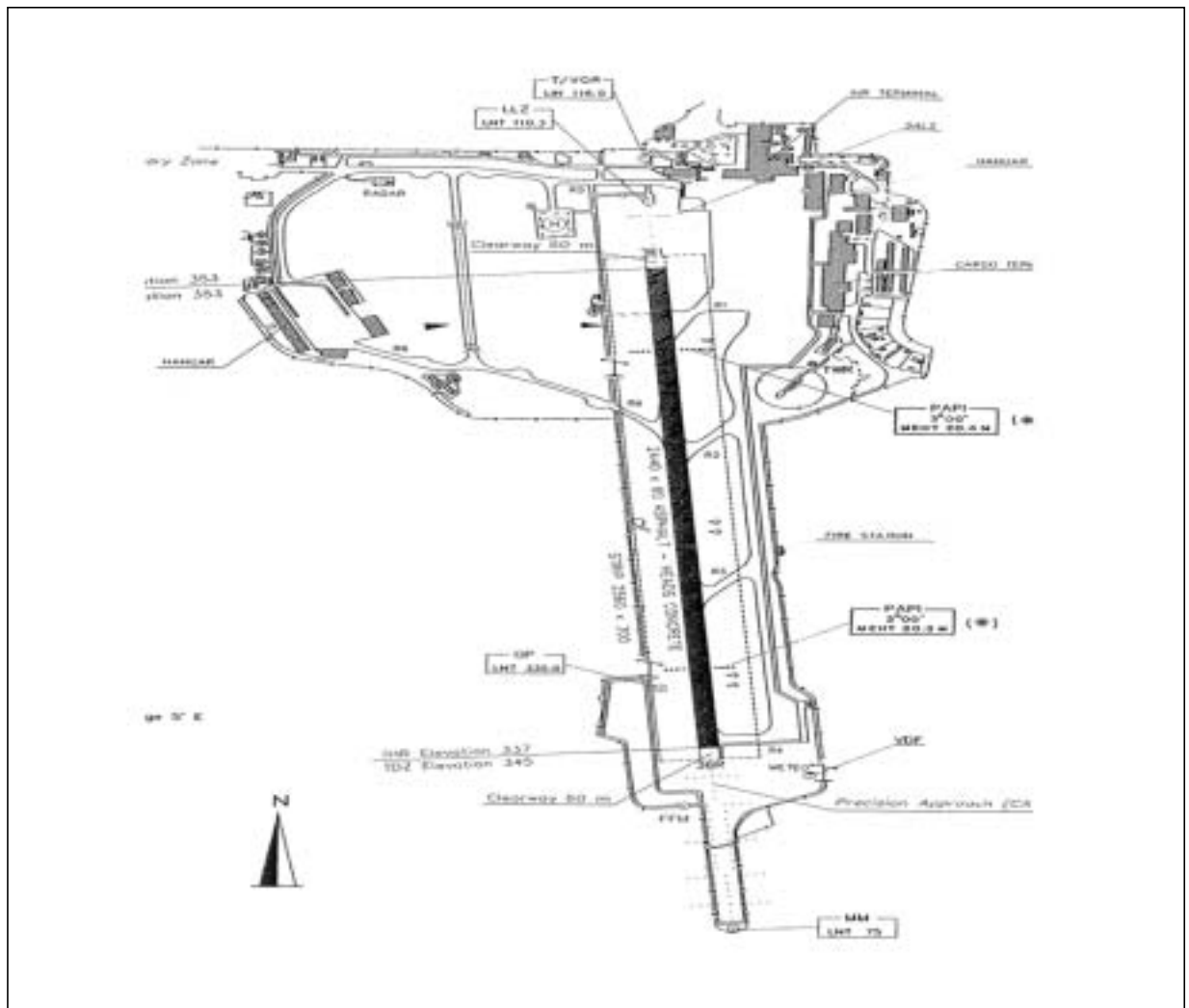
Gradually the performance of aircraft used by General Aviation became similar to that of Commercial aircraft and frequently required the use of runway 18L/36R.

This did not happen rapidly but took place gradually over the time and in parallel with equipment and traffic volume; such traffic increase also gradually involved more international flights. While the airport has been subject to this evolution no adequate action was taken to adapt to the new operational needs. While the North apron and the taxiway parallel to and East of RWY 18L/36R have been subject to upgrade in order to match ICAO requirements in terms of signage and ground movement management, the West apron, RWY 18R/36L, TWY R5 and TWY R6 have not been updated and were not consistently upgraded.

The investigation has recognized a wide deficiency in the state of implementation and maintenance of airport standard signage.

Within the competence of this investigation, a complete assessment of the operational status of Milano Linate airport has been conducted by the Swedish Aviation Safety Authority (Luftfartsverket), as requested by SHK. The audit was conducted in two separate surveys on November 28, 2001 and March 14, 2002. The full audit report is attached to this report and has been timely sent to ENAC for any pertaining action ensuing (see attachment A).

1.10.1. Milano Linate airport



This map was drawn from AIP Italy current the day of the accident (see attachment A).

This paragraph describes the physical situation of the Milano Linate airport at the time of the accident. The Linate airport is located 4.32 NM East-Southeast of Milano (geographic coordinates: 45°27'01" North and 09°16'46" East).

The airport elevation is 353 feet AMSL.

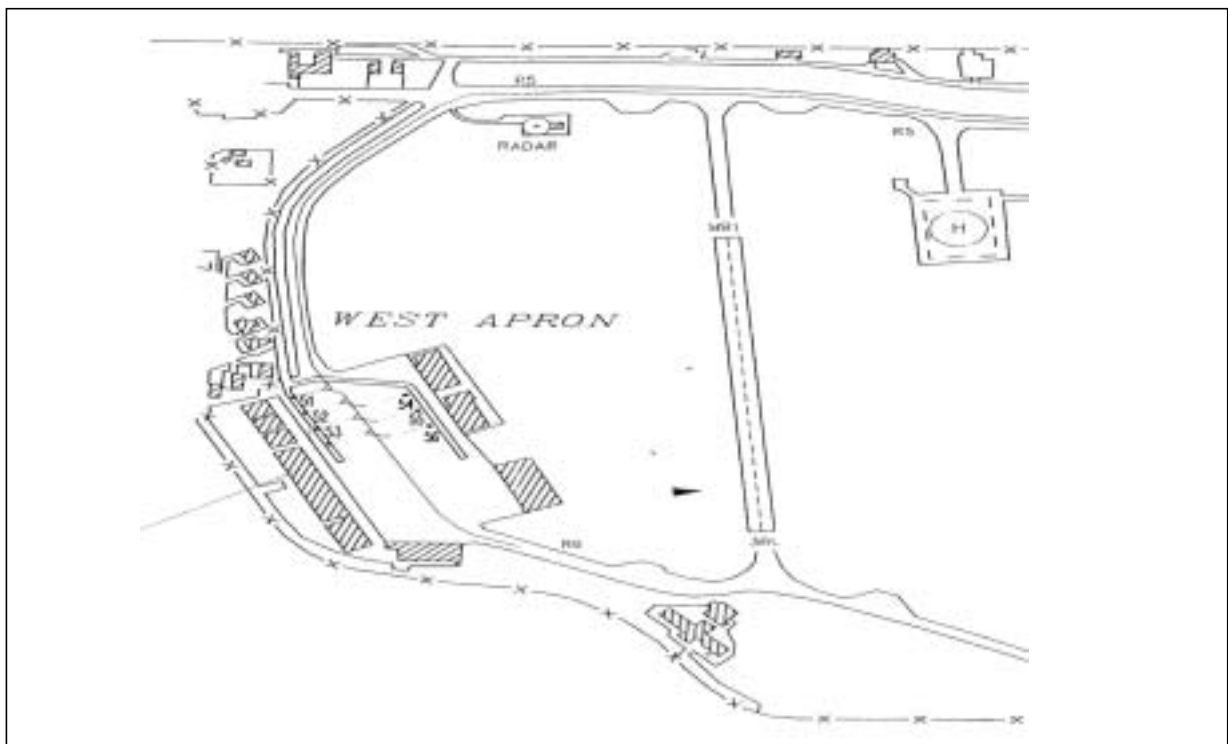
Milano Linate operates as international and domestic airport and is used for commercial and general aviation traffic.

The airport has two parallel runways, oriented at 176°/356°: 18L/36R commonly referred to as the *Pista principale* (Main runway) and 18R/36L used and referred to as *Pista turistica* (Tourist runway) or (General Aviation runway).

Runway 18L/36R is 2.440 meters long and 60 meters wide and 36R is certified for ILS CAT

I/II/III operations. The threshold elevation of runway 36R is 338 feet (103,02 meters); the threshold elevation of runway 18L is 353 feet (107,59 meters). There is a difference of 15 feet (4,57 meters) between the thresholds of runway 18L and 36R, which creates a positive slope for RWY 36R. Runway 18R/36L is 600 meters long and 31 meters wide and is only suitable for small general aviation aircraft traffic. The two runways are serviced by two distinct aprons referred to in official documentation (AIP Italy) as: North apron (*Piazzale Nord*) and West apron (*Piazzale Ovest*). Parallel and East of the runway system, a taxiway usually referred to as **Main taxiway** runs parallel from North apron along the runway's full length (there was no specific reference to it available on any official document). That taxiway connects with RWY 18L/36R through four intersecting taxiways. Clockwise, starting from the North, the taxiways are denominated R1, R2, R3 and R4. Continuing clockwise, the next taxiway (intersecting runway 18L/36R) is denominated R6 and connects the runway to the Southern end of the West apron, after intersecting the Southern extension of Runway 18R. At the North end of the West apron, TWY R5 connects the West apron to the North apron after intersecting a taxiway (without specific denomination) that connects to a Military Air Force area and the (Northern) extensions of runways 36L then 36R. The expression "Main runway extension" was not defined in AIP Italy.

1.10.2. West apron



West apron: this map was drawn from AIP Italy current at the date of the accident (the picture is deformed).

A yellow taxi line runs for the whole length of the West apron (joining TWY R5 and TWY R6 centerlines). Along the sides of that taxi line there were six parking stands numbered from 51 to 56, regularly marked by lead-in yellow lines as indicated on the map. The parking stands were North of a refueling station, which was not reported on any official map or document. South of the refueling station there were another six parking positions each with a lead-in yellow line (orthogonal to the central taxi line); they were not marked (no numbering identification). The six parking stands faced a hangar of ATA. These lines all lead to a further yellow line (parallel to the central taxi line) which continued turning South-East so as to join with the central taxi line. The yellow taxi line just described, lead aircraft southerly then easterly to a position where it was possible to continue either towards TWY R5, leaving the West apron towards the North or towards TWY R6, leaving the West apron towards South-East (see photograph 5).



Photograph 5 - Taxiway selection for TWY R5 or TWY R6.

At the branching where the line parted there were markings painted in yellow showing R5 and R6 respectively, to the left of each line. The characters painting was worn out and they did not conform to the color, form or proportions as described in ICAO (Annex 14, Chapter 5.2.16.4.b and appendix 3 and/or 4).



Photograph 6
Marking showing direction TWY R5.



Photograph 7
Marking showing direction TWY R5.

Where the yellow taxi line curved (at the split), the markings were positioned to the left of the lines and on a slanted angle from the pilot viewpoint (see photographs 6 and 7).

The R6 horizontal yellow marking was the only identification available from that position and through the entire length of the TWY R6 to its end where it intersects runway 18L/36R; there were no other indications, markings or signs, identifying TWY R6 throughout its entire length.

The yellow line leading towards South-East was partially worn out and it had been intermittently covered with black paint (to cover an old path that had been modified), thus resulting in a non-uniform line (see photograph 8).



Photograph 8 – Discontinued path marking.

The taxi path shown on Jeppesen charts was not reproducing the effective yellow taxi lines set up as existing at accident time (see attachment U).

Taxiway R5 and R6 had green lights center line for their entire length. The taxiway center lights started for both TWY R5 and TWY R6 upon exiting the apron. The first TWY R6 light was at about 80 meters from the split R5-R6. The closest TWY R5 light was at about 350 meters from the split R5-R6. The yellow line that turned to the left (Northbound, towards TWY R5) had no green lights all across the West apron.

The lead-in yellow lines for the numbered parking stands were duly reported in official maps (AIP Italy), while the yellow taxi lines of the stands without identification numbering were not reported. All yellow taxi lines on the West apron did not have green lights.

1.10.2.1. Unofficial markings S1, S2, S4, S5, S5

Early in 1996, to cater for an expected commercial demand (traffic increase), a study had been conducted to allow the usage of an additional number of parking stands on the West apron by light commercial aircraft (narrow body aircraft) that would normally park on the North apron. A specific meeting was called on March 13, 1996 with the participation of DCA, ENAV, SEA and ATA to verify and agree on the necessary steps to be taken to complete the project (see attachment V).

It was agreed that it was necessary to adopt a number of measures and therefore they were listed in a document:

REPORT OF THE MEETING HELD ON MARCH 13, 1996.

Subject: Aircraft movement management on apron.

Some of the measures contained in the report were implemented and duly reported in official charts (AIP Italy), such as the numbering of parking stands from 51 to 56 and the realignment of the West apron main taxi centerline. Some other of the measures listed had been implemented but their implementation was not reflected in official documentation, namely the S1 and S2 markings on TWY R5; and similarly the S4 and S5 markings on TWY R6 (see photographs 9 and 10). As for the S3 marking (according to the project that was never officially implemented) it should have been in North apron area, but, instead a second S5 marking was present there. Finally, other measures listed in the report were never implemented, such as the runway length signs for RWY 36L at TWY R6 intersection and a traffic light to serve Military Air Force traffic on TWY R5.



Photograph 9 - S4 marking and ICAO pattern B runway - holding.



Photograph 10 - S5 marking and ICAO pattern B runway - holding.

No documentation was found signaling the existence of/or regulating the operational intended meaning of such S1-S5 markings and of their position. No documentation has been found instructing SEA to enforce the decision and to activate the placement (painting) of the markings.

The following statement pertaining to the report of the before mentioned meeting, was offered by a controller:

...after the accident, I casually found a document titled REPORT OF THE MEETING HELD ON MARCH 13, 1996 , in a book-case situated at the first floor of the Control TWR building offices, while I was performing a non routine check and ordering of unused documents...

The controller further declared that he assembled in a folder and ordered a number of documents pertaining with TWR operations. The statement contains the following text:

...the document mentioned, related to the March 13, 1996 meeting, was not available in the TWR control room the day of the accident...

(See attachment W)

All controllers interviewed declared that they were not aware of such markings.

(See attachment X)

The report also made mention of the necessity to move one of the parking stands because of its proximity with the petrol station (these views were also forwarded to the Milano Province competent Firemen office). AIP Italy made no mention about the petrol station and therefore it was not reported on the West apron charts.

From November 1998 a number of flight slots were transferred from Milano Linate to Milano Malpensa. Consequently a significant reduction in flights involving Milano Linate took place, from 15.000 movements to 8.000 per month (see attachment Y); therefore the necessity to transfer parking stands allocation from the North apron to the West apron did not materialize. However, the now un-necessary markings S1, S2, S4 and the two S5 markings remained in place (as previously described), unused and ignored by official documentation.

1.10.2.2. Taxiway R5

Taxiway R5 was provided with a yellow center guideline with green lights for its entire length, from the Northern end of the West apron until the entrance at the North apron. At the first bend towards East a white taxiway guideline coming from the military area joined the centerline and was also provided with lights.

Taxiing clockwise along R5 from the West apron, the following situation was present along the taxiway:

- a) a vertical illuminated direction sign with the indication **R5->** in red on black background to the left of the taxiway; at the time of accident the sign was partly hidden by tall grass and difficult to read (see photograph 11);
- b) before the extension of the RWY 36L and immediately before a small apron on the side a marking with runway-holding position, ICAO pattern B, marked **S1**, with one part on each side of the yellow center guideline;
- c) before the extension of RWY 36L centerline and immediately after the small apron on the side, a marking with runway-holding position, ICAO pattern A;
- d) past the extension of the RWY 36L and immediately before a second small apron on the side, a marking with runway-holding position, ICAO pattern A, turned opposite to the taxi direction;
- e) immediately after the second small apron on the side, a marking with runway-holding position, ICAO pattern B, marked **S2** with one part on each side of the yellow center guideline and turned opposite to the taxi direction;
- f) before the extension of RWY 36R, there was a bar with unidirectional yellow lights, followed by a marking indicating “STOP” in white characters which was associated with a runway-holding position, ICAO pattern B;
- g) after the extension of RWY 36R and immediately before the entrance to the North apron, another bar with unidirectional yellow lights turned opposite the direction of taxi and without any graphic indication.

Taxiing from the North apron towards TWY R5, a vertical non illuminating location sign showed the indication **5** in black on red background to the left of the taxiway. This sign was partially covered with tall grass growing in front of it (see photograph 12).



Photograph 11 - Location sign at TWY R5 entrance (exiting West apron).



Photograph 12 - Location sign at TWY R5 entrance (exiting North apron).

1.10.2.3. Taxiway R6

Taxiway R6, was provided with a yellow center guideline and green lights for its entire length, from the South-East end of the West apron until the entrance of RWY 18L/36R.

Taxiing counter clockwise along TWY R6 coming from the West apron the following situation was present along the taxiway:

- a) before the extension of RWY 18R and immediately before a small apron on the side a marking with runway-holding position, ICAO pattern B, marked **S5**, with one part on each side of the center guideline;
- b) past the Southern extension of RWY 18R and immediately after a second small apron on the side, a marking with runway-holding position, ICAO pattern B, marked **S4** with one part on each side of the center guideline and turned opposite to taxi direction;
- c) approximately 180 meters before the entrance into RWY 18L/36R and in connection with a third small apron on the side, a marking with runway-holding position, ICAO pattern B together with a



Photograph 13 – CAT III vertical sign on TWY R6.

- bar with unidirectional red lights, preceded by a white line across, with the word **STOP**;
- d) close to the unidirectional red lights bar there was the only vertical sign displayed on the entire length of TWY R6; a single illuminated vertical sign with the indication **CAT III**, white text on red background, to the left of the taxiway positioned left of the runway-holding position sign (see photograph 13);
 - e) immediately before RWY 18L/36R a marking with runway-holding position, ICAO pattern A, without any graphic indication.

Comment

- There was no identification signage for TWY R6 for its whole length.
- During the survey conducted by the investigating team, an unused structure very similar to the one holding the **R5** sign was found; coming from the West apron the structure was at the beginning and left of the TWY; it was not possible to find information about the removal of the sign it held.
- AIP Italy made mention of “white alternate flash light indicators” (described in Jeppesen charts as “flashing white lights”) situated at RWY 36R exit at taxiway R1 and R6 entrance; in reality, the lights had been removed since October 19, 1992 when the following set up was implemented: installation of unidirectional green taxiway center lights towards the runway (TWY-->RWY direction) and of unidirectional (color coded) yellow-green lead-in lights from the runway to the taxiway was implemented (RWY-->TWY direction). At the same location an electronic anti incursion device was in place but it was not functioning since it had been deactivated (see attachment Z).
- On December 1998 the electrical switches individually controlling the lights of the bars at R1 and R6 had been deactivated, therefore all bars remained permanently lighted irrespective of visual conditions (see attachment AA).

1.10.2.4. The path followed by the Cessna 525-A

On the morning of October 8, 2001, the Cessna encountered the following scenario upon starting his taxi, after having received the taxi clearance from GND controller:

- a) the yellow taxi lines that the aircraft followed when leaving their parking positions were sufficiently visible but did not indicate the parking number;
- b) the yellow taxi lines were not as reported in AIP Italy and Jeppesen charts;

- c) the alphanumeric markings at the partition point, were the yellow line exited the parking position in front the ATA hangar, leading to R5 or R6, were not in conformity with ICAO Annex 14 (Chapter 5.2.16.4.b);
- d) the markings were partially worn and positioned at an angle (slanted) from the pilots' perspective, they could be confused with each other;



Photograph 14 - West apron aerial photograph (lower side).

- e) there was no vertical signage supporting the horizontal markings;
- f) South of RWY 18R, on TWY R6, the two horizontal markings **S4** and **S5** with holding-position markings ICAO pattern B, were not shown in AIP Italy or in the Jeppesen charts;
- g) before entering into RWY 18L/36R, there was a white **STOP** marking on the taxiway; this position was not identified in AIP Italy or Jeppesen charts; further on, towards RWY 36R, it was followed by a yellow holding-position marking ICAO pattern A, then by a unidirectional and permanently lit red lights bar and finally, to the left of that bar an illuminated vertical sign (white characters on red background) signaling **CAT III**;
- h) the **STOP** sign was not ICAO standard;
- i) the red bar lights on TWY R6 were not controllable by ATC since 1998, therefore they were permanently left lighted (ON) irrespective of time and visual conditions; ICAO Doc 4444 states: *Stop Bars shall be switched on to indicate that all traffic shall stop and switched off to indicate that traffic may proceed*;

- j) along with the lights bar on TWY R6, in proximity of RWY 18L/36R, there had been an associated anti incursion sensors system; evidence shows that it had been deactivated in 1998; no evidence has been found as to the reasons and the decision for the deactivation;
- k) the centerline green lights of taxiways were not divided by sectors and they were not controllable by ATC; they could either be all ON or all OFF;
- l) the white flashing lights at the intersection of TWY R6 with the RWY 18L/36R had been deactivated since October 19, 1992 when the installation of the exit yellow/green unidirectional lights from RWY 36R towards TWY R6 was implemented;
- m) on West apron, at the R5/R6 split of the yellow line exiting the parking position in front of the ATA hangar, the first green centerline light of TWY R6, was at a distance of 80 meters;
- n) from that same partition point R5/R6, the yellow line leading (northerly) towards TWY R5 through the West apron had no green lights embedded; the first green centerline of TWY R5 was at a distance of 350 meters from the split;
- o) at the split, the partition R5/R6 marking of the yellow line exiting from the parking position in front the ATA hangar, was the only identifying signal available for TWY R6 from that position and for the entire length of TWY R6 itself.

1.10.3. Charts and maps

All documentation described in this report was current the day of the accident.

1.10.3.1. Aeronautical Information Publication – AIP Italy

The official documents for Italian airports are published in the AIP Italy. These documents are published by ENAV and contain all rules, regulations and aerodrome information as issued by ENAC and ENAV.

Aerodrome publications are used to distribute the information necessary to the pilots for the aircraft ground movements from the parking position to the runway and vice versa, in accordance with ICAO standards. They should indicate all the aprons with their relevant horizontal markings, the parking positions, the taxiways with their existing signs, the location of the holding positions and the STOP BARS and should be conforming with ICAO Annex 14.

Permanent NOTAM are also included in this manual.

Attached is the set of Milano Linate airport AIP Italy (see attachment A) and other documentation current on October 8, 2001:

- **AERODROME CHART ICAO**, AGA 2-25.5 dated February 25, 1999;
- **AIRCRAFT PARKING/DOCKING CHART**, AGA 2-25.7 dated January 29, 1998;
- **PROVISIONS FOR GENERAL AVIATION ACFT**, AGA 2-25.3 dated April 22, 1999, a document containing general rules: **PROVISIONS FOR GENERAL AVIATION ACFT** contained rules that were not solely applicable to General Aviation aircraft but also to Commercial aircraft and **SPECIAL RULES FOR TWY USE**.

Comparison of the content of that documentation with the operational practice commonly adopted shows a number of noteworthy deformities:

- some instructions were not adopted consistently by operators - see **a)** below;
- other were lacking the necessary precision, hence leading to possible misunderstandings, - see **a)** and **b)** below;
- some other did not match the (de facto) current airport layout signage - see **c)**, **e)**, **f)**, **g)** and **h)** below;
- other were conflicting with other Orders - see **d)** below.

Namely, procedures to be followed and described in the **PROVISION FOR GENERAL AVIATION ACFT** paragraph, stated (the following reported text is exact the AIP Italy wording repetition):

- a) **Aircrafts to/from Linate West (ATA) will be stopped by TWR at the Stop signal on TWYL R6.**

The instruction for aircraft taxiing to/from West apron, required stopping at the **Stop signal** existing on TWY R6 (non ICAO standard marking).

Moreover, AIP Italy documentation did not show the position of that **Stop signal**.

Upon issuing that specific instruction, controllers did not use the wording **Stop signal**, (**segnale di stop** in Italian) as indicated in AIP Italy, but commonly referred to as **Stop bar**, (**barra di arresto** in Italian) in similarity with the Order n. 35/97 (paragraph. 2.10.6.6.), which required to stop aircrafts at the **Stop bar** (**barra di arresto** in Italian) of TWY R5.

According to the wording used in the official documents referenced, (AIP Italy, Orders) **Stop signal** (**segnale di stop** in Italian) was the required wording to be used for TWY R6 and **Stop bar** (**barra di arresto** in Italian) was the required wording to be used on TWY R5.

Controllers consistently used the wording **Stop bar** for both TWY R5 and TWY R6 stopping positions.

Moreover, pilots were routinely instructed to cross such **Stop signal/Stop bar** while the lights were ON, since there was no selective switching capability by ATC.

b) ***TWYL R2 and R3 must be not used.***

This instruction clearly forbid to taxi on the taxiways R2 and R3.

c) ***ACFT landed in Category III must report RWY 36R vacated to TWR, using TWYL R1 – R6 when have passed white alternate flash light indicators which are designated in each side of TWYL.***

The “white alternate flash light indicators” at TWY R1 and TWY R6 had been removed when the installation of alternate yellow-green lights took place in October 19, 1992, to mark the exit from the runway and the entrance into TWY R6. The deactivation (removal) of “white alternate flash light indicators” had not been reported in AIP Italy or in any NOTAM although notification had been requested by SEA (see attachment Z).

Paragraph ***SPECIAL RULES FOR TWY USE*** stated:

d) ***According to Provision N.42/1693/A3/4.1 dated 5/11/97 of CAA any aircraft prior to taxi on the stretch of TWYL R5 located along the extended RCL RWY 36R shall request and obtain specific ATC authorization.***

The information, contained in the above paragraph under the title of *Rules for taxiways use*, did not mention the *Stop bar* prescribed in Order 35/97.

e) ***Taxing allowed on main taxiway only.***

The ***AIRCRAFT PARKING DOCKING CHART*** reported the denomination of the North apron and West apron, as well that of taxiways R1, R2, R3, R4, R6 and R5 and the numbering of parking positions of North apron and West apron (only part of them for the West apron). It did not denominate taxi lines within the aprons. The taxiway parallel to runway 18L/36R (East of the runway) was not identified by a specific code name (denomination); it was generally referred to by ATC and pilots as the **Main taxiway**.

Moreover the (de facto) airport layout signage did not match AIP Italy description.

f) ***Markings: S1, S2, S4, S5, S5.***

None of the charts available in AIP Italy identified the yellow markings S1, S2, S4, S5, S5.

g) ***Taxi-lines on the North apron.***

Taxi-lines on North apron had no denomination.

Evidence shows that previous and superseded versions of AIP Italy maps (1997) showed the existence of taxi lines identified with the letters A, B, C and D. Subsequent to the new publication, documentation available shows that ENAV (AIS Directorate General) had requested comments for competence to DCA Linate about the *new taxi and parking charts*; the reply from DCA suggested amendments but made no mention of the missing taxi-lines denomination. There is also evidence of a letter from ENAV, dated April 26, 2001, requesting ENAC to *...denominate Alpha, Bravo, Charlie and Delta the taxi-lines of the North apron* (see attachment AB). At accident time such request had not been accepted but controllers and pilots commonly used the old denomination **Alpha line** during taxi related communications.

h) ***Taxi-lines on the West apron.***

Taxi-lines on West apron did not match the AIP Italy description. Some yellow lines were worn out and some had been painted over with black paint; evidence was found of paths that had been cancelled and modified (see attachments A and U).

Finally, concerning aircraft movement to and from the West Apron it is possible to summarize that the specific documentation did not correspond to the actual airport layout and/or lacked information about:

- parking positions in the southern part of the West apron;
- taxiway guidelines from the parking positions;
- signs for the runway-holding positions S1 and S2 on taxiway R5;
- signs for the runway-holding position, ICAO pattern "A";
- presence of non standard Stop bar on taxiways R5 and R6;
- names of the taxiway guidelines at the North apron;
- signs for the runway-holding position S3 (marked S5) on the North apron;
- signs for the runway-holding position S4 and S5 on taxiway R6;
- signs for the runway-position, ICAO pattern "A", on taxiway R6.

(See attachment U)

1.10.3.2. Jeppesen charts

Jeppesen is an international company that produces aeronautical charts of navigation based on source information acquired from different nations including AIP Italy; they are in use by many Italian and foreign operators.

According to JAA regulations (JAR OPS 1.1040): *An Operator shall ensure that the Operations Manual contains all instructions and information necessary for operations personnel to perform their duties.*

Air Evex had a subscription to the Jeppesen ERM04 Airway Manual addressed attn: D-IEVX, Flughafen Halle 3, 51147 Köln-Bonn, Germany. This is the manual for Europe, which includes the navigation charts for the Milano Linate airport. It is presumable that the crew were using the Jeppesen charts in effect at the time of the accident.

The Jeppesen charts for Milano Linate current the day of the accident, contained information derived from AIP Italy with few minor differences:

- a) on the parking/docking chart (Plate 20-9B dated June 2001) the taxiway that runs parallel and close to runway 18L/36R was denominated "A" for a portion between the North apron and the intersection with TWY R2; AIP Italy did not report any denomination for that portion of the taxiway;
- b) on TWY R1 and R6, before entering the runway, charts indicated the position of two flashing white lights; the position of the flashing white lights was not shown in the AIP Italy maps, but was only described in the AIP Italy airport information pages **PROVISIONS FOR GENERAL AVIATION ACFT** AGA 2.25.3;
- c) the Fire Station was shown on the aerodrome charts but not labeled as Fire Station;
- d) Jeppesen charts did not report the instructions contained in the relevant paragraph of **SPECIAL RULES FOR TWY USE**, of AIP Italy airport information pages which stated:

According to Provision n. 42/1693/A3/4.1 dated 5/11/97 of CAA any aircraft prior to taxi on the stretch of TWYL R5 located along the extended RCL RWY 36R shall request and obtain specific ATC authorization.

(See attachments A and AC)

1.10.3.3. SAS Flight Support documentation

The SAS crew was using Aerodrome charts published by SAS Flight Support, containing information taken from AIP Italy.

According to JAA regulations (JAR OPS 1.1040): “An Operator shall ensure that the Operations Manual contains all instructions and information necessary for operations personnel to perform their duties”.

The SAS Flight Support documentation contained information taken from AIP Italy with few minor differences:

- a) the Parking chart showed TWY R6 in a different position than the official AIP Italy maps (minor discrepancy);
- b) the Aerodrome chart did not report the position of the fire station;
- c) the North apron chart area showed taxi lines (A,B,C and D) which were not reported on AIP Italy maps valid at accident time.

(See attachment AD)

1.10.4. Aerodrome Surface Movement Indicator - ASMI

Aircraft ground movement control is very important to assure an orderly and speedy flow of traffic, in order to keep to a minimum the penalisation imposed by Low Visibility Operation procedures. ASMI radar is a valuable equipment to verify traffic separation on the movement area of the airport.

Milano Linate had been equipped with ASMI radar for many years for ground movement assistance in low visibility conditions. Due to its analogue technology design some shortcomings and limitations rendered it inadequate to sustain the rapid increase in traffic developed in 1997 (it suffered from interferences, reliability record, low definition especially West of runway 36R).

From the end of 1994, because of the poor reliability of the system in place, ENAV (at that time AAVTAG) had planned installation of a new radar system, type *NOVA 9000 SMGCS*, integrated with a video camera with infrared beams for the control and guidance of aerodrome ground movements.

The project was approved by all interested parties on March 30, 1995. Then the project implementation was subject to the approval by Air Navigation Service of DGAC of the antenna location.

The answer from the Air Navigation Service of DGAC came on April 3, 1995 with a denial, **de**

facto stalling the operation. Along with other comments, the reply letter (see attachment AE) objected that:

- a) *only minimal advantages would be offered by the antenna placement and installation (the same advantages could be achieved by the installation of two stop bars);*
- b) *negative psychological impact would be suffered by pilots because of the addition of an obstacle in low visibility conditions and not;*
- c) *absence of reported difficulties in handling of ground traffic since the linearity of the traffic scheme at Milano Linate;*
- d) *that the pylon sustaining the equipment would be temporary, until when the radar would be relocated at the new TWR, as provided by the new regulating plan;*
- e) *the ASMI will still be operating.*

The same document indicated that:

In general terms, it is the opinion of the this office, that domestic plans involving investments should take into account the harmonization and integration now taking place at European level so as to avoid the acquisition of equipment that would become obsolete in view of the rapid technological development in this area.

While it is not possible to comment on a) ad b) it is inevitable to recall the runway collision occurred in 1980 when an Alitalia aircraft collided with a General Aviation aircraft entering the active runway from TWY R6.

The ASMI was called out of service on November 29, 1999 with NOTAM n. 4880 (see attachment H). Later, in July 2000, ENAC who had substituted DGAC cleared the project with the sole amendment that the radar antenna would be placed at the same location of the ASMI radar antenna now being dismantled.

At accident time the installation had been suspended for technical reasons (hardware stored for a lengthy time had to be serviced).

Three days before the accident NOTAM 1 A 4557/2001 stated:

VALIDITY FROM 2001 10 05 1000 TO 2001 12 31 2300 EST PERM AND RADAR ASMI OUT OF SERVICE REF AIP COM 2-20.

This NOTAM was the last in an uninterrupted sequence started on November 29, 1999; they all reported the same inefficiency.

1.10.5. The baggage building

The baggage handling area of Linate airport was located in a building attached to the West of the main air terminal building, where TWY R5 enters the North apron, 460 meters beyond the RWY 36R end and 50 meters East of the RWY centerline extension; at the North-western limit of the North apron (see attachment A).

The building was built in accordance with the Transportation Ministry, DGAC, airport Department, Unit 21, construction criteria and was approved on October 3, 1991. The approved construction project was in accordance with existing regulation with regard to obstacle clearance; however, six years later, ENAV recognized that the structure infringed on the obstacle limitation surface (by 1 meter) and a suitable obstacle lighting system (red lights) was installed. The position of the building, although in accordance with existing norms, has been decisive in absorbing the sudden and violent impact of the Boeing MD-87.

1.10.6. ATC Organization and associated procedures

Milano Linate airport ATC was organized in accordance with the operational procedures as detailed in the following set of official documents:

AIP Italy, AIC, NOTAM, OdS, IPI manual published Linate CAV (March 6, 2000), DOP 2/97 issued by ENAV (February 4, 2000), the manual *Airport Emergency and Accident Procedures manual Norme e procedure per stati di emergenza e di incidente*, issued by DCA, in Order n. 4/89 (July 13, 1989), ENAC Deliberation n. 18/99.

AIP Italy specified in RAC 1-1 GENERAL that:

...rules and procedures applicable in Italian air space..., conform with ICAO Annex 2 and 11, DOC 7030 and applicable parts of DOC 4444.

DOP 2/97 specifically referenced:

DOC 9476 AN 927 – SMGCS (Manual of Surface Movement Guidance and Control System) and, *DOC 9365 AN 910 – Manual of All-Weather Operations.*

IPI manual specified that procedures and general rules to be adopted are described in:

DOC 4444, Annex 2, 3 and 11.

Considering the conspicuous amount of documents referred, for an easier consultation and analysis, it was deemed useful to group them by subject and summarize them in the following paragraphs:

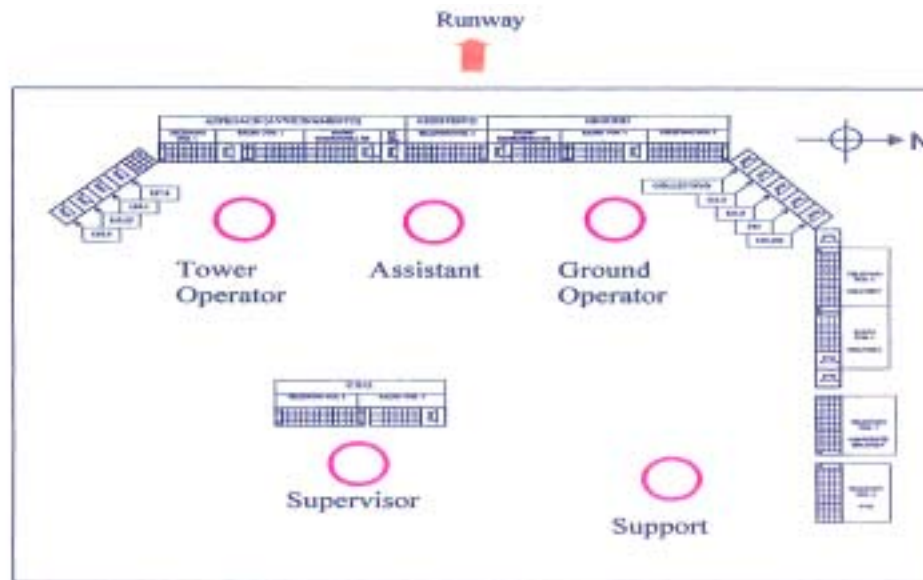
- 1.10.6.1. ATC organization;
- 1.10.6.2. IPI general instructions; (March 6, 2000);
- 1.10.6.3. ENAV, Service Order 35/97 (TWY R5 and TWY R6 taxiing procedures) (November 7, 1997);
- 1.10.6.4. Low visibility operations rules: ENAV, document DOP 2/97 (February 2, 2000); ICAO, Doc 9476-AN/927; DCA Orders 2/85 (November 29, 1985), 2/92 (November 10, 1992), 2/94 (November 29, 1994);
- 1.10.6.5. Airport Emergency and Accident Procedures - DCA Order 4/89 (July 13, 1989);
- 1.10.6.6. Emergency exercises;
- 1.10.6.7. Directives to ensure inspections as prescribed by articles 801 and 802 of the Italian Code of Navigation; ENAC Deliberation n. 18/99 (DCA Linate ref. N. 3743 of November 10, 1999 and DCA Linate ref. N. 3744 of November 10, 1999).

1.10.6.1. ATC Organization

In year 2000, Milano/Linate aerodrome had approximately 300 movements per day during wintertime. During summertime the number of movements per day was around 400.

Runway 36R was normally in use and it was equipped with ILS CAT III-B approach landing system, which means that aircraft could perform landing when Runway Visual Range (RVR) was at a minimum of 75 meters.

In the aerodrome TWR there were four controller positions, and a fifth relief position. Three positions were side by side and facing the maneuver area; two more positions were, the fourth amid the room while the fifth was in the back; they were to be manned as follows, starting from the three facing the maneuver area (as depicted in the following chart):



Milano Linate Tower - Station layout and controllers' position distribution (picture is deformed).

The controllers occupying the positions were:

- 1) a TWR controller, was responsible for runway-in-use and also departing and arriving airborne aircraft;
- 2) a GND controller was responsible for movements on taxiways, start up and departure clearance as per flight plan;
- 3) a controller was responsible for the coordination of the communications with Milano Area Control Center (ACC), ARO and DCA;
- 4) a CSO - shift supervisor controller - who was the head of the team; the supervisor position was amid the room;
- 5) a fifth controller was present, to assist as needed under CSO instruction, in relief for the front positions in case of operational needs.

1.10.6.2. General instructions for controllers – IPI manual

In addition to the documents described in previous paragraphs, below is a list with a summary of the main duties of each controller function as defined in the IPI (Internal Permanent Instructions) manual published on March 6, 2000.

CSO, the shift supervisor controller:

- is responsible for the quality and regularity of the operations;

- enforces the operative duty standards, seeing to the regularity in the enforcement of these;
- is responsible for the technical/operational management of the TWR;
- according to his competence he sees to the implementation of appropriate coordinated operation as far as particular events are;
- changes the configuration of the TWR according to the traffic.

CTA, the TWR controller:

- controls all the IFR and VFR traffic within the CTR;
- carries out all operations applying ATC regulations;
- puts into practice the planning prepared by the Shift Supervisor (CSO);
- activates the light switch of the sensitive areas (R1, R6).

CTA, the GND controller:

- regulates the traffic of aircraft, vehicles and persons in the maneuver area;
- transmits to departing aircraft the pre-take-off data;
- transmits to departing aircraft the departure clearance and restrictions applying;
- transmits ATIS in case of malfunction of the automatic system.

CTA, the assistant controller (AC) acting as coordinator:

- assists the CTA, TWR and GND with telephone coordination with other Air Traffic Control units (Milano Arrival, Milano ACC);
- maintains connection with the ARO for General Aviation and VFR flights schedules;
- carries out the necessary coordination with the DCA, ARO and all other aerodrome organizations when needed.

Chapter 9 of IPI detailed the procedures to be adopted to ensure the safety of operations during ILS CAT II/III approaches and for departures.

In the general instructions section of the IPI manual, it was specified that the provisions contained in DOP ENAV 2/97 were to be implemented even if not explicitly reported in the IPI.

The same document stated that:

- *safety of CAT II/III operations depended heavily on the integrity of ILS system, more so than for CAT I operations.*
- *The CTA (controller) was responsible to convey to the pilots accurate and updated informa-*

tion on the status of ground facilities and weather information. The sole responsibility of the Controller was to inform about the type of operations in progress at the airport, after careful analysis of the deficiency list for the system. The decision as to which type of category of operation to conduct, CAT I, II or III was the sole responsibility of the Pilot-in-command.

In addition to the tasks mentioned, here is a list of other provisions covering operations in low visibility conditions:

CSO, the shift supervisor area or responsibility:

- inform DCA of the actual reduced visibility and await for approval before initiating the required procedures;
- inform Milano Arrivals on the actual LVP in force;
- monitor, through contacts with the responsible units, the appropriate measures adopted for the existing weather conditions;
- modify the category of LVP operations according to the information forwarded to him by DCA pertaining the functionality of the system;
- ascertain that the CAT II, CAT III *in progress* message was properly included in the current ATIS;
- issue the required NOTAM when asked by DCA;
- inform pilots of intervening malfunctions or degradation within the system that could affect landing minima;
- register time of activation/deactivation of LVP operations on the daily log.

CTA, TWR Controller, area or responsibility:

- issue proper instructions to aircraft taxiing at holding positions CAT II/III;
- ascertain that TWY R2 and TWY R3 were not to be used;
- ask confirmation that runway had been vacated and at the crossing of the flashing white lights;
- operate the control of the Stop bars and stop lights at the Holding point of 36R;
- take the necessary steps in case of malfunction of ASMI and aerodrome radar (CDS 1000).

There was a specific clarification comment:

The Controller does not have the right or the competence to verify the status of applicability to the aircraft or the pilots for the type of operation to be conducted or requested by the pilots. The competent Authority to check for the status of applicability of licenses, with respect to LVP, is ENAC.

1.10.6.3. ENAV Order 35/97

The Order was the consequence of a pilot report occurred many years back. While taking off from RWY 36R, the pilot observed an aircraft crossing at what appeared to him to be the runway end; as a matter of fact an aircraft was taxiing along TWY R5 well behind RWY 36R end. Because of the optical effect the pilot judged that the aircraft might be on the runway and he precautionary rejected take off.

The Order mandated for:

In order to ensure, that during takeoffs from Runway 36R and landings on Runway 18L, no aircraft or other vehicle is present on the portion of taxiway 5 corresponding to the extension of Runway 36R, the TWR shall instruct traffic taxiing on R5 to stop at the Stop bar before the crossing.

This instruction was normally issued by the controller, but, in low visibility conditions, when the pilot taking off would not be able to see the crossing aircraft, occasionally it was not implemented by the controller.

1.10.6.4. Low Visibility Procedures

ENAV document DOP 2/97

The document issued by ENAV technical department, DOP 2/97, stated that pursuant to other regulations and deliberations and in accordance with ICAO DOC 9476-AN/927, (see following point 2), the procedures to be adopted at Italian airports not equipped with operational ASMI radar, were as described in chapter IV, Low Visibility Operations.

When a deterioration or malfunction of radio aids occurs at an airport, certain limitations are imposed to normal operations:

- in some instances, the airport category class can be downgraded (i.e. a failure in the lighting system may result in day operations only);
- in other cases, operations can continue, but weather minima are affected (i.e. in the case of radio aids and other lighting malfunctions);
- when the ground surface movement radar becomes unusable, specific procedures can be enforced that do not encroach on the category of operation of the airport, but limit significantly the number of movements permitted.

DOP 2/97 listed three conditions of visibility for Low Visibility Operations, for airports not equipped with ASMI radar, to regulate the movement of aircraft and other vehicles on the maneuver area.

Visibility 1 conditions, visibility sufficient to taxi and avoid collision with other aircraft/vehicles on TWY and intersections by direct visual observation, and for ATC operators to exercise visual control of all such traffic.

Visibility 2 conditions, visibility sufficient to taxi and avoid collision with other aircraft/vehicles on TWY and intersections by direct visual observation, but insufficient for ATC operators to exercise visual control of all such traffic.

Visibility 3 conditions, visibility not sufficient for pilots to taxi autonomously and for ATC operators to exercise visual control of all such traffic.

For the *Visibility 3 conditions*, the same requirement was applicable as for *Visibility 2 conditions*, with an additional restriction; departing traffic could be cleared to start taxiing, with or without the assistance of a FOLLOW-ME, only when:

- any landing aircraft had already reported to be steady at his assigned parking bay;
- any departing traffic ahead of him had already taken off.

The only comment that mentioned the present visibility conditions on October 8 early morning was made by the pilot of flight AZ 300 who stated, at 05.09:32 hrs, one hour before the accident; he informed that he observed a vehicle moving nearby his aircraft while he was waiting at RWY 36R holding position; the pilot had addressed the TWR with the following statement:

Just to know that there is somebody circulating around... since visibility is low...

The information does not significantly suggest that transition to *Visibility 3 conditions* was to be considered; even taking into account that there was a comment on the procedure description for *Visibility 2 conditions* that read:

the procedures described above shall be implemented with due caution, as much as the situation will require.

The decision to switch to (assess, then declare) a *Visibility 3 condition* was problematic, because of the following:

- 1) the information available to the pilots did not inform about the above mentioned procedure governing LVO (contained in DOP 22/97);
- 2) pilots were not aware that the transition to the procedures required for *visibility 3 conditions*

would depend from their assessment of the visibility during taxi (from a “pilot report”);

- 3) the assessment of the expression *visibility not sufficient for pilots to taxi autonomously* is found to be most generic, subjective and dependent from undefined variables.

The procedure was subsequently amended by ENAC two weeks after the accident with document n. 3333/AIA of October 22, 2001; the amendment to DOP 2/97 confirms that the previous evaluation and assessment criteria was inadequate.

The amending text stated:

Chapter IV paragraph 4.1 conditions of visibility 3: substitute:

visibility which is not sufficient for the pilots to taxi autonomously...

with the words:

RVR visibility of 400 meters or less.

Subsequently, a month after the accident, Milano Linate airport Director issued Order n. 104/01 of November 9, 2001, to additionally specify that:

Article 1. The following procedures shall be adopted at Milano Linate airport for the ground movement of aircrafts, in low visibility conditions:

a) with ground surface radar functioning...

b) without ground radar functioning... (...omissis...)

Specifically, for item *b) without ground radar functioning...* at paragraph 10, it read:

10. with visibility less than 200 meters (read at one of the points A, B, or C), only one movement at a time shall be allowed on the movement area with the assistance of the Follow-me.

Another Order from the airport Director followed, on November 14, 2001, n. 105/01, specifying further:

Article 1: point 10 of article 1 is modified as follows:

with visibility of 150 meters RVR or less (read at one of the points A,B, or C) only one movement at a time shall be allowed on the movement area, with the assistance of the Follow-me.

ICAO DOC 9476-AN/927

ICAO DOC 9476-AN/927, introduction to paragraph 1.4, read:

The SMGC system depends primarily upon two operational conditions. They are:

a) the visibility condition.

b) the traffic density.

At page 1-2 paragraph 1.6 it stated:

The main reason is to enable an aerodrome to operate safely in the intended conditions. The system should be designed to prevent collision between aircrafts...

It is necessary to point out that the wording of DOP 2/97 (and all other Orders and amendments that followed) and DOC ICAO 9476-AN/927 valid the day of the accident, which was referenced in DOP 2/97, differed significantly.

Precisely, in ICAO DOC 9476-AN/927, visibility conditions were not conditioned solely by the absence of a radar, as stated in ENAV DOP 2/97, but they were linked to the efficiency of an SMGCS, the radar being only one of the components. The ICAO document, in addition to considerations regarding ASMI radar efficiency, further gave guidelines for LVO implementation based on airport traffic density and SMGCS components state of efficiency.

Specifically, ICAO DOC 9476 stated:

a) Table 2-1, page 2-1

Table 2-1 Visibility and traffic conditions associated with SMCG systems - Explanation of terms.

b) In paragraph “**Visibility conditions**”, page 2-1, point 3:

Visibility less than 400 m RVR (low visibility operations).

The paragraph that follows shows the table of required correspondence between the traffic density definition and the actual number of hourly movements:

TRAFFIC DENSITY

Light: not greater than 15 movements per runway...

Medium: of the order of 16 to 25 movements per runway...

Heavy: of the order of 26 or more movements per runway...

The document then listed the basic equipment required and in page 2-3, table 2-2, it specified the necessary system complement for the SMGCS.

In particular, here is a list of equipment (systems) required for **traffic density Light** (less than 15 movements per hour) in visibility 3 condition, namely with visibility less than 400 meters:

- ***clearance bars,***
- ***stop bars,***

- *establishment of standard taxi routes,*
- *use of radiotelephony procedures and phraseology,*
- *operation of lighting aids,*
- *selective switching of stop bar.*

To operate in visibility 3 condition, namely with visibility less than 400 meters, in a traffic density defined as *traffic density Medium* (between 16 and 25 movements per hour) the list of equipment (systems) required would be adjusted with the addition of:

- *monitoring of surface movement radar SMR,*
- *selective switching of taxiway center line lights.*

DCA Orders 2/85, 2/92, 2/94

The above mentioned Orders, issued on November 29, 1985, November 10, 1992 and November 29, 1994 current when the accident occurred, mandated norms for the safety of ILS CAT II/III operations.

The following extracts from DCA Order 2/85 and current the date of the accident is of some relevance.

Article 4

This article specifies the procedure to be enforced for the notification of ILS CAT II/III operations beginning and end.

UCT shall signal via a dedicated automatic system the beginning and the ending of such operations (CAT II/III) to the fire station, Sanitary Service, Electrical Power Plant, UMA, Safety officer of SEA. The receiving Offices will confirm reception, by means of the same automatic system, selectively activating the dedicated switch (for CAT II or CAT III, as will be the case), to confirm reception.

Article 5

This article specifies the placement of the fire fighting squad equipment; it did not specify the minimum number of vehicles (equipment) to be used and manned.

During CAT III operation, the fire station shall position the fire fighting vehicles (equipment) outside of the Station and the same will be manned continuously.

Article 7

This article spells a generic indication lacking any specific reference to which STOP position was implied or to its location.

During CAT II/III operations, taxiing aircrafts to/from West apron shall be mandated by TWR to stop at the Stop sign at taxiways R5 and R6.

Article 7 was subsequently modified by airport Director Order on January 25, 1986:

As a partial modification to Order, Art. 7, and the provision therein contained, in case of CAT II/III operation, aircrafts coming from ATA should be stopped only at the Stop situated on taxiway R6 and not as erroneously indicated in Art. 7, also at the Stop on taxiway R5.

Article 11

This article spells instruction on the usage of the white flashing lights that were removed on October 19, 1992. No evidence was found of any subsequent Order that mentions their removal (deactivation).

Aircrafts landing in CAT II/III on RWY 36R and vacating the runway at taxiways R1 and R6 shall inform the TWR when they have crossed by the alternating flashing white lights siding those taxiways.

(See attachment Z)

1.10.6.5. Airport norms and procedures for emergency and accident - DCA Order 4/89

The Manual *Norme e procedure per stati di emergenza e di incidente*, Norms and Procedures to be adopted for emergencies and accidents, containing norms current the day of the accident, was based on the Milano Linate DCA Order 4/89 issued by the airport director and dated July 13, 1989.

The document listed:

- definitions;
- summaries of ICAO prescriptions;
- radio call signs;
- telephone/radio contacts;
- general instructions;
- procedures for emergency conditions;

- procedures for accidents inside of the airport perimeter;
- procedures for accidents outside of the airport perimeter;
- attachments.

When comparing the documentation describing the procedures to be followed in case of accident against the unwinding of events, the following deformities emerge:

Page 4/89-18 *Authorised Organisations*

Paragraph 3

DCA and TWR are the only organisations authorised to declare and enforce emergency and accident state.

Moreover, any person or organisation who has notice of a circumstance leading to an emergency or accident, has the obligation to immediately inform UCT who will then act in accordance to sections 1, 2 or 3.

The emergency procedure enforced the day of the event, on October 8, 2001, was initiated by a phone call from the State Police operations center to the fire station, without regard to the aforementioned provision.

Page 4/89-20 *Radio/telephone black out*

Paragraph 7

Radio/telephone black-out was not enforced; evidence acquired show that on the contrary a significant number of calls have been received by TWR.

06.13:03 ARO (direct line)

06.13:46 FLUSSO (direct line)

06.17:10 SEA n. 2730 (SAS) (internal line)

06.18:45 AEROLOGICA (direct line)

06.18:59 ENAV n. 231 (internal line)

06.20:47 ENAV n. 230 Alitalia (internal line)

06.21:48 SEA n. 2730 AirOne (internal line)

06.22:25 SEA n. 2730 (internal line)

06.23:21 SEA n. 2730 Iberia (internal line)

06.24:02 ARO (direct line)
06.25:36 ENAV n. 231 (direct line)
06.25:59 ENAV n. 231 (direct line)
06.27:48 ENAV n. 231 (direct line)
06.27:51 SEA n. 2730 KLM (internal line)
06.31:35 FLUSSO (direct line)
06.36:15 VITROCISSET n. 2282 (internal line)
06.37:45 FLUSSO (direct line)
06.40:46 SEA n. 2730 British Airways (internal line)
06.49:35 FIC (direct line)

Many of the calls listed here were not justified by any operational need but they required and absorbed some attention from TWR personnel.

What follows is a list of failures to adhere to prescribed obligations under the plan covered in this section.

Page 4/89-31 TWR

Paragraph 2.1.2

- TWR did not receive the required information from UCT;
- TWR did not relay to the fire station essential information as required by the Emergency plan (time, accident location, type of aircraft);
- TWR could not relay other pertinent information, in absence of info provided by UCT, to fire station (PAX number, crew, fuel, dangerous goods).

Page 4/89-33 fire station

Paragraph 2.2.2

After initiating rescue operations, did not notify to UTC of the number of fire fighting equipment in use, an assessment of the gravity of accident and a request for more rescue equipment.

Comment: at 06.40 hrs, five aircraft LX-PRA, I-DEAS, AZ 2021, AP 937 and I-LUBI were still on movement area with engines running.

Page 4/89-36 UCT

Paragraph 2.4.1

The following prescribed procedure was not enforced:

Command position activation... a representative of each unit (Organisation) will reunite at UTC offices...

Paragraph 2.4.2

Did not relay to Tower information about PAX, crew member, estimated fuel and dangerous goods on board aircrafts involved.

There was a prescription to make use of a specific map enclosed in the published emergency procedure as *attachment n. 1* to locate and identify unambiguously the position of an occurrence. That map (*attachment n. 1*) was never used. It was based on a coordinates grid that would have helped to guide rescuers to any specific airport position and avoid misunderstanding with TWR. Actions were carried out guided by personal initiative (self initiative of individuals) instead of in application to the instructions listed in the current plan.

It was further found that the day of the event the map site description differed from the actual site configuration:

- the airport topographic plan showed prior to page 1 of the plan booklet was not current with the correct AIP Italy description;
- West apron was denominated General Aviation;
- North apron had no denomination;
- some buildings were not reported;
- at page 11 a table summarizing the call signs to be used gave no indication (in the pertinent paragraph: *firemen*) to specify the unit of the Fire brigade and associated call sign, assigned to maintain radio communication with TWR;
- the call sign Victor 10 was reserved for a so called ***Torretta Distaccamento*** (the best translation of which would be *Detachment Turret*); that denomination does not seem to be indicative enough for the function represented by the FSCC (control centre).

Evidence of the following amendments to the DCA Order 4/89 has been found:

December 7, 1989	maps
March 16, 1994	attachment 1 and 2
(? ?,)1995	(undetermined)
January 15, 1996	radio and telephone links

The above documents of March 16, 1994 (attachment 1 and 2) failed to report the identifying denomination for operational airport movement area currently used (see attachment AF).

ENAV, SEA and fire station have no record of having received the above-mentioned amendments. It was not possible to determine the cause for their missed reception.

1.10.6.6. Emergency exercises

ICAO Annex 14, Paragraph 9.1.12, required the scheduling of an *Aerodrome emergency exercise* to be conducted according to specific and detailed instructions.

The plan shall contain procedures for periodic testing of the adequacy of the plan and for reviewing the results in order to improve its effectiveness.

Note: The plan includes all participating agencies and associated equipment.

The plan shall be tested by conducting:

- a) a full-scale aerodrome emergency exercise at intervals not exceeding two years; and*
- b) partial emergency exercises in the intervening year to ensure that any deficiency found during the full-scale aerodrome emergency exercise have been corrected; and reviewed thereafter, or after an actual emergency, so as to correct any deficiency found during such exercises or actual emergency.*

Note: The purpose of the full-scale exercise is to ensure the adequacy of the plan to cope with the different types of emergencies. The purpose of a partial exercise is to ensure the adequacy of the response to individual participating agencies and components of the plan, such as the communications system.

Accordingly, the airport director made provision for emergency exercises to be carried out; their outcome is illustrated in documents attached hereto.

- a) Exercise conducted on August 2, 2000.

A simulation of an air accident was called. The exercise started at 10.40 and ended at 11.20. The following are abstracts from a meeting report subsequent to the exercise event:

- the forming (manning) of the Command post at UTC was achieved with 20 minutes of delay;

- negative comments were expressed signifying that the location at UTC offices of such Command post was not adequate;
- a number of communication links between Fire brigade, UCT and Medical first aid center were not activated.

On September 20, 2000, the airport director issued a written memorandum (ref. 3755) to various subjects (Police, Fire brigade, Linate UCT, First aid center, SEA, Safety Department) informing about certain amendments to be made to the communication procedures contained in the Emergency plan, the memorandum specified:

...Awaiting the final text of the Emergency plan which will be adopted after the real simulation...

Modifications dealt with certain duties attributed to First aid center (external telephone contact to public line health emergency number 118), judicial Police, communications by FSCC to UCT in case of downgrading of the airport; other items covered were assembly points for ambulances (see attachment AG).

b) Exercise conducted on June 27, 2001.

A large scale emergency exercise was programmed. The exercise was planned and programmed meticulously, no surprise effect was built in. All personnel involved had been forewarned and informed of their duties.

After the exercise a meeting was called to summarize results in a document; it was conducted the same day and with the participation of all Organizations involved, the following emerged:

- the Firemen arrived at accident site in 2 minutes and 20 seconds;
- it was recognized that a mobile Command post would have been useful;
- the location of UCT was not found appropriate;
- Command post had not been manned because none of the Organization's representatives showed up.

The document concluded with the following footnote from the airport director:

The Plan will be revised to take due account of the comments offered and all Organisations are invited to nominate a representative for the Committee that is hereby appointed.

(See attachment AG)

1.10.6.7. Directives to ensure abidance to articles 801/802 of Italian Navigation Code

ENAC deliberation n. 18/99

The implementation procedures for articles 801 and 802 of the *Italian Navigation Code (Codice della Navigazione)*, enacted by ENAC on July 6, 1999, stated:

Airport Directors shall discharge their obligation regarding the correctness of aircraft documentation, as prescribed in Italian Navigation Code articles 801-802 and Chicago Convention article 16. In pursuance of the above, before aircraft departure DCA officials shall conform to the following:

DOCUMENTATION TO BE OBTAINED BEFORE DEPARTURE

The paper lists numerous documents belonging to aircraft documentation to be kept on board.

FORMALITY OF THE PROCEDURE

In discharging their inspections and duties, officials shall evaluate carefully the essence of the control required against the availability of office technical and organizational resources; the need to avoid unnecessary delays to air traffic shall also be assessed.

Among other, here is a brief summary of operational suggestions to be followed:

- *pay extra attention to operators of Countries not belonging to JAA, then of operators of JAA countries;*
- *pay extra attention to operators that have not yet been certified according to JAR-OPS.*

Planning shall also account for General Aviation.

Additional guidance was offered in the following comments in an **ADDITIONAL GUIDANCE** paragraph:

*...pending the adoption of a specific UE Council directive, aligned with an ICAO plan... (omissis)... a procedure has been issued jointly by RAI-DGAC for a random inspection program...
... it is further emphasized that inspections and checks, may lead to flight cancellations when conditions warrant, according to Navigation Code art. 802...*

The document also specified that:

...DCA on all airports shall individually program the above mentioned checks... (omissis)... and issue more detailed operational instruction.

Document DCA Linate ref. 3743, November 10, 1999

The airport director subsequently issued guidelines for the implementation of Italian Navigation Code articles 801-802, here are some relevant extracts:

Operational inspections

Officer in charge of traffic inspections shall monitor the operational environment on aprons, runways and taxiways checks for FOD elimination, correct vehicle circulation, abidance to norms and airport rules, refueling, etc, ...in order to verify constantly the safety level of the apron and other movement areas and its correspondence to ICAO safety regulations.

Document DCA Linate ref. 3744, November 10, 1999

Another document specified:

Due to the relevant traffic reduction, the service is reorganized in accordance with guidelines laid down in the previous document (reference number 3743). Examples are offered regarding inspections of apron, air terminal and inspections on board aircraft.

It further stated conclusively that:

The inspective activity shall be twofold: first aimed at the verification of immediate operational regularity (i.e. that pilot and aircraft documentation is current and valid), to be followed by subsequent check to procedures enacted.

A paragraph addressed specifically the case of General Aviation flights:

General Aviation flights will be cleared automatically, except following an explicit interference by the officer on duty.

Attached to the documental checks listed, there was a specific form called ***foglio di controllo*** (*control form*) that had to be filled by the pilots.

The form called ***foglio di controllo*** (*control form*) belonging to the Cessna flight of October 8, 2001 did not contain pilots' license type and expiry date (see attachment AH).

1.11. FLIGHT RECORDERS AND OTHER EQUIPMENT

1.11.1. DFDR of the Boeing MD-87

The MD-87 was equipped with a tape Digital Flight Data Recorder (DFDR) Honeywell p.n. 980-4100-DXUN, which was recovered. The recorded data were read (decoded) at the BFU (Germany) laboratory on October 25-26, 2001 at the presence of ANSV investigators and other accredited representatives from entitled States. The data were subsequently processed at ANSV technical laboratory facility for further analysis.

All data were found coherent with the flight up to the collision with the Cessna (approx 39 seconds after start of takeoff run). The DFDR has continued to record data for about 16 seconds after the collision.

After the collision with the Cessna some parameters became erroneous or unreliable, but the acceleration data seems to be correct until final impact (into building). Consequently, some recorded data found unreliable, have been calculated by interpolation of reliable recorded data available.

The only speed registered is the IAS (Indicated Air Speed) which becomes unreliable or zero after the collision.

DFDR recording stops about 56 seconds after start of takeoff (about six seconds after the MD-87 made contact with the runway for lack of energy, subsequent to the brief flight).

(See attachment AI)

Other significant recorded data retrieved, indicates the following:

- a) stabilizer trim was correctly set for takeoff;
- b) the aircraft taxied into the runway, lined up and stopped after 8 seconds;
- c) correct takeoff power was set for the procedure selected, FLEX thrust was EPR 1,91;
- d) static takeoff technique was adopted; throttles were advanced to a position corresponding to 42-44% thrust for 8 seconds, then gradually and correctly advanced to the desired value: 1,91 EPR;
- e) all engine parameters were normal until collision time;
- f) rotation occurred at 132-137 kts (244-253 km/h);
- g) NLG (nose landing gear) lift-off was achieved at 142 kts (262,7 km/h), 37 seconds after start of takeoff run;

- h) one second after lift-off of NLG, at 144 kts (267 km/h) and all engine parameters being normal, the elevator was commanded to nose UP (deflections recorded were 17° and 23° respectively for the LH and RH sections);
- i) at 146 kts (270 km/h), DFDR reading shows a condition of transit for the RH slat and the RH MLG; at the same time the aircraft collision noise was recorded by the CVR;
- j) at the same time the RH engine RPM parameter become zero and other parameters (EPR, F/F, EGT) are frozen with incoherent values.

Post collision significant parameters were recovered which show the following:

- k) HDG=356° (runway heading), IAS= 146 kts (270 km/h), attitude +10,3°;
- l) gradual advancement of the throttles to which only LH engine parameters show some coherence;
- m) LH engine parameters indicate a rise of FF and EGT with decrease and fluctuation of N1 value and decrease and fluctuation of EPR ranging from 1,20 to 1,55;
- n) flight parameters show that an altitude of 35 feet (10,67 meters) was reached in about 5 seconds;
- o) large and rapid travel of elevator position from neutral towards maximum deflection UP;
- p) coordinated activation of aileron and rudder to the left to maintain runway heading;
- q) one second before runway contact, throttles were set to IDLE;
- r) after ground contact engine reverse thrust was commanded, causing the LH engine reverse thrust mechanism deployment and EPR maximum reverse thrust setting recorded was 1,498;
- s) the LH reverse thrust mechanism deployed eleven seconds after the collision;
- t) rudder was maintained deflected to the left and manual braking applied;
- u) no braking action was available for LH MLG;
- v) recorded data shows that the aircraft has been airborne for about twelve seconds after collision (the aircraft rotation, AIR/GND switch signal, started about three seconds before collision);
- w) LH MLG made contact with the ground a few seconds before full contact with the runway of NLG and RH wing tip;
- x) for the first nine seconds after collision, vertical and longitudinal accelerations were positive.

After the collision, the IAS recording was invalid. Based on recorded forces, the MD-87 ground speed (GS) and distance to the impact point had been derived from calculation.
(See attachment AU)

1.11.2. QAR of the Boeing MD-87

Quick Access Recorder type Penny & Giles p.n. 51434-1 is a magnetic ribbon recorder used for maintenance and it is not approved as crash recorder. The QAR of the MD-87 was installed in the electronic bay, immediately after the NLG.

The recorder was removed the day after the accident and it has been decoded on October 17, 2001 at the SAS facility in Copenhagen under the surveillance of ANSV and SHK Sweden. It was found that the equipment had ceased functioning at the first collision with the Cessna due power feed loss; the recorder is normally fed by the electrical RH bus.

1.11.3. CVR of the Boeing MD-87

The Honeywell CVR (SSCVR) p.n. 980-6020-001 series 2305 was installed on the right hand side of the AFT cargo bay, along with the DFDR. It was found 10 days after the accident because it was buried in debris that was moved off-site to improve access to the baggage building.

The CVR was played back on October 25-26, 2001 at a BFU facility in Germany and subsequently translated in English from Swedish language through SHK assisted by SAS CIT (Company Investigation Team) under ANSV supervision.

The recorder uses a continuous loop system, recording on four channels and thence overwriting any data older than thirty minutes. The data is kept on solid-state digital chip.

In order to get the full picture of the collision sequence and to verify the origin of the last VHF transmissions an analysis has been performed on the last second of recorded CVR-sound. Due to the capacity of the power supply, the CVR operated in 0,8 seconds after the electrical power was lost. The complete collision scenario was therefore included in the recording. Transcription of the last 30 minutes can be found in attachment AU.

The four channels are linked as follows:

- track n. 1: service interphone;
- track n. 2: radio receiver (VHF) selected on the RH radio panel;
- track n. 3: radio receiver (VHF) selected on the LH radio panel;
- track n. 4: area microphone.

Comment: the recordings of channels 2 and 3 are downstream of the volume control of the respective radio panels.

1.11.4. Cessna 525-A recorders

There was no recording system installed for flight data (CVR/FDR) as it is not required for aircraft with a maximum takeoff mass of less than 5.700 Kg.

1.11.5. ACARS of the Boeing MD-87

The ACARS (Aircraft Communications Addressing and Reporting System) is a digital air/ground transmitting radio equipment designed to forward automatically data from aircraft to Airline base. The ACARS of the MD-87 transmitted the takeoff signal at 06.10:18 hrs, which was received at the Copenhagen SAS base.

1.11.6. ELT of the MD-87

The ELT of the M-87 was located on the upper part of the fuselage near the vertical fin; it was a TSO: C91 type ELT (AF) (AP) (P). This type of equipment is designed to automatically transmit a radio signal on the emergency frequency (121.5 MHz) when subjected to sufficiently large impact forces.

An emergency signal has been recorded at the Milano Linate TWR facility for the duration of 18,6 seconds after collision time.

1.11.7. ARTEX equipment of the Cessna 525-A

An emergency equipment – ARTEX - transmitting on 121.5 MHZ, was installed on the Cessna. There was no recording of its transmission on the TWR tapes.

1.12. WRECKAGE INFORMATION

The two aircraft were removed from the accident site before completion of site recognition, therefore it was not possible to determine the exact position of the crew and passengers of the Cessna. Moreover it has not been possible to make a complete documentation (map) of the acci-

dent site and therefore some factual information was lost.

The reconstruction of aircraft collision/impact phases has been possible through the analysis of DFDR/CVR data and the wreckage state and debris distribution along the accident path, the baggage building impact area and photographs available.

1.12.1. The Boeing MD-87 wreckage

The MD-87 fuselage broke into three sections upon impact with the baggage building when two main pillars were destroyed causing the splinter they sustained to fall over the aircraft wreckage.

- Front section: from forward pressure bulkhead (behind the weather radar) to the leading edge of the wing assembly.
- Intermediate section: from the leading edge of the wing assembly to the afterward pressure bulkhead.
- Tail section: from the afterward pressure bulkhead to (and including) the empennage.

What follows is a detailed description.

1. The front section (forward fuselage), remained outside the baggage building, and the RH side appeared mostly intact. The cabin floor was mostly intact with seat track structure separated and collapsed on the LH side. The cockpit section was mostly intact. The pedestal was deformed and displaced to the left and the control columns also appeared to have been displaced to the left. Forward galley attachment structure had either separated at impact and/or been removed by the fire brigade to facilitate access. A large part of the forward fuselage section RH side overhead structure had also been cut away by rescuers.
2. The intermediate section (mid fuselage from approximately above the wing box to just ahead of the aft pressure bulkhead) was under a portion of the baggage building concrete roof, which had collapsed onto the fuselage and wing structure. Overhead bins had become detached in this area. With the exception of the slat mechanism and a portion of the center wing box still attached to the RH wing, nothing from the center fuselage section was recovered intact. The right wing, from the wing center section centerline was essentially intact, but fire damaged by the post-impact fire. The tip of the left wing, remained outside of the collapsed building. The inboard left slat horn (fairing) was found on the runway and is believed to have been torn off in the collision with the Cessna. Slat n 2 and 3 were missing. The major (remaining) part of the LH wing (outboard of the Landing Gear Attachment) was destroyed

by fire. The LH Main Landing Gear assembly was found collapsed in its wheel well, and was mostly intact, but with the tires consumed by fire. The RH Main Landing Gear attach fitting was still mounted to the wing and the upper portion of its cylinder was still attached to the fitting. The lower portion of the RH MLG cylinder was severed from the upper cylinder. This (lower) part of the RH Main Landing Gear assembly was found on the runway, having separated from the aircraft at collision point.

3. The tail section of the airplane from the aft pressure bulkhead, including the vertical and horizontal stabilizers remained outside the building and was not consumed by post-impact fire. The center portion of the horizontal stabilizer structure and the tip of the vertical stabilizer came to rest on the roof of the baggage building just above the remainder of the tail section. The left engine broke up into three parts at impact with the building edge and was found lying outside the building with the thrust reverse assembly in the deployed position while the compressor area entered the building.

1.12.2. Summary of the Boeing MD-87 wreckage

Significant aircraft items found between collision point and building impact zone:

- LH Nose Landing Gear (NLG) wheel damaged;
- NLG spray deflector damaged and partly missing;
- RH Main Landing Gear (MLG) strut broken;
- RH MLG wheel assembly found far away from collision point (at about 550 m near TWY R1 on the left side of the runway);
- RH engine nose cowl damaged at six o'clock position by contact with RH MLG wheels;
- RH engine separated from aircraft before aircraft touch down;
- RH MLG door damaged and separated from aircraft at collision;
- RH hydraulic service panel ripped off at collision point;
- LH inboard slat fairing ripped off at collision point.

Aircraft broke apart at impact with the cargo building. The forward part of the fuselage remained outside the building. The wing assembly detached from the fuselage and slid into the building and broke into fire. The empennage broke off and remained outside the building.

1.12.2.1. Other significant cockpit items

- Nose landing light switch was in BRIGHT position;
- Wing landing light switches were in EXT position;
- LH panel airspeed indicator needle was indicating 0 knots;
- RH panel airspeed indicator needle was stuck on a 149 knots indication;
- LH throttle and Reverse Lever was in the MAX REVERSE position;
- RH throttle was in a forward thrust position;
- Landing gear handle was not found in its normal place in the cockpit, and can therefore not be confirmed to be in the down selected position;
- Flap handle was in the FLAP 40 position;
- the Spoiler handle was in the "DEPLOYED" position;
- both FIRE handles were in the forward, not activated position;
- both fuel levers were in the ON position;
- LH fuel pump switches (2) were in ON position;
- CENTRE fuel pump switches (2) were in ON position;
- RIGHT fuel pump switches (2) were in OFF position;
- the EFIS switch was in the BOTH ON 1 position.

The possibility of displacement of switches, levers, etc. during the impact or during rescue work cannot be ruled out.

1.12.3. The Cessna 525-A wreckage

The Cessna was destroyed by collision forces and a post-collision fire.

The airframe separated into several sections during the collision:

1. cockpit/cabin;
2. wing assembly;
3. empennage/tail cone and engines.

What follows is a detailed description.

1. The cockpit/cabin section of the fuselage was mostly consumed by the post-collision fire. The radome and nose baggage area was charred, but showed no sign of impact damage.
2. The LH wing showed no sign of collision forces; however it was mostly consumed in the post-collision fire. No control surfaces from the LH wing were found.

The outboard part, 1/3 of the right wing, separated during the collision and had no fire/heat damage. Both the outboard right wing section and the leading edge exhibited rubber transfer marks. The marks began at the leading edge of the outboard wing rib and went aft and inboard; the wing separated just inboard of the marks. The tire marks on the underside of the outboard right wing section is believed to originate from the MD-87 LH MLG outboard (#1) tire. The right aileron separated from the right wing and did not have fire/heat damage. The underside of the right aileron exhibited more rubber transfer marks. The aileron was bent approximately 90 degrees.

3. The empennage/tail cone section was the only one not to sustain significant fire damage. The entire horizontal stabilizer separated from the vertical stabilizer during the collision. Neither horizontal stabilizer nor elevator was complete (one piece). A large section of the right elevator remained attached to the stabilizer at the two inboard hinges. The outboard area was separated.

The LH horizontal stabilizer and elevator sustained heavy damage from impact forces at their rear and lower side. Rubber marks were observed on the bottom of the elevator in the area of the torque tube and on the bottom of the elevator and elevator trim tab. Rubber marks were also observed on the rear spar of the stabilizer.

The vertical stabilizer remained attached to the matching structure of the tail cone. Parts of the MD-87 structural elements (wing fillet fairing) were found embedded in the stabilizer. Collision forces reduced the vertical stabilizer chord by approximately 75%. The structure in the damaged area was pushed aft and slightly to the LH.

The LH engine remained partially attached to the pylon structure. There was an area of impact damage on the upper side of the LH engine; the damage suggests the engine was struck and cut by an object moving from the inboard to the outboard side of the engine and from the front to the back (30° angle with engine axis), probably by the MD-87 inner flap structure.

The right hand engine separated from the pylon structure during the collision; it further separated into two pieces.

The outboard side of the right engine exhibited two areas of a side impact. The distance between the two areas of damage was consistent with the distance between the two tires on the MLG of the MD-87.

Audible sounds coming from the Cessna wreckage were heard by rescuers until about time 11.00 and they reportedly audible at a distance of 1.500 meters (see attachment AJ).

1.12.4. Summary of the Cessna 525-A wreckage

Significant aircraft items found in the collision area:

- aircraft separated into three main parts, front fuselage, wing assembly, empennage;
- front fuselage and wing assembly destroyed by fire;
- LH horizontal stabilizer outer part cut off;
- RH wing tip cut off;
- vertical stabilizer top containing remains of MD-87 wing filet fairing;
- engine 1 penetrated and ripped longitudinally;
- engine 2 separated from aircraft.

1.13. MEDICAL AND PATHOLOGICAL INFORMATION

Post-mortem examinations have been conducted by Medical consultants entrusted by the Judiciary Authority, at the Milano Municipal morgue (October 15 and 16, 2001).

Chemo-toxicological examinations were conducted at the Forensic Institute of the University of Milano.

The examinations indicated absence of toxic substances, drug and alcohol that could have impaired the function of the crews.

1.13.1. Boeing MD-87 occupants

Necropsy results permitted recognition of the Boeing MD-87 crew visually and by comparison with pre and post mortem data available.

According to the response of the Medical experts team, all occupants death, including crew, is

attributable to the sudden traumatic collision associated with the consequences of instantaneous impact kinetic deceleration on vital human functions, resulting in fatal injuries. Most examined bodies suffered multiple traumatic injuries and it was not possible to determine sequentially their effect in relation to the cause of the fatality.

Two crew members (CA) have had a modest exposure to fire, but toxicological exams confirmed that consequent alterations were not produced while in life.

The exam of upper aerial cavities of all deceased occupants have established the absence of carbon residues, suggesting that fire was not the cause for any of the fatalities of the MD-87 occupants.

1.13.2. Cessna 525-A occupants

For the Cessna occupants, more elaborate recognition techniques were necessary due to the poor conditions of the bodies. DNA from bodies was compared with samples retrieved from personal effects and permitted a positive recognition.

Subsequently, on June 27, 2002 a forensic legal advice was conducted to ascertain if the occupants of the Cessna could have survived three minutes after the collision.

For one of the two passengers it was possible to determine, following examination of the upper aerial cavities for carbon residues, that death was the outcome of traumatic injury and not fire; fire exposure was post-mortem. The other passenger was exposed to smoke absorption which could indicate that traumatic injuries were not the immediate cause of death, but the combined effect with fire exposure was fatal.

For the two pilots it was not possible to identify sufficient traumatic consequences that could suggest that death was induced by traumatic alterations. Chemo-toxicological exams indicate smoke absorption in the upper respiratory system, suggesting that death may have been the result of combined effect of traumatic events and fire exposure.

An assessment ordered by the Magistrate concluded that:

No basic element was found or any probability can be considered accountable that survival would have been over 3 minutes for all occupants of the Cessna.

It has to be considered and underlined that notwithstanding the CO and cyanide intoxication evidenced, taking into consideration the extension of the fire exposure suffered by the pilots, even in the event of immediate rescue the survival prognosis would have been totally unfavorable.

1.13.3. Occupants of the baggage building

Eight employees were present in the building when the impact occurred.

Two security officers employed by SEA and two baggage handlers employees of the same handling agent died and were victims of the fire that spread furiously inside the building.

Another baggage handler suffered extremely severe injuries but survived.

Three other baggage handlers sustained minor injuries and were back to work within the month of October 2001, after brief periods of absence (details omitted).

1.14. FIRE

1.14.1. The fire brigade

ICAO Annex 14, Chapter 9 makes provision for the minimum stock required for fire fighting equipment based on airport classification, ICAO Doc 9137-AN/898 part 1. Such classification is established by ICAO and it is based on aircraft type that makes more transits on the airport. Specifically Milano Linate airport is classified as *category 8*.

The total fire brigade equipment available on site at the airport was overabundant in respect of the minimum required stock as provided for in ICAO documents.

The equipment available to the Milano Linate airport Fire brigade was as follows:

Vehicle, type	Radio call sign	Crew
DRAGON, hydro foam	Victor 1	1 Foreman, 1 Fireman
DRAGON, hydro foam, powder extinguisher	Victor 2	1 Foreman, 2 Firemen
TUCANO, hydro foam	Victor 3	1 Foreman, 3 Firemen*
RAMPINI, quick intervention	Victor 5	1 Foreman, 1 Fireman
PERLINI, hydro foam	Victor 8	1 Foreman, 1 Fireman
Vehicle for Aircraft accident intervention	Victor 9 (ASA)	1 Foreman, 1 Fireman
Fire truck pump/tank (APS)		
Jeep		Reserved for Head of Department

* two of the three firemen of this truck, Victor 3, are equipped with special overalls suitable for aircraft penetration in case of accident (see attachment AK).

During fire fighting operations and rescue that followed the accident, other units from outside the airport were dispatched from Milano firemen provincial center.

A total of 96 Fire brigade firemen and an unspecified number of firemen who had just terminated their working shift have joined during the operations; 27 fire fighting equipment vehicles and other support equipment were used.

1.14.2. The MD-87 fire

The Boeing MD-87 had the following exposure to fire. The fuselage was only partially attacked by flames. Fire developed mainly inside the baggage building when the fuel contained in the LH wing and center tanks dispersed and ignited inside the intruded area (ten tons of fuel were on board). Fire covered a large area, which had also been very heavily damaged structurally. In this scenario the intervention of the firemen was utterly impaired and made extremely difficult because the wreckage of the fuselage blocked the entrance.

Ignition of fire is presumably similar to what is described for the Cessna with the addition of high-energy impact conditions.

No assessment or analysis was conducted on fire effect on specific parts of the wreckage.

1.14.3. The Cessna 525-A fire

From findings and evidence gathered of the Cessna aircraft and its occupants (including medical and pathological information), it is assumed that fuel dispersion as a consequence of the collision may have caused an immediate open air fire, specifically to the front section of the wreckage and the wings. Fuel quantity contained in the tanks is not known and can only be presumed sufficient for the flight to Paris-Le Bourget. Many causes can explain the immediate ignition occurred after the collision and the structural splitting of the wreckage: friction of metal with the runway surface, electrical, contact with high temperature elements, etc.

1.15. SURVIVAL ASPECTS

For a better understanding of the events and circumstances of the post accident interaction of all concerned in the handling of the catastrophic emergency situation, key items of factual information gathered has been ordered chronologically as follows.

As a reminder please note that next to the time of each communication, the elapsed time from the time of collision is shown bracketed (00.00:00); while the elapsed time from the time when the Cessna wreckage was found will be shown in square brackets [00.00:00].

At accident time the airport was operating in ILS CAT III conditions and the fire station, according to Order 2/85 of November 1985 should have available the prescribed stock of fire fighting equipment, as provided in ICAO Annex 14. The emergency equipment should have been positioned as prescribed outside of the station and manned, ready to intervene.

ICAO Annex 14 (Vol 1, chapter 9, paragraph 9.2.21) Recommendation for Fire brigade: “response time not exceeding three minutes to any point of each operational Runway, in optimum visibility and surface conditions”.

At **06.09:37** hrs (-00.00:44) the Boeing MD-87 reported on TWR frequency 118.1 MHz that he was rolling.

06.10:21 hrs (00.00:00) Aircraft collision time

At 06.10:38 hrs, about one minute after take off roll start, the MD-87 impacted with the airport baggage building.

The TWR controller, having not seen the aircraft on his radar monitor (used for take off and landing traffic), called the ACC Radar Control on the direct telephone line. The radar controller answered that the aircraft was neither in radio contact nor present on his radar screen.

06.11:58 (00.01:37)

ACC: *Yes?*

TWR: *Listen, report if the Scandinavian has called*

ACC: *Which Scandinavian?*

TWR: *686 taking off*

ACC: *686 Scandinavian, I do not see him*

TWR: *Neither do we, he disappeared and he does not answer any more*

ACC: *Really?*

TWR: *Yes.*

ACC: *(...altercation...)...OK.*

TWR: *No. Milano does not have it, not even on radar.*

ACC: *Hmm...(...) (...) (he speaks with someone else there).*

TWR: *I will let you know.*

ACC: *OK thank you.*

The phone call ended at 06.12:22 hrs (00.02:01).

The TWR controller requested to Approach control to stop the approach sequence for landing (AZ 2012 was next for landing).

A few seconds after this call, the pilot of AZ 2023, parked at A 15, very close to the baggage building reported to Linate GND frequency the information received from a ramp agent servicing his flight.

06.12:40 (00.02:19)

AZ 2023: *Listen we are at Alpha 15, behind us we heard, a couple of minutes ago, three bangs sequenced...and...the ramp agent reports that she has seen behind us, at the runway end, a red streak of fire of... some...something...towards...the localizer antenna.*

The fire brigade have declared in their report that at 06.12:00 (00.01:39) they received notification that a fire had been reported near airport entry Gate n. 5, a service entrance located along the northern border of the airport (North of baggage building area), close to the town taxi station (just outside the airport perimeter).

Two airport Police officers servicing at Gate n. 5 reported that they were by the sentry-box when they heard a succession of bangs culminating with a stronger one (which made them initially think about a possible terrorist attack) and they subsequently saw intense light over the baggage building. Immediately after, they saw a SEA worker embraced with flames coming towards them. They helped the man as best they could and one of the officers, using his portable radio, called the Airport Police center to report. The officer, who took the call, at the airport Police center, immediately informed the fire station by phone. This was done on a non recorded phone number, so there is no precise timing for the event.

Upon receiving the information the FSCC dispatched two fire fighting vehicles:

- Victor 2, carrying hydro foam powder extinguisher, Dragon;
- Victor 3, carrying hydro foam extinguisher, Tucano.

The vehicles proceeded via a peripheral internal road, entered the North apron near the TWR and reached the baggage building area (see attachment G).

The alarm signal was activated by TWR approximately at the same time.

The system in use is based on a challenge/respond equipment but has no recording facility attached, therefore activation time could not be determined precisely. It is reasonable to assume that the signal was issued immediately before a phone call which was recorded on the DCA-TWR direct phone line, when a DCA officer enquired about the alarm activation.

06.13:35 (00.03:14)

DCA: *Yes, tell me, has the alarm being issued?*

TWR: *Hmm, Yes... we have the Scandinavian... we do not find him...*

A few seconds later, at 06.13:51 (00.03:30) FSCC, code name Victor 10, using the service radio frequency 440.450 MHz, issued the instruction to all fire fighting vehicles to proceed to airport Gate n. 5.

Victor 10: *To all Victor, proceed towards Gate n. 5, to all Victor go to Gate n. 5.*

With all evidence the FSCC decision to send the fire squad was in relation to another unrecorded information, received by phone, suggesting the possible involvement of the MD-87.

There is also evidence of a declaration by a Finance officer who had called the fire station reporting that there was an aircraft involved in the fire at the baggage building (see attachment AL). There is no recording of such call.

Subsequent to the call of Victor 10, the following vehicles were dispatched from the fire station and followed the peripheral service road:

- Victor 1, carrying hydro foam powder extinguisher, Dragon;
- Victor 5, rapid intervention vehicle, Rampini;
- Victor 7, carrying hydro foam extinguisher, Perlini;
- Victor 9, emergency vehicle, (ASA);
- APS, an auxiliary pump/tank vehicle, for ordinary intervention.

Comment: all firemen vehicles and trucks were equipped with two radios, tuned on two different frequencies. The first was tuned on 440.450 MHz, service frequency received at the TWR

and taped (recorded); the other frequency 73.950 MHz, (channel 20) was for the exclusive use of the firemen, not tuned at TWR and not taped (not recorded).

At 06.14:12 hrs (00.03:51) GND controller stopped aircrafts, LX-PRA and I-DEAS, already taxiing on TWY R5 and instructed them to return to West apron.

At 06.14:45 hrs (00.04:24), after about one minute, TWR asked the fire station confirmation that the alarm signal had been received (call on direct telephone line):

TWR: *Did you hear the alarm?*

Fire station: *Yes, yes we already sent...*

TWR: *OK.*

Fire station: *They are on their way.*

TWR: *OK.*

It is reasonable to assume that the exchange lead to a misunderstanding. The fire station operator may have thought that the TWR controller knew exactly about the situation and the position of the MD-87. The TWR controller did not ask where the rescue team had been sent.

At 06.14:56 hrs (00.04:35) TWR instructed aircraft I-LUBI to clear RWY 36R (the aircraft had already lined up for take off from RWY 36R).

Again another possible misunderstanding may have occurred due to an ambiguous message is exchanged between TWR controller and a pilot:

TWR: *IndiaBravoIndia Linate you should clear on Romeo 4 at your... excuse me on Romeo 1 at your right hand side report runway clear.*

I-LUBI: *Via Romeo 1 we shall report runway clear.*

I-LUBI: *IndiaBravoIndia confirm Romeo 1 to the end?*

I-LUBI: *Can you say again we did not understand, sorry.*

TWR: *Yes... the important is that you clear me the runway.*

I-LUBI: *If you wish we can vacate at holding position, we exit here... we proceed to the holding bay.*

TWR: *Oh yes for the moment maintain the bay, thank you.*

The communication ended at 06.15:48 (00.05:27).

At 06.15:25 hrs (00.05:04) a call was made from TWR on service radio frequency 440,450 MHz, while the previous communication was going on TWR frequencies, the call was directed to FSCC.

TWR: *Victor you may enter the runway, from this moment the runway is clear, you may enter the runway. Make us a report for the whole length. We are missing an aircraft who should have taken off but at the moment it is not in flight so tell us what you may see on the runway, just in case.*

To that request Victor 10 responded at 06.16:12 (00.05:51) hrs, by issuing the following radio call to all Victor but without the specific request made by the Tower.

Victor 10: *To all Victor from Operations Control centre, you can enter the runway as well... for the time being it has been closed.*

There is evidence that a lack of coordination existed among controllers; while I-LUBI was instructed to taxi on the runway and vacate from TWY R1, firemen were asked to enter the runway ...*since it is clear...*

Instead, the inspection request made by TWR was interpreted by the fire station as a clearance to use the runway for equipment movement. The inspection request was not perceived since the FSCC already knew the position of the MD-87, therefore the operator merely relayed to the Victor vehicles:

...you can use the runway...for the time being it is closed.

At 06.15:52 hrs (00.05:31) I-LUBI vacated the runway at TWY R4 and taxied to RWY 36R holding position.

The First Aid center of the Milano Linate airport was located near the baggage handling building (see attachment AM).

Impact noise alerted the personnel servicing the unit which acted immediately; they coordinated promptly with external units calling for medical rescue teams according to their procedures (see attachment AN).

At 06.16:03 hrs (00.05:42) a doctor of the First aid center called TWR on radio (440.450 MHz) and informed:

DOCTOR: *Doctor to TWR, it is a Scandinavian Airlines aircraft*

This had been the first time that a call to the TWR, among those that are on record, identified positively the aircraft involved in the accident.

At 06.16:21 hrs (00.06:00) a communication exchange between Victor 1 and TWR sheds some doubt. Until then, apparently the TWR ignored the exact position and condition of the Boeing MD-87, possibly known only to the Fire station Control centre.

After the call from the doctor the situation now seemed reversed. The following exchange raises doubts about the correct information available at the Fire station Control centre.

Victor 1 asked the TWR if the aircraft had been localized and the TWR responded in the affirmative. A few seconds later TWR instructed Victor 1 to go towards the First Aid center and report. During that time, Victor 2 and Victor 3 should have arrived near the baggage building, while the other four vehicles (and among them Victor 1), were on their way along the peripheral service road. The following exchange has probably taken place while the four vehicles were on their way:

At 06.16:21 hrs (00.06:00)

Victor 1: *TWR from Victor 1.*

TWR: *Victor 1 from TWR.*

Victor 1: *Did you localize the aircraft?*

TWR: *It is a Scandinavian Airlines aircraft against the toboga (denomination of part of the baggage area).*

06.16:35 (00.06:14)

Victor 1: *Copied.*

TWR: *Victor 1 TWR.*

TWR: *Victor 1 TWR.*

TWR: *Victor 1 Linate TWR.*

Victor 1: *Go ahead TWR for 1.*

06.17:00 (00.06:39)

TWR: *OK Victor proceed to the infirmary, an aircraft has been reported to have overrun the runway close to the infirmary, go the infirmary and report us.*

06.17:15 (00.06:54)

Victor 1: *Roger.*

06.17:37 (00.07:16)

Victor 1: *All Victor here, I want all Victor here.*

This has been the first communication made by Victor 1 suggesting that he had arrived at the impact scene (baggage building).

06.18:27 (00.08:06)

Victor 1: *TWR for 1.*

TWR: *Victor 1 TWR go ahead.*

Victor 1: *So, here the aircraft is on fire, we are working on it and we shall inform you later.*

This is the first direct information issued from fire station to TWR.

06.18:43 (00.08:22)

TWR: *It is ok Victor 1 you are at runway end, what is the position of the aircraft on fire?*

06.18:52 (00.08:22)

TWR: *Victor, Victor from TWR.*

06.19:00 (00.08:39)

TWR: *Victor, Victor from TWR.*

06.19:16 (00.08:55)

TWR: *Victor, Victor from TWR.*

06.19:32 (00.09:11)

TWR: *Victor, Victor from TWR.*

06.19:42 (00.09:21)

TWR: *Victor, Victor from TWR.*

At 06.20:22 hrs (00.10:01) a TWR controller asks the fire station operator on the direct line phone about which Victor is in radio contact with the TWR;

the answer was: *1 (one).*

06.20:57 (00.10:36)

TWR: *Victor, Victor from TWR.*

06.21:47 (00.11:26)

TWR: *Victor 1 TWR.*

06.21:56 (00.11.35)

TWR: *Victor 1, Victor 1 TWR.*

06.22:25 (00.12:04)

TWR: *Victor 1, Victor 1 TWR.*

06.22:30 (00.12:09)

Victor: *Go ahead who is calling for 1, TWR.*

TWR: *OK Victor I want to know the exact position where you are operating. Is the runway clear? Or is it occupied? How many vehicles are on the runway?*

06.22:43 (00.12:22)

Victor 1: *Just in front of the infirmary, let's say, in the vicinity of the infirmary.*

TWR: *Understood. Then you do not have equipment on the runway?*

Victor1: *Nothing.*

06.22:53 (00.12:32)

TWR: *Copied.*

At 06.24:06 hrs (00.13:45) the following conversation took place on the direct phone line TWR-fire station:

FIRE STATION: *Hmm, we want to know if there are persons involved, practically... if you know something.*

TWR: *Hmm, we do not know... I mean I think yes there are... there is the Scandinavian on take off that had passengers on board...*

At 06.24:27 hrs (00.14:06) the GND controller, answering a call from AZ 2023, makes a revealing statement when he responds with a question:

GND: *Sorry, which aircraft? There are two of them unaccounted for.*

At 06.25:21 hrs (00.15:00) from TWR there is a telephone request to ATA (phone internal number 230), asking if the Cessna aircraft had returned to the parking area. The reply was:
I will have this checked... I will call you back...

At 06.25:24 hrs (00.15:03) an operator of the FSCC (Victor 10) asks Victor 1:

Victor 10: *But...is the aircraft a large one?*

Victor 1: *The aircraft is part of the fire, I cannot tell you more ... at the moment...*

Victor 10: *Is the fire still heavy?*

Victor 1: *It is... still going on... we are trying to contain it, we are now replenishing water tank for another spread.*

During extinguisher agents refill operation the driver of the unit returned to their base station to refill as necessary, while the foreman remained on the accident scene. This could explain the vagueness of the previous answer to the question:

But...is the aircraft a large one?

Also because TWR had previously informed Victor 1 that:

It is a Scandinavian Airlines aircraft against the toboga.

During that time the TWR was coordinating the movements of various aircrafts:

I-LUBI holding near RWY 36R head, AZ 2021 and AP 937 at CAT III holding point at the South end of the parallel taxiway.

Then, at 06.26:39 hrs (00.16:18) I-LUBI was cleared to enter the runway and taxi towards TWY R6 to return to the West apron.

AZ 2021 and AP 937 were cleared to maneuver to taxi back to the North apron.

06.26.39 (00.16:18)

I-LUBI: *We are entering now and will vacate on Romeo 6, IndiaBravoIndia.*

From 06.29:27 hrs (00.19:06) there is a different controller voice on GND frequency.

At 06.29:43 hrs (00.19:22) from TWR there was a request to fire squad (440,450 MHz) asking them if they could see two aircrafts involved in the fire, but there was no answer.

The pilot of I-LUBI notified the TWR that he wanted to vacate on Romeo 2.

06.30:06 (00.19:45)

I-LUBI: *Linate IndiaBravoIndia.*

06.30:08 (00.19:47)

TWR: *BravoIndia.*

06.30:09 (00.19:48)

I-LUBI: *I have Romeo 6 in front of me, we vacate the runway the first on the right since there is a fire on the runway... Romeo 2.*

06.30:09 (00.19:55)

TWR: *BravoIndia copied, then you will hold on Romeo 2 because we have other aircraft on the taxiway.*

06.30:23 (00.20:02)

I-LUBI: *Copied, we maintain...on Romeo 2, there is fire on the runway, things that are burning, wreckages in flames.*

TWR: *Received... thank you.*

During the next minutes TWR was coordinating the movements of I-LUBI, AZ 2021 and AirOne 937, while GND was trying to understand more from the pilot of LX-PRA.

06.32:41 (00.22:20)

GND: *RomeoAlpha, excuse me, we are trying to understand what might have happened, and... you were... you had been instructed to taxi following the German, right? the DeltaIndiaEchoVictorXray.*

06.32:55 (00.22:34)

LX-PRA: *Yes, right, I confirm, but when we started taxi, as we reported on..., it was not in sight, therefore we started taxi for Romeo 5, but we have not seen the German.*

At about the same time 06.32:26 (00.22:05), a telephone call to TWR from ATA confirmed that the Cessna did not return to the parking area.

At 06.33:14 hrs (00.22:53) further telephone request from TWR to fire station requesting if an examination of the runway had been conducted.

TWR: *Yes this is TWR, listen, I need to talk... to talk with one of your vehicles because there is a small aircraft missing, a private plane. Somebody has reported things... wreckages in flames, on the runway. Therefore... I want to know if earlier on firemen entered the runway, yes or no?*

Fire station: *earlier on firemen went directly to Gate n. 5, they did not enter the runway, they went through...*

TWR: *But we...*

Fire station: *...the peripheral.*

TWR: *...but we had cleared them to enter the runway.*

Fire station: *Hhm we do not know... maybe they did not see it because of the fog, they went directly to Gate n. 5.*

TWR: *Anyhow let me talk with a vehicle on frequency.*

Fire station: *Yes, OK.*

TWR: *Bye.*

Fire station: *Bye.*

TWR: *Bye.*

The call ended at time 06.33:49 (00.23:28).

At this stage, two officers from the UCT, who were present at the baggage building area, watching the scene and monitoring the radio calls, using the service frequency, volunteered to inspect the runway and report. Their call sign was Delta 2.

At 06.33: 15 hrs (00.22:54)

DELTA 2: *Are you missing a private aircraft?*

TWR: *Yes, a private aircraft is missing! A Cessna 525 DeltaIndiaEchoVictorXray, and we want to know... what happened on the runway. Because the firemen did not report... they only told us that there was an aircraft involved in an accident by the First Aid center, but they did not report about the runway! Therefore we want to know what happened on the runway!*

06.33:41 (00.23:20)

DELTA 2: *OK! Then... now we try to go on the runway.*

06.33:46 (00.23:25)

TWR: *Copied!*

During the next three minutes the FSCC asked Victor 1 to look for an aircraft on the runway, but Victor 1 replied that they were busy replenishing with extinguishers. TWR again asked if the state of the runway was known, but Victor 1 confirmed that no firemen vehicle had entered the runway. At the same time Delta 2 with the UTC officers on board was driving on the runway towards TWY R6.

At **06.36:50** hrs (**00.26:29**) [**00.00:00**] the report came from the UTC officers that they had found the Cessna in flames on the runway; the communication came through the service radio (440.450 MHz).

DELTA 2: *TWR from Delta 2... There is an aircraft on the runway.. ah, what... what remains of an aircraft, TWR from Delta 2.*

At **06.37:22** hrs (**00.27:01**) [**00.00:32**] the TWR controller ordered firemen to enter the runway:

TWR: *Victor 1 you must enter the runway, there is another aircraft involved in the accident near Romeo 6.*

Victor 1: *Copied, we go right away.*

At 06.39:06 hrs (00.28:45) [00.02:16] the TWR asked UCT officers (Delta 2):

TWR: *Yes ... but do you see any fire fighting vehicles there...on the runway..?*

At **06.39:10** hrs (**00.28:49**) [**00.02:20**] UCT answered:

Delta 2: *There is one just arrived now but... no...*

This was one minute and forty-eight seconds after the formal request made by the TWR for the firemen to operate.

At **06.41:58** hrs (**00.31:37**) [**00.05:08**], the information came from Delta 2 that the fire had been extinguished:

Delta 2: *this is UCT... we were calling... the fire has extinguished here on the runway.*

At 06.58.26 hrs (00.48:05) [00.21:36] during a phone conversation on the direct line, the TWR requested the DCA for the number of passengers that had boarded the two aircrafts.

Removal of the bodies of the Cessna was completed around 11.00 a.m.

At 18.20 of the next day, October 9, the last body was recovered from the Boeing MD-87.

It has been witnessed that an electronic equipment of the Cessna was still transmitting an alarm sound similar to an ELT signal; it has been reported that at around 11.00 hrs of October 8 it was audible at an estimated distance of 1.500 meters.

There is no trace of the recording of that signal on the TWR tapes for emergency frequency 121.50 MHz.

1.16. TESTS AND RESEARCH

Decoding of the DFDR of the Boeing MD-87 at BFU laboratory at Braunschweig (Germany), see paragraph **1.11.1. DFDR of the Boeing MD-87.**

Decoding of the QAR at SAS laboratory, Copenhagen (Denmark), see paragraph **1.11.2. QAR of the Boeing MD-87.**

Playback of the CVR of the Boeing MD-87 at BFU laboratory and subsequent translation with the cooperation of SHK and SAS CIT, see paragraph **1.11.3. CVR of the Boeing MD-87.**

Reconstruction of the wreckage of the Boeing MD-87 and Cessna, see paragraph **1.19. USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES.**

Test of the TWR radio receiver and volume for frequency 121.5 MHz, see paragraph **1.19. USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES.**

Transcripts of radio and telephone communications pertaining the incident were obtained from the Magistrate office (audio files on CD); while the original tape was not made available.

It was not possible to test the efficiency of the Cessna ARTEX equipment, the transmission of which were not present on the tapes recorded; the equipment has been seized by the Magistrate (criminal inquiry) and has not been made available.

It has not been possible to receive testimonies from the GND controller, the TWR controller and the TWR Supervisor controller, as they made themselves unavailable pending the judicial procedure they are subject to in relation to the accident.

Survey at fire station facilities and equipment at the airport site; see paragraph **1.19. USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES.**

1.17. ORGANISATIONAL AND MANAGEMENT INFORMATION

The operations at the Milano Linate aerodrome is regulated by a group of organizations with various functions and competences, as follows.

- a) ENAC is the regulatory body for Italian Civil Aviation and is under the control of “Ministero delle Infrastrutture e dei Trasporti”. It is represented at Linate by the local DCA, managed by the operational unit UCT.
- b) The aerodrome director is the head of the DCA, responsible for safety matters and coordi-

nation through the UCT operational unit.

- c) ENAV SpA controlled by “Ministero dell’Economia e delle Finanze”, but under the surveillance of the “Ministero delle Infrastrutture e dei Trasporti”; it is present at Milano Linate airport with the local CAV, “Centro Assistenza al Volo”, and is responsible for Air Traffic Control provision, aeronautical information and meteorological services. ATC was provided and regulated in accordance with norms and regulations contained in AIP Italy, AIC, NOTAM, ODS and with due regard to ICAO Annexes 2 and 11 and ICAO DOC 4444 and 7030.
- d) SEA is a private company that stipulated a convention with ENAC for the supply of the complete management of the Milano Linate and Malpensa airports.
- e) ATA “Ali Trasporti Aerei”, is a private supplier of ground handling services to General Aviation operating at the West apron. ATA is a subcontractor for SEA.

All subjects listed from a) to e), together with other subjects located on the airport site, were party of a CASO - *Comitato Aeroportuale per la Sicurezza Operativa* or *Airport Technical Safety Committee* under the jurisdiction of the airport director, dealing with the solution of local operational problems arising. CASO Committee meetings were called randomly and often dealt with matters other than air safety.

The following CASO meeting reports were the only ones that have been obtained during the survey that was conducted by this investigation (see attachment AO).

- April 19, 1999 – Security matters at airport entry gate n. 2 and Peripheral entry gate located at Peschiera Borromeo County (**Comune** in Italian).
- May 14, 1999 - Security matters at Peripheral entry gate at Peschiera Borromeo.
- November 15, 1999 – Millennium bug.
- November 9, 2000 – Problems arising at Peripheral entry gate at Peschiera Borromeo, fuel spilling on apron, evacuation plan for Air Terminal.

1.18. ADDITIONAL INFORMATION

1.18.1. International Civil Aviation Organization (ICAO)

The Convention on Civil Aviation (Chicago December 7, 1944) also known as the “Chicago Convention” represents the basic source of aviation legislation. The Convention on International Civil Aviation instituted the International Civil Aviation Organization (ICAO) which establishes principles for the safe, regular and efficient operation of international civil aviation. The ICAO, a specialized branch of the United Nations Organization, has to adopt and modify international *Standards And Recommended Practices* (SARPs) that are annexed (ICAO Annexes) to the Convention.

The international *Standards* are a specification, the uniform application of which is necessary for the safety and regularity of international civil air navigation, while the *Recommended Practices* are a specification, the uniform application of which is desirable in the interest of safety, regularity or efficiency of international civil aviation.

The Annexes to the Convention on International Civil Aviation (18 in number as of today), that prescribe *Standards* and *Recommended Practices* are represent technical regulations regarding air navigation.

The Annexes are not an integral part of the Convention and are not enforced immediately by States. The ratification of the Chicago Convention and the fact that it becomes executive in a State does not imply the automatic adoption of the Annexes in the State’s regulation, whereas the Convention makes provision for non adoption by States of the *international standards*, provided they notify ICAO.

Contracting States to the Chicago Convention are therefore called to adjust national legislation to the ICAO regulations and not to conform automatically.

1.18.2. ICAO Annex 14

Since 1 November 2001, days after the accident investigated in this report, ICAO has introduced a new requirement for States to certify their aerodromes open to public use in accordance with the ICAO Annex 14 Volume I specifications and other relevant ICAO specifications and national regulations. ICAO has now been mandated by the 33rd Session of the ICAO Assembly, to carry out safety oversight audits of airports and air traffic services starting from 2004, in continuation of the successful on-going Safety Oversight Audit Program in the fields of Personnel Licensing, Aircraft Operations and Aircraft Airworthiness.

1.18.3. ICAO Annex 14 SMS (SARPs) and Joint Aviation Authorities (JAA) requirements

In line with ICAO Annex 14 Safety Management System (SMS) SARPs, to become effective in conjunction with the ICAO Manual on Certification of Aerodromes, the statements listed below can be found in the Safety Objective and Safety Management policy Statements, as devised by a JAA group of experts.

The JAA – Group of Airport and Ground Aids (AGA) Safety Regulators (GASR), is tasked with the development of a harmonized approach to safety regulation of airports and ground aids operations in view of their future integration in Joint Aviation Requirements.

Safety objective.

An Aerodrome organization with its facilities, equipment and systems shall be designed and operated so that for any hazard the combination of the probability of occurrence and the seriousness of the consequences of the hazard occurring must not result in a level of risk that is unacceptable.

Safety Management Policy Statements.

Safety Management Systems shall include the following:

- *A statement that the highest priority shall be attached to safety in relation to all business activities.*
- *A business objective for safety that shall minimize the Aerodrome's contribution to aviation accident risk to as low as reasonably practicable.*
- *A commitment by the organization to adopt an explicit, pro-active approach to safety management.*
- *Statements of safety-related responsibilities throughout the organization.*
- *Compliance with all appropriate safety standards.*
- *That the safety assurance processes used by its external suppliers comply with the Aerodrome's safety management standards and requirements.*

Regarding prevention of runway incursions the following installations and measures are required:

- *Runway Guard Lights, (RGL)*
- *Taxiway Lights*
- *Stop Bars*

- *Runway-holding Position Markings*
- *Surface Movement Radar*
- *Air Traffic Controllers*

1.18.4. Safety Management System

A Safety Management System represents a philosophy and working method within any type of organization that shall ensure that specified safety standards are established, reached and maintained within all type of activities. The system shall include systematic methods suitable for: the detection of deviations from standards, the initiation of corrective actions and the follow up of the results. The Safety Management System shall have an impact on all ongoing activities and decisions related to flight safety. Procedures for the Safety Management System shall be documented in an Operational Manual available to and used by all persons engaged in activities that have an impact on safety.

1.18.5. The European Action Plan for prevention of runway incursions, the recommendations

During the last decade Runway Incursions have been recognized as a global problem. It was mainly assessed as a problem on the North American continent. Attention of runway incursions was thereafter also focused on in Europe and in this context a safety initiative was launched.

The European Action Plan (EAP) for prevention of runway incursions is the result of the combined efforts of organizations representing all areas of aerodrome operations. This action plan is made available to the National Aviation Safety Authorities and other involved parties.

Here is a shortened extract giving a background and recommendations concerning: General Principles, Aerodromes, Communications, Air Traffic Services and Regulatory Issues that have relevance to the actual accident at Milano Linate.

In July 2001 a joint runway safety initiative was launched by JAA (GASR), ICAO and EUROCONTROL to investigate specific runway safety issues and to identify preventative measures. To carry out this work a Task Force was subsequently formed. It comprised representatives from the JAA, EUROCONTROL, ICAO, GASR, ACI, AEA, ECA, ERA, IATA, IAOPA, IFALPA, IFATCA plus other professional organizations like Air Navigation Service Providers (ANSPs) and Aircraft Operators.

The following understanding has been used for the purposes of this work, although a globally

accepted definition of “runway incursion” has still to be formally agreed by ICAO:

A runway incursion is the unintended presence of an aircraft, vehicle, or person on the runway or runway strip.

Below are 37 recommendations as devised by the European Action Plan for the prevention of runway incursions:

General principles

- *At individual aerodromes, as designated by the National Aviation Safety Authorities, a Runway Safety Team should be established to lead action on local runway safety issues.*
- *A local runway safety awareness campaign should be initiated at each aerodrome for Air Traffic Controllers, Pilots and Drivers and other personnel who operate on or near the runway.*
- *Confirm that all infrastructure, practices and procedures relating to runway operations are in compliance with ICAO provisions.*
- *Where practicable, ensure that specific joint training and familiarization in the prevention of runway incursion is provided, to the pilots, air traffic controllers and vehicle drivers, to increase understanding of the roles and difficulties of personnel working in other areas.*

Aerodrome Operator Issues

- *Verify the implementation of Annex 14 provisions and implement maintenance programs relating to Runway operations e.g. marking, lighting, and signage. Ensure that signs and markings are clearly visible, adequate and unambiguous in all conditions.*
- *Works in progress - Ensure that information about temporary work areas is adequately disseminated and that temporary signs and markings are clearly visible, adequate and unambiguous in all conditions.*
- *Assess the need for additional ICAO standards for aerodrome signage marking and lighting. Make recommendations to ICAO where appropriate.*
- *Implement Safety Management Systems in accordance with ICAO provisions.*
- *Ensure a continued focus on runway safety in internal audit activities.*
- *Introduce a formal Driver training and assessment program, or where already in place review against the Driver training guidelines.*

- *Introduce formal communications training and assessment for Drivers and other personnel who operate on or near the runway.*
- *Implement the standard ICAO naming conventions for taxiways.*

Communications (Language, Radiotelephony, Phraseologies and Procedures)

- *Use full aircraft or vehicle call signs for all communications associated with runway operations.*
- *Verify the use of standard ICAO RTF phraseologies.*
- *Use the ICAO read-back procedure (including Drivers and other personnel who operate on the maneuvering area).*
- *Improve situational awareness, when practicable, by conducting all communications associated with runway operations using aviation English.*
- *Improve situational awareness, when practicable, by conducting all communications associated with runway operations on a common frequency.*

Air Navigation Service Provider Issues

- *Implement safety management systems in accordance with ESARR3 provisions.*
- *Survey the different methods and techniques in use to indicate to controllers that a runway is temporarily obstructed and recommend Best Practice.*
- *Whenever practical give ATC en-route clearance prior to taxi.*
- *Develop an ICAO compliant procedure applicable if an aircraft or vehicle becomes lost on the aerodrome maneuvering area.*
- *Aircraft shall not be instructed to cross red stop bars when entering or crossing a runway unless contingency measures are in force, e.g. to cover cases where the stop bars or controls are unserviceable.*
- *Ensure that ATC communication messages are not over long or complex.*
- *Ensure that ATC procedures contain a requirement for explicit clearances to cross any runway. Includes non-active runways.*
- *Identify any potential safety benefits of carrying out runway inspections in the opposite direction to runway movements and if appropriate adopt the procedure.*

- *Use standard taxi routes when practical to minimize the potential for pilot confusion, on or near the runway.*
- *Where applicable use progressive taxi instructions to reduce pilot workload and the potential for confusion.*
- *Avoid infringing sight lines from the tower and assess visibility restrictions from the tower, which have a potential impact on the ability to see the runway, and disseminate this information as appropriate. Recommend improvement when possible and develop appropriate procedures.*
- *Ensure that runway safety issues are included in training and briefing for ATC staff.*
- *Identify any potential hazards of runway capacity enhancing procedures when used individually or in combination and if necessary develop appropriate mitigation strategies. (Intersection departures, multiple line up, conditional clearances, etc.)*
- *Do not issue line up clearance to an aircraft if this aircraft will be required to hold on the runway for more than 90 seconds beyond the time it would normally be expected to depart.*
- *When using multiple line-ups, do not use oblique or angled taxiways that limit the ability of the Flight crew to see the runway threshold.*

Regulatory Issues

- *Confirm that all infrastructure, practices and procedures relating to runway operations are in compliance with ICAO provisions.*
- *Make the appropriate regulations available to ensure implementation of safety management systems in accordance with the applicable standards.*
- *Ensure that safety assurance documentation for operational systems (new and modified) demonstrates compliance with regulatory and Safety Management System requirements.*
- *National Aviation Safety Authorities should focus on runway safety in their inspection activities.*
- *Certify aerodromes according to ICAO provisions, Annex 14.*

1.18.6. Runway incursions at Milano Linate airport

The following runway incursion events have come to the attention of ANSV; they have occurred prior and after the October 8, 2001 accident and they are reported here as background information. With the exclusion of the event occurred on October 10, 1980 all other events listed are on file at ANSV.

a) RUNWAY INCURSION ON DECEMBER 10, 1980

A commercial transport aircraft DC-9, registration marks I-DIKC, taking off from RWY 36R collided with a Mitsubishi MU-2B private aircraft, registration marks I-NARI, that had lined up at the runway near TWY R3 and was awaiting a take off clearance. The General Aviation private aircraft had taxied out from the West apron via TWY R6 and had been instructed to hold at the Stop. The DC-9 had taxied on the parallel taxiway on his way from the North apron. The investigation conducted did not determine the causes for the event. When the accident occurred the visibility was 3.500 meters and for that reason consequences have not been too dramatic since the pilot of the DC-9 could minimize the consequences of the collision.

(See attachment AP)

b) RUNWAY INCURSION ON SEPTEMBER 18, 2001

A British Midland pilot reported that he had witnessed a runway incursion at Milano Linate airport; the BM pilot reported having heard the following conversation between TWR and a pilot:

TWR: *Where are you going? You have entered the active runway*

Pilot: *Oh, sorry*

TWR: *It's OK; there is no traffic at the moment*

This report has been forwarded to ANSV by AAIB UK on October 17, 2001.

(See attachment AP)

c) REPORT RECEIVED FROM AAIB AUSTRIA

The AIB of Austria relayed a report from the pilot of an Austrian registered aircraft. The date of the event is unknown. The reporting pilot was supposedly familiar with the airport. Having been instructed to taxi via TWY R6 for runway 36R, he erroneously taxied via TWY R5.

The pilot reported that his conduct was the consequence of his expectation to be cleared via TWY R5 since he had previously used that taxiway. The controller did not spot the pilot's error until the pilot himself reported it. The controller then cleared him to taxi on runway 18R to join TWY R6 in accordance with the instruction received.

The pilot made the following declaration:

Since I used the last time Romeo 5, I taxied this time also on Romeo 5. I realised the mistake, I informed the GND control and we were instructed to continue via RWY 18R to Romeo 6.

(See attachment AP)

d) RUNWAY INCURSION ON OCTOBER 7, 2001

The event occurred on October 7, 2001, less than 24 hours before the accident investigated in this report.

At 13.56 hrs the aircraft I-DDVA, having been instructed to taxi from West apron to RWY 36R via TWY R5, taxied instead via TWY R6; the read back was incorrect but the controller did not notice the read back mistake:

I-DDVA: *IndiaVictorAlpha, from ATA, ready to move*

GND: *IndiaVictorAlpha, taxi North, on Romeo 5, the H 1010*

I-DDVA: *1010, will call back at the stops, VictorAlpha*

Comments:

- the pilot's read-back did not contain the description TWY R5 but the controller either did not notice it or did not deem it relevant;
- the controller used the words **at the stops**; a phraseology that was consistently used by the controllers when they instructed aircrafts to taxi either on TWY R5 or TWY R6.

The aircraft was taxiing on TWY R6 instead of being on TWY R5; the visibility was more than 2.000 meters but the mistake was not spotted by the controller. Only when I-DDVA had almost reached the entrance to the RWY 18L/36R, the pilot spotted another landing aircraft coming in, ERJ-264 who that had entered TWY R6 vacating the runway after its landing. The pilots saw each other and they could clear their crossing at the stopping bays on TWY R6. The words of the pilot of I-DDVA shows that he was convinced (in following his expectation) that he had to proceed via TWY R6, thus ignoring the clearance received by GND.

I-DDVA: *VictorAlpha is already on Romeo 6, what do I do, shall I enter the first bay here on the left?*

GND: *VictorAlpha I had instructed you on Romeo 5, hmmm... hold on a moment*

I-DDVA: *Yes, however we copied Romeo 6, we repeated Romeo 6, for sure we made a mistake*

The controller commented that the pilot did not abide by the instruction received and the pilot

replied that he had made a communication that in effect he did not make.

The pilot of I-DDVA must have had a firm expectation and confusing TWY R5 with TWY R6.

I-DDVA: *Do you want that VictorAlpha taxi on the tourist runway and continue on Romeo 6?*

GND: *VictorAlpha is already on Romeo 6, Romeo 5 is at the North. You can continue to the end and report when at the stops at the end, your code is FourSixSixFour*

(See attachment AP)

e) RUNWAY INCURSION ON FEBRUARY 28, 2002

Another RWY incursion occurred on February 28, 2002; the incident has been investigated by ANSV and the Final Report was released by ANSV on May 10, 2002 and published.

The event was spotted by TWR controller who noticed it on the ground movement radar screen: a runway incursion had occurred while another aircraft made an erroneous position report during the runway vacate phase. The controller took action to anticipate the unfolding of events.

An aircraft was at holding position for CAT III at runway 36R of Milano Linate, in the takeoff sequence. The TWR controller instructed him to: ***hold short of Rwy 36***. The pilot read-back correctly while another aircraft was landing. After the aircraft landed he entered the runway and lined up without receiving the prescribed clearance. The TWR controller spotted the movement on his ground movement radar monitor. He initially cleared the landing aircraft to vacate via TWY R1, but the pilot mistakenly engaged TWY R2 reporting he had vacated the runway; the controller corrected him and cleared him to re-enter the runway and taxi to TWY R1.

A third aircraft was now approaching the runway to land, the controller took action and issued instruction to perform a missed approach procedure.

Comment: considering that the prevailing low visibility conditions could not allow a visual assessment of the situation by the controller, it can be underlined that the availability of a ground movement radar, which was being tested since December 19, 2001 (after the October 8, 2001 accident) had been paramount in averting a potential traffic conflict.

1.19. USEFUL AND OR EFFECTIVE INVESTIGATION TECHNIQUES

1.19.1. Assemblage of parts of the aircrafts

The wreckage of both aircraft was moved temporarily in an area inside the airport formerly used by helicopter operations; the wreckage parts were piled up for an initial inspection and piece sorting. Subsequently they were transferred into a hangar where an assemblage of significant parts took place for the purpose of analyzing the correct sequence of events during collision and impact.

The wreckage of the MD-87 has been secured with the aid of a tubular structure along the main longitudinal axis for the assemblage. The right wing, due the space available in the hangar, has been adjusted parallel to the main aircraft body, where it was still possible to conduct impact sequencing and interaction analysis useful to understand the dynamics of the event.

The Cessna wreckage was placed horizontally on the bare floor and tentatively assembled correctly as far as possible for the same purpose.

The method adopted and the resulting reconstruction scenario has been useful for the correct sequence of events determination; the method of comparing and checking a number of significant pieces of evidence, notably the assessment of the physical (mechanical) interaction of significant elements from the numerous wreckage parts recovered.

The analysis and comparison of wreckage fragments and DFDF/CVR data made possible events identification, their sequence and their presumed interaction as reported extensively in paragraph **1.12. WRECKAGE INFORMATION** (see attachment AQ).

1.19.2. Milano Linate radio test (frequency 121.50 MHz)

On March 4, 2003, a test was conducted on the emergency frequency receiver, 121.5 MHz of the Milano Linate Tower.

The test was conducted at the presence of the Investigator-in-charge and the TWR controller in charge for the Operations Office of the SAAV (previously CAV) of Milano Linate. It was found that when the volume control (rheostat) is set at position **minimum**, the ELT signal was readable from the adjacent (GND controller) console, moving away from that position, the sound

decreased gradually and at a distance of five meters it became inaudible. With the volume control set at **maximum**, the sound was clearly audible all over the TWR room.

1.19.3. Equipment survey at fire station facility

During the survey it has been found that incoming telephone calls at FSCC were not being recorded; activation of the automatic emergency alarm had to be transferred manually by an operator; it is then relayed to an acoustic and visual device inside Operations centre; all vehicles were equipped with two service radios, the first one was tuned on frequency 440.450 MHz, the second was tuned on 73.950 MHz (channel 20). The latter, exclusively accessed by firemen and their Operations center, was in use for specific operational purposes.

CHAPTER II

ANALYSIS

2. ANALYSIS

In analyzing the documentation available and in consideration of the complexity of the interactions that were identified, the reconstruction of the chain of events sheds light on the causes that led to this accident.

The factual evidence available to this date has been documented in Chapter I.

With reference to the ICAO model, this investigation has focused on the three factors that are recognized to be conducive to accidents: the technical factor, the environmental factor and the human factor. To some extent they may all be present, but in this case two are more evident and intermixed, human and environmental factor.

The reconstruction of the accident has been made possible after analysis of:

- radio communications of Milano Approach, TWR and GND frequencies;
- transcription of communications exchange on service radio frequency;
- transcription of telephone calls exchanged on all phone lines connected to TWR;
- MD-87 CVR communications transcription;
- MD-87 CVR sound analysis;
- MD-87 DFDR data analysis;
- Tower controllers declarations to the magistrate conducting the judicial inquiry;
- analysis of aircraft parts after cleaning of the runway and wreckage reassemble.

Other deductions were made by logic connection of the above mentioned elements.

The directly involved persons from ATC were not available to be interviewed by ANSV due to their involvement in the judicial inquiry running parallel to the accident investigation.

2.1. PRE-ACCIDENT CIRCUMSTANCES

Events reconstruction was made possible through the analysis of radio communications exchanged on Milano Approach, Linate Tower, Linate Ground frequencies; testimony of persons directly involved and others who were in the knowledge of facts directly related to the events; data recovered from DFDR and CVR of the MD-87 and analysis of available documentation.

Other deductions were possible from comparison and logic connection of available elements.

2.1.1. Environmental situation

Analysis of the situation suggests that the meteorological conditions of the day of the accident have been instrumental in determining the work performance of the controllers, the pilots and the rescue operations. The airport physical structure and organization is also to be considered in strict relationship with the course of events.

As it has been reported the prevailing weather conditions were that of a foggy day and at accident time the Runway Visibility Range was not more than 200 meters.

Reduced visibility, the number of traffic movements as allowed by the “Visibility 2 condition” interpretation in compliance with published regulation (see paragraph **1.10.6.4. ENAV DOP 2/97**), the absence of adequate instruments to effectively monitor aircraft position, the personnel shifting, all contributed to complicate TWR controllers work.

Cockpit workload for the MD-87 crew was apparently normal and professionally handled reflecting the existing operational conditions. Pilots conversation and performance do not show evidence of particular taxi difficulties or lack of positional awareness from start of taxi to runway line up.

Cockpit workload for the Cessna crew cannot be evaluated since no recording system was available. From the R/T recordings available, it can only be said that no difficulty has been reported during taxi in connection to the visibility.

It can only be presumed both that the decision to land in Milano Linate arriving from Köln and the following decision to depart for Paris Le Bourget in violation of regulations, may have been subject to commercial pressure.

2.1.1.1. Aerodrome facilities - Signage and other ground aids

a) Publications

The investigation team finds it remarkable that holding positions marked on taxi way R5 and R6 were missing in officially published documentation. It is evident that data missing in the publications to Air Operators can contribute to accidents and incidents. In general, the risks they pose are not immediately affecting Flight Safety but for planning purposes they are needed. Since the Aerodrome had not published Runway Holding Positions for runway 18R/36L, parallel to and with connections to the main runway 18L/36R, these discrepancies contributed to the accident in such a way that neither the Cessna crew nor the Air Traffic Controller in position had the right information or the cues to receive position reports or to give actual position information.

b) Lighting

An Aerodrome with the capacity to offer LVO under ILS-CAT III B conditions has a strict requirement to be equipped accordingly. As mentioned in paragraph 1.18.3. ICAO Annex 14 Standards and Recommendations, the following installations and measures are required for prevention of runway incursions:

- Runway Guard Lights;
- Taxiway Lights;
- Stop Bars;
- Runway-holding Position Markings;
- Surface Movement Radar;
- Air Traffic Controllers.

As found during the investigation at Linate airport:

- Runway Guard Lights (RGL) were not present;
- Taxi lights were not controllable and sectionalized;
- Stop bars were not controllable;
- Surface Movement Radar was absent.

This means that four out of six installations and measures for prevention of runway incursions were missing.

Runway Guard Lights (RGL) should under certain conditions be installed on every taxiway connected to the runway as the last resort to remind a flight crew that they must have a clearance to continue before entering an active runway.

Taxiway Center Line should be sectionalized in coherence to ATC clearances and taxiway usage as needed for different limits depending on use of runways and intermediate holding positions. A further requirement for LVO is that taxiway center line lights (green) should be installed on the taxiway continuing onto the runway and serve as lead-in lights from the taxiway entering a runway. These lights, from the runway to the taxiway, must be color coded in alternate green and yellow to show either ILS critical area or the lower edge of the inner transitional surface. This is relative to how the usage of the taxiway is decided.

The Cessna crew followed the green centre-line lights on the taxiway and was cleared to cross the lit red light bar because the Ground controller believed that the aircraft was on TWY R5. ATC had no immediate possibility to switch the bars or taxiway center line lights and could not monitor aircraft ground movement with a radar. The above-mentioned requirement to operate in low visibility, has to be put in context with the deficiencies observed and reported below regarding signs.

It must be recalled that the visibility conditions were poor with an estimated visibility of 50 –70 meters (RVR 200 meters). In relation to the actual situation at Milano Linate aerodrome the markings, signs and lights on the apron and taxiways must be considered together for their possibility of giving correct cues and information to the crew.

The analysis above gives room for the conclusion that the Cessna crew was not aided properly with correct cues to enhanced their positional awareness. The failure of the aerodrome to comply with requirements in this matter has contributed to the accident.

c) Signs

As can be seen from the photographs in Chapter **1.10. AERODROME INFORMATION**, signage was not satisfying the standards in ICAO Annex 14 in many cases. This includes lack of direction signs, instruction signs, location signs and "No Entry" signs. Furthermore, the few signs that were present were partly hidden in grass or difficult to read.

The lack of position, direction, location signs and proper markings on the West apron were three factors that made situation awareness for the Cessna crew difficult. When Cessna commenced taxiing, albeit in the wrong direction, position and direction signs were missing all the way up to the only and final sign **CAT III** before entering the main runway 18L/36R, the active runway. Further on, taxiway designators showing **R6** along the taxi route would have served the purpo-

se of a “trigger” to the Cessna crew. So would also a “runway vacated” sign 150 meters from the center line of the main runway 18L/36R.

Although the runway 18R/36L is not intended for instrument use, runway-holding position signs would have served the purpose of triggering the position to the crew.

As mentioned above the Runway-holding positions from S1 to S5 were unknown to ATC. It is easy to realize the difficulties ATC personnel may face when controlling aircraft on ground movements if the aerodrome maps in use do not correspond to the physical situation. In addition to have correct maps available ATC personnel should be given repeated opportunities to visually inspect all signs and markings on the runway and taxiway systems. It has not been able to establish that this has been the case for the Milano Linate controllers.

d) Naming

When it comes to the matter of naming the runway and taxiway system in combination with signage and markings, guidance is found in the ICAO Aerodrome Design Manuals on how to reach a practical solution. In this respect it is recommended to start with a defined point in the runway system with clockwise designation of aprons and taxiways and use combinations of letters and numbers as stated in ICAO Annex 14; avoiding the use of **MAIN**, **EAST** and **WEST** (apron, runway, taxiway, etc,...) and so forth.

The actual naming at Milano Linate aerodrome did not consequently meet this recommendation. As Milano Linate aerodrome has two runways but only one to be used under LVO conditions, the signage and designation of the runway system should have been such that confusion to pilots is avoided by the use of proper signs and designations.

e) Equipment and installations

Surface Movement Radar to be used under LVO is only one means of compliance for the safe ATC operation; other sensors can accomplish the same. It should be mentioned that these types of sensor equipment are at the present time only used for surveillance purposes. It should be pointed out that Milano Linate ATC would have had a better chance of detecting aircraft during prevailing conditions at the time of accident.

The risk contribution caused by the absence of Surface Movement Radar is assessed also in the parallel investigation of the performance of the ATC but in this case it is fair to assume that the absence of such equipment moderately contributed to the accident. Considering the enhancement of flight safety contributed by a Surface Movement Radar the investigating team finds it remarkable that a new radar had been a project since 1994 but was still not operational and that Milano Linate aerodrome has not had a functioning Surface Movement Radar since November 1999.

The Cessna was instructed to follow a path with no adequate signage and markings to allow their identification. The absence of radar monitoring capability and the absence of an anti incursion efficient system allowed the aircraft to cover a path that the controller could not monitor (identify). The presence of markings **S4** and **S5** unknown to the controllers added to the confusion evident in the radio communications.

2.1.1.2. Organization and management

As is common for all international airports of the same category to which Milano Linate belongs, many administrations, organizations and operational units were supposed to carry out their duties in a coordinated manner.

The operational situation at accident time can be depicted as –inadequate- and was the result of the complex management and handling of the whole organization.

At Milano Linate airport, procedures responded to regulations derived from ICAO documents and recommendations, ENAC orders and instructions, ENAV documents, airport director Orders.

It has been found that in many instances, some regulations were not in conformity with the documents they referenced or contradictory; in other cases they were not clearly intelligible and self-explanatory and furthermore some were worded in a generic and unclear way.

A typical example is to be found in Order 35/97, where mention is made of a *stop bar (barra di arresto)* which could easily be confused with the same name **Stop bar** worded in ICAO documents but in effect the Italian document referred to elements installed and (physically) present at the airport which were quite different from what the ICAO definition implied.

Another example is to be found in ENAC's deliberation n. 18/99. It laid down norms and guidelines to airport directors aimed at inspiring their inspective role and function, in conformity to Italian Navigation Code articles 801 and 802. The document also required DCA to issue detailed internal instructions towards their enforcement by DCA officers.

To conform to the above mentioned deliberation, on November 10, 1999 the Linate airport director issued a document (reference 3744), in which inspection examples were illustrated. One of the paragraphs specifically referred to General Aviation. Its wording unequivocally stated:

General Aviation flights will be cleared automatically except following an explicit intervention of the officer on duty.

The Cessna was certified to operate in CAT I and the flight plan stated that the pilot was only qualified for CAT I operations. Operation of the aircraft in reduced visibility conditions should have alerted airport authorities and induced some checking.

In DOP 2/97 issued by ENAV, instructions were detailed about the applicable procedures to be implemented at airports not equipped with ASMI and in low visibility conditions.

The classification usable to determine the visibility conditions reported in the official documentation already mentioned, stated for:

visibility 3 condition - visibility not sufficient for pilots to taxi autonomously...

had been amended in three successive instances after the accident occurred:

- RVR visibility of 400 meters or less... (October 22, 2001)
- Visibility below 200 meters or less... (November 9, 2001)
- **below 150 meters...** (November 14, 2001)

It is interesting to analyze available statistics showing the RVR readings for Milano Linate airport during the period 1996-2000:

Year	1996	1997	1998	1999	2000
Observations total	15.837	14.245	16.572	16.364	16.850
RVR > 400 meters	98,31 %	98,08 %	98,14 %	96,99 %	97,43 %
400 meters > RVR > 200 meters	1,04 %	0,74 %	0,76 %	1,41 %	1,21 %
200 meters > RVR > 150 meters	0,44 %	0,65 %	0,68 %	0,97 %	0,91 %
RVR < 150 meters	0,21 %	0,53 %	0,42 %	0,64 %	0,45 %

In analyzing that data it can be concluded that the visibility assumed for reference in DOP 2/97 as amended on November 14, 2001, 150 meters, would allow Milano Linate to be operational without any traffic limitation for most of the year, even in the absence of a ground movement radar.

However, the actual state of signage and anti incursion systems installed at the airport, at this report publication date, are significantly different from the situation existing at accident time (see attachment Y).

2.1.1.3. Operations

The MD-87 crew operated in accordance with SAS operations manual.

No discrepancies were found between its content and recognized international flight standards.

According to the Cessna aircraft owner, the crew operated in agreement with private flights rules. In any case the Cessna crew should have operated in accordance and within the limits prescribed for ILS CAT I weather conditions.

2.1.1.4. Aircraft capability

Both aircraft were equipped for the type of operations for which they were certified. No malfunctions had been notified that should have deserved analysis.

The MD-87 was equipped and certified for commercial flights including low visibility down to ILS CAT III-A minima.

The Cessna was equipped and certified for commercial and private flights down to the visibility required for ILS CAT I minima.

2.1.2. Personnel

Audition and interviews during the course of the investigation, from early stages to late interviews (during auditions of witnesses), indicate an accumulation of emotional stress in the aftermath of the event for many of the persons involved. It has been found that many individuals suffered from deep and significant symptoms of what it is believed to be emotional stress. This, particularly applies to operators that were directly and immediately exposed (air traffic controllers) to the event and subsequent (post event) operational aspects.

From testimonial and unsolicited declarations of individuals (air traffic controllers) who were exposed to the event, it is assumed that a significant amount of stress was accumulated causing immediate negative effects and perhaps still causing anxiety and other psychological consequences to the detriment of their actual job performance.

There is no specific regulation that takes care of that aspect in relation to safety of operations, but it is known that at European level for instance, the problem is being identified and studied. Eurocontrol also has been active in promoting studies and information papers, including statistics. According to what is widely understood, there are three kind of operators who suffer mostly from exposure to air disasters:

- passengers and crew who have been exposed directly;
- witnesses, air traffic controllers, search and rescue operators (firemen, doctors, etc...);
- relatives of victims.

All personnel exposed may have had a different exposure ranging from personal feeling (victims relatives) to perceived responsibility burden (controllers). The highest the involvement the most acute the effects will have developed. Statistically, a very number of the individuals that were involved in an accident will have developed an emotional reaction within the next 24 hours.

Among them, a significant minority, not having received a psychological support, have shown stress symptoms lasting from six months to a year after the event; furthermore, severe reactions have been recorded in a few cases.

Emergency crew should have received specific training to cope with the psychological effects of accident scenario exposure. Other personnel involved are not normally prepared to such traumatic exposure and should need post-accident psychological support.

It is difficult to evaluate the impact of post-accident stress induced in all involved and to relate it with safety of operations during their subsequent normal working activity. The opportunity for a psychological support offered to such individuals is to be addressed. The lack of which may result in a degraded condition which is not conducive to a mental fair and objective judgment capacity. Such a measure would not only ensure regularity of operations but would have beneficial effects on safety.

Comment: the station manager of SAS received such assistance immediately after the event and for a period he has enjoyed an adequate rehabilitation assistance (see attachment AR).

2.1.3. The Boeing MD-87 and the crew

The MD-87 was airworthy and equipped for the intended flight. Maintenance had been performed by an approved JAR 145 organization.

Pilots were holding all necessary licenses and were qualified to operate in low visibility conditions including low visibility takeoffs and ILS CAT III-A approaches.

2.1.4. The Cessna 525-A and the crew

The Cessna was a brand new aircraft, registered on September 2001. It was owned by a German private citizen and on request to be registered to the AOC of Air Evex which was owned by the same German citizen. The owner of the plane declared that he had organized the flights (transfer of the aircraft from Köln, Germany to Milano Linate for an intended flight to Paris Le Bourget and back to Milano Linate). The pilots were on contract with Air Evex, but according to the owner, at his request the day of the flight they were acting outside of their normal employer shift of duty to perform the private flight.

Documentation obtained during the investigation shows that the Cessna Company had asked for Air Evex to perform a demonstration flight from Milano to Paris and back for an agreed payment. Based on this evidence, as reported in paragraph **1.5.1.3. The status of the Milano Linate**

to Paris Le Bourget flight, it is possible to assume, in contrast with the declaration of the owner of the aircraft, that (see attachment I):

- that the nature of the flight was **commercial**;
- the designated PIC could legally operate the commercial flight;
- the designated co-pilot could legally operate the commercial flight;
- the crew could not operate (takeoff) with visibility lower than 400 meters;
- the crew could not perform ILS CAT II/III operations.

The Cessna aircraft was operating normally and no malfunctions had been filed; unfortunately, but consistently with regulations (still) current, it was not equipped with any recording device. The crew held qualification for ILS CAT I landing minima (minimum visibility of 550 meters). Both pilots were qualified as PIC on the Cessna 525

The pilot acting PIC on this flight had landed 5 times in Milano Linate, twice in year 2000, therefore it is assumed that he had a sufficient knowledge of the airport layout.

The pilot acting co-pilot had landed 7 times in Milano Linate from 1999 to accident time, twice in year 2001; therefore it is believed that he was more familiar with the airport layout.

No documentation has been made available that would indicate if any of the two pilots had received low visibility operations training and qualification; specifically, no training and no qualification for takeoff in visibility below 400 meters.

2.1.5. ATC situation

Based on findings obtained in this investigation, it is recognized that the licensing and qualification of controllers was not fully conforming ICAO Annex 1. Furthermore, that ATM was not responding to Safety Management System criteria such as they are now being developed by ECAC States who shall collectively introduce the additional requirements contained in Eurocontrol Safety Regulatory Requirement (ESARR) documents.

Operational situation inside TWR, at accident time, was to be considered complex due to meteorological conditions and the number of aircraft assisted. Furthermore a personnel shift occurred at 06.00 by which three of the five controllers were substituted.

It is possible to presume that at accident time the supervisor controller, CSO was momentarily absent; testimony available indicates that at 06.11:00 hrs (39 seconds after the collision) he was present (see attachment AS).

Therefore, according to DOP 2/97, the visibility condition present at Linate airport at the moment of the event were those described by **Visibility 2 conditions** and rendered the prescribed procedure applicable. The assumption is based on the fact that none of the crew operating at that time: AZ 410, AZ 2021, AZ 2017, AP 935, AZ 1719, AZ 2019, AZ 226, AP 937, I-LUBI, D-IEVX, LX-PRA, I-DEAS, SK 686, had declared taxiing difficulties attributable to low visibility. If that had occurred, the controllers would have evaluated the necessity to switch to **Visibility 3 conditions** and applied the required procedures for the condition.

The GND controller, from 05.54:23 hrs when the MD-87 requested taxi clearance from parking stand A 13, to 06.10:21 hrs, collision time, had assisted nine aircrafts in the takeoff sequence and two after their landing for a total of eleven movements in nearly sixteen minutes. During that time he had handled 126 radio communications.

The TWR controller, from 05.58:43 hrs to 06.10:21 hrs had assisted five aircrafts in the takeoff sequence and one landing aircraft (plus another aircraft who enquired about visibility conditions on the runway); a total of seven movements in eleven minutes. During that time he had handled 73 radio communications.

Scrutiny of the movements at event time shows that from 05.10:47 hrs to 06.10:27 hrs, the following movements are recorded.

Twenty-one movements from the aprons to RWY 36R: SN 3154, AZ 2015, AP 933, IB 4657, AZ 2017, IG 254, SA 935, AZ 1719, AZ 2019, AZ 226, AZ 2021, SK 686, AP 935, AZ 410, I-LUBI, LX-PRA, I-DEAS, D-IEVX, AP 937, OS 222, SIRIO 0051.

Three movements from RWY 36R to apron: AZ 2008, AZ 1278, AZ 2010.

Twenty-four movements in total were controlled in the hour preceding the event.

Aircraft movement control was made demanding because of the absence of a ground radar to assist, the absence of other devices that would have allowed a positive control of aircraft and other vehicle position (runway anti incursion system, controllable Stop bar, taxiway lights subdivision by sector) and by the absence of a meaningful signage, especially on the West side of the airport.

ICAO DOC 9476, page 2-1 defines *traffic density heavy* when the number of movements is 26 or more per hour.

The same ICAO document states that in *traffic density light*, when the number of movements is less than 16 per hour, the *visibility 3 condition* (visibility less than 400 meters), could not be applicable to Linate airport because other compulsory requirements were not met (stop bar, adequate lighting equipment, etc.,..).

2.1.5.1. R/T communications

During analysis of R/T communications, a transmission (call) of uncertain origin was recorded on TWR frequency 118.1 MHz. The timing is about 12 seconds after first collision **06.10:33**, lasting ca 0,5 second (11,7 second after sound of first collision, 11,1 second after last sound of collision on CVR).

It is known that when a transmission from an aircraft or ATC stops a transient is left with the last sound, like a fingerprint; therefore analysis of such recorded transients were carried out for a comparison test.

From comparison with the MD-87 DFDR registrations, VHF 1 keying, it was possible to assume with good probability that the brief transmission recorded was originated by the MD-87 radio (see attachment AU).

2.1.5.2. Taxi clearances

The following analysis was developed from the communications transcription of West apron traffic on October 7 and 8, 2001 on GND frequency 121.8 MHz; it is aimed at understanding factually the wording of the *taxi clearance* instructions issued by ATC and their acknowledgement, *read back*. Only traffic using West apron is involved in this selection.

For a better understanding, only selected relevant communications have been listed (and numbered for ease of understanding); they have been grouped by aircraft and not in their chronological transmission order and they have been numbered to facilitate the analysis.

Analysis of the phraseology

- a) The word *main* (*principale*) has been used without discrimination when issuing clearances to mean both RWY 36R and the North apron.
- b) The words *report the stops*, *report the bars*, *report at the stop-bar*, have been used both in clearances involving TWY R5 and TWY R6, without any other clarification or identification for the route to be followed.
- c) Wordings like *report before crossing* and *entering main*, have been used alternatively in conjunction with clearances referring to TWY R5 or TWY R6.
- d) The words used both by controllers and pilots to identify positions and taxiways were not in conformity with the information reported in AIP Italy, the following were used: *main apron*, *main*, *main runway*, *main apron*, *stop*, *bars*.

- e) To identify the West apron (reserved for General Aviation flights), controllers referred to it alternatively using the words: *General Aviation*, *ATA*, *West apron*; only one identifying name is reported in AIP Italy, the *West apron*.
- f) To identify the North apron (reserved for Commercial flights) controllers referred to it alternatively using the words: *Main parking*, *main (principale)*, *main apron*; the apron is referenced on AIP Italy as *North apron*.

Clearance confirmation, read-back

Pilots have acknowledged all taxi clearances issued by controllers, but when the read-back did not conform to the clearance, the controller failed to recognize and correct the difference.

- In seven instances read-back were missing part of the clearance (4, 8, 10, 11, 14, 18, 22).
- In four instances the entire clearance was missing from the read-back (9, 13, 15, 17).

(See attachment O)

The factual recollection and analysis suggests conclusively that:

- 1) the phraseology used consistently did not conform to the standard;
- 2) had often been open to pilot interpretation;
- 3) frequently, the read-back procedure had not been implemented;
- 4) English language had not been used consistently;
- 5) in some instances deformity has been recognized between the instructions issued by the GND controller and the information available to the pilots;
- 6) terminology used throughout, identifying RVR readings was not the standard ICAO: ALPHA, BRAVO and CHARLIE were consistently used instead of the ICAO wording TDZ, MID and STOP-END.

Moreover the wording **main taxiway** was not referenced as such in the AIP charts (there was no denomination) for the taxiway parallel to the RWY 18L/36R. Consequently, SAS Flight Support charts, used by the MD-87 crew and the Jeppesen charts used by the Cessna crew also did not show a denomination for that taxiway.

Above mentioned observations and analysis indicates that the internal quality assurance was not functioning properly in the Tower.

2.1.6. Meteorological situation

The meteorological situation existing at event time was substantially coherent with the forecast.

2.2. MILANO LINATE AIRPORT

Milano Linate airport had two distinct areas of operations: one used by mainly Commercial aviation traffic (North apron) the other used mainly by General Aviation traffic (West apron). There is a distinct difference in how the East side and the West side of the Milano Linate airport has been treated with regard to visual guidance measures and the provisions given for ATC to have optimal possibility to conduct safe operations. It is necessary to mention that both sides of the aerodrome should have the same standard if operations had to continue under LVO conditions. At the time of the accident, Runway Visual Range (RVR) was less than 200 m, and this value was measured with high intensity runway lighting in use and a light output that is considerably higher than what can be expected at other positions at the aerodrome. The meteorological visibility would then be around half that value or lower. This was a difficult environment in which to taxi and maintain positional awareness, both on the West apron and on the taxiways, without the required signage.

2.2.1. Safety Management System and Manuals

The management and operational situation at Milano Linate aerodrome was complicated and involved the three major organizations. This was a complex system and special measures would be needed in order to have an efficient Safety Management System in operation. ENAC, ENAV SpA and SEA interacting with each other, would have required an adequate safety management system and a regulated operational coordination. ENAC was the regulator authority but also responsible for the management and operations of the aerodrome. ENAV and SEA were separate suppliers of ATC and ground handling.

The lack of a centralized safety management system may have caused the lack of official documentation update, a contributing factor in the chain of events described in this report.

As stated in paragraph **1.18.4. Safety Management System**, the basis for a safe operation of a major aerodrome is a well functioning Aerodrome Safety Management System including an Operation Manual. To the knowledge of the investigation team there was no functional Safety Management System in operation at Milano Linate aerodrome. Neither within the aerodrome man-

agement nor in any of the major organizations involved. No Operational Manual had been established and no Quality System Requirements had been incorporated and put into operation. No performance agreements seemed to exist between involved organizations regarding safety matters.

The absence of a specific culture and of a functioning Safety Management System has limited each actor at the aerodrome to see the “overall picture” regarding safety matters. Instead there is evidence of a lack of coordinated efforts, which proactively should have been handled by ENAC through an Aerodrome Safety Committee – CASO (“Comitato Aeroportuale per la Sicurezza Operativa”) and with procedural descriptions in an Operations Manual. Also Performance Agreements between the parties involved should have provided grounds for safe aircraft operations. One key tool in the Safety Management System is a well functioning reporting system and consequent remedial actions following. The reason for not having a proper reporting system can be blamed on the consequences of the punitive environment that exists. It can be said that a no blame culture for individual mistakes, set aside intentional deeds, in an operational situation encourages occurrence reporting and corrective action for maintaining safe operations.

Apparently there were different types of meetings (CASO) and activities where different operational matters were handled that were not directly related to safety issues. However, without specified procedures, scheduled activities, responsible post holders etc. as specified in ICAO Annex 14 Standard and Recommendations, that was not enough. Safety audits were also performed on an ad hoc basis. The result was poor communication between the organizations in safety matters, late decisions and slow handling of safety issues and loss of important information from operations with respect to incidents and deviations.

It also means that the Milano Linate aerodrome did not meet the flight safety standards specified in ICAO Annex 14 which is remarkable considering it being a major international aerodrome.

It is the opinion of the investigating team the absence of a functioning Safety Management System is the main cause for most of the discrepancies found and should be considered as one of the main contributing factors to the accident.

2.2.2. Aerodrome facilities

a) Publications

Procedures to be adopted were complex and not adequately described; this is evidenced by the following extracts from Orders, Service Orders and AIP Italy documentation regarding to TWY R5/R6 movement prescriptions.

Order 2/85 published on November 29, 1985

During CAT II/III operations, taxiing aircrafts to/from West apron shall be mandated by TWR to stop at the Stop sign at taxiways R5 and R6.

Order 2/85 as amended on January 25, 1986

As a partial modification to the Order, Art. 7, and the provision therein contained, in case of Cat II/III operation, aircraft coming from ATA should be stopped only at the Stop situated on taxiway R6 and not as erroneously indicated in Art. 7 also at the Stop on taxiway R5.

Order 35/97 published on November 7, 1997

In order to ensure, that during takeoffs from Runway 36R and landings on Runway 18L, no aircraft or other vehicle is present on the portion of taxiway 5 corresponding to the extension of Runway 36R, the TWR shall instruct traffic taxiing on R5 to stop at the Stop bar before the crossing.

AIP Italy documentation valid from April 22, 1999

Aircrafts to/from Linate West (ATA) will be stopped by TWR at the Stop signal on TWY R6.

And:

In accordance with DGAC provision N.42/1693/A3/4.1 dated November 5, 1997, all aircraft before taxiing on the part of TWYL R5 located along the extension of RCL RWY 36R, must request and obtain specific clearance from the ATC.

To summarize:

- aircraft to/from ATA (West apron), shall always be stopped at TWY R6 STOP;
- aircraft shall always request and obtain clearance to ATC before crossing runway 36R extension.

It is important also to mention here that the wording of Order 35/97, required that traffic should stop at the **Stop bar** (*barra di arresto*). The markings present could not have had that denomination since they did not conform to the description in ICAO Annex 14.

Moreover the instructions of this document (AIP Italy documentation valid since April 22, 1999) contained rules that were not solely applicable to General Aviation aircraft but also to Commercial aircraft and again:

Aircrafts to/from Linate West (ATA) will be stopped by TWR at the Stop signal on TWY R6.

The instruction could be interpreted as constituting an obligation for all traffic to/from West apron to follow TWY R6.

Therefore the procedure could be interpreted in two ways:

that in low visibility conditions aircraft should taxi via TWY R6 exclusively;
in low visibility conditions all aircraft could taxi via TWY R5 or TWY R6.

It can also be assumed that pilots, conversant with internationally known standards, may have been confused by the improper definition of a Stop bar not recognizable as such (ICAO standard).

The other instruction to be read in the same paragraph - *TWYL R2 and R3 must be not used* - clearly forbid to taxi on the taxiways; but it could also be interpreted as an explicit instruction to back-track on the runway after taxiing via TWY R6 for the purpose of reaching the line up position of RWY 36R and not on TWY R2 or TWY R3 (perhaps to avoid conflict with traffic occupying the taxiway parallel to the runway).

b) Signage

Markings and signs, as described in CHAPTER I of this report, were not in accordance with ICAO Annex 14 which recommends the adoption of:

- *direction signs;*
- *instruction signs;*
- *location signs;*
- *no entry signs.*

The lack of adequate signage may have contributed to make situation awareness difficult for the Cessna crew during taxi; it should further be noted that for the entire taxi path there was no sign indicating TWY R6. On that taxiway, before crossing the extension of RWY 36L there were no holding position type A markings.

The absence of information available to controllers about the S1, S2, S4, S5, S5 markings added difficulty for the controllers to assess aircraft position on the maneuvering area.

In ICAO *Aerodrome Design Manuals*, precise guidelines are offered for the correct denominations to be used at all airport locations. The naming of taxiways at Linate airport did not conform with the above.

Use of surface movement radar is one way of creating a safe aircraft operation during LVO. Other movement sensor systems can also be of assistance. Unfortunately, neither the surface movement radar nor the other sensors system were in function at the time of the accident. It should be pointed out that had these been operational, Milano Linate ATC would have had a

better chance of localizing aircraft during LVO.

As reported, at the time of the event runway visual range (RVR) was less than 200 meters and this value were measured with high intensity runway lighting and at a light output. In other parts of the airport, the visibility will have been around half that value or lower.

The analysis above gives room for the conclusion that the aerodrome did not meet the requirements for LVO under ILS CAT III-B conditions. The Cessna crew was not aided properly with correct markings, lights and signs that would have enhanced adequate positional awareness. The available airport charts also did not fully reflect the markings, lighting and signs in existence on that day.

c) Lighting and runway anti invasion systems

An aerodrome with the capacity to offer LVO under ILS CAT III-B conditions has a strict requirement to be equipped accordingly.

The following installations and measures are required for prevention of runway incursions:

- runway guard lights (RGL), should be installed on all taxiways which connect to runways to warn the pilots that a specific clearance is to be obtained before entering;
- taxiway lights, selectable in coherence with taxi instructions; furthermore they should be green/yellow color-coded at runway intersection;
- stop bars, selectively controlled in coherence with taxi instructions;
- runway-holding position markings;
- surface movement surveillance radar.

At the time of the event, at Linate airport, runway guard lights (RGL) and the sectionalized taxiway green lights were not installed.

Taxiway center line should be sectionalized to allow controllers to issue instructions visually intelligible to the pilots with regard to ATC clearance limits (lights ON, lights OFF). The Cessna crew followed the green center line lights on the TWY R6 and had been cleared to cross the bar lights because the controller believed that the aircraft was at the runway 36R extension, on TWY R5.

It must be recalled that the visibility conditions were very poor; it can be affirmed that the pilots were not helped by visual aids; they had to cross a red lights bar that could not be switched off. On the other hand ATC did not have the possibility to follow the aircraft ground path, surface

movement radar being out of service and the absence of other warning sensors.

It can be concluded that the Cessna crew could not avail of the required aids that would have helped in overcoming the mental expectancy they were following and therefore they were unable to achieve a correct positional awareness.

The aerodrome did not meet the requirements for LVP under ILS CAT III B conditions. The failure of the aerodrome to comply with requirements in this matter was a contributing factor to the accident.

2.3. EVENTS PRIOR TO THE COLLISION

2.3.1. The Boeing MD-87

2.3.1.1. ATC/MD-87 communications

ATC GND/MD-87 communications were conducted using standard phraseology and read-backs were correct. CVR recordings indicate normal cockpit operations were carried out in an orderly manner.

The MD-87 crew switched from GND frequency 121.8 MHz to TWR frequency 118.1 MHz at 05:59:44 hrs and contacted TWR at 06:01:24 hrs.

The Cessna crew asked taxi clearance to GND frequency 121.8 MHz at 06:05:27 hrs; approximately four minutes after the MD-87 had left that frequency and was in contact with TWR on frequency 118.1.

The MD-87 crew could not have known about the Cessna's movements.

2.3.1.2. The MD-87 takeoff status

Significant post accident cockpit items are listed in paragraph **1.12.2.1. Other significant cockpit items**. The possibility of displacement of switches, etc at impact with the baggage building or during the rescue work of course cannot be ruled out. However, below analysis summarizes the MD-87 status at the collision with the Cessna as a standard takeoff without any abnormal readings or settings.

- The Nose Landing light switch was in BRIGHT position (normal for take-off).

- The Wing Landing light switches were in EXT, but not ON position (normal for take-off in fog and according to SAS Flight Operations Manual).
- The LH panel airspeed indicator needle was indicating 0 knots consistent with a loss of airspeed (total air pressure) to Air Data Computer 1.
- The Right panel airspeed indicator needle was stuck on a 149 knots indication, consistent with a sudden loss of electrical power to the airspeed indicator. The indication is very close to the airspeed as recorded by the Flight Data Recorder at the time of collision with the Cessna, where the loss of Right Engine resulted in the loss of electrical power from the Right Generator system. The shortcuts activated the AC Cross-tie lockout function, thus preventing connection between RH and LH AC Systems.
- The LH throttle and reverse lever was in the MAX REVERSE position, consistent with Flight Data recordings and the reverse buckets actual position.
- The RH throttle was in a position slightly forward of idle, which is normal for an engine failure situation.
- The Landing Gear handle was not found in its normal place in the cockpit, however the DFDR readout and actual landing gear positions confirms that the Landing Gear was down and locked.
- The flap handle was in or near the flap 40 position which is normal landing setting. The Flight Data however indicates that flaps were between 9.5 and 8.8 from the time of collision with the Cessna until impact with the baggage building. It could be assumed that the flap handle has moved during the impact with the baggage building. If the flaps had been selected to more than 11 degrees the slats should normally have moved to the fully EXT position. The Flight Data show that after impact with the Cessna the LH slats were in the MID position. The RH slats however were recorded to be in a transient position (consistent with the collision with the Cessna's vertical stabilizer) and that a split between LH & RH slats existed.
- The spoiler handle was in the ARMED and DEPLOYED position, which is the normal position after a landing.
- Both FIRE handles were in the forward, not activated position.
- Both fuel levers were in the ON position, indication that no attempt to shut down engines had taken place.

- The LH fuel pump switches (2) were in ON position.
- The CENTER fuel pump switches (2) were in ON position.
- The RIGHT fuel pump switches (2) were in OFF position. This could indicate an attempt to avoid pumping fuel to the position of the lost RH Engine, but can also be a result of accidental handling during the rescue work.
- The EFIS switch were BOTH ON 1 position. Not normal, but consistent with an attempt to restore EFIS indications on R/P Primary and NAV displays when both EFIS screens went blank as all electrical power on the RH AC electrical system was lost.

2.3.2. The Cessna 525-A

The direct reason for the collision between the MD-87 and the Cessna was that the Cessna was on the runway when the MD-87 took off. Two plausible scenarios can be discussed:

- a) the Cessna crew intended to taxi via **R5** but made a navigational mistake;
- b) the Cessna crew believed that they were to taxi via **R6** even though he read-back correctly **R5**.

As described in Chapter I, it is possible to find several contributing factors that give support for both alternatives. The environmental situation for the Cessna crew was definitely such that it was possible to get lost in the dense fog and taxi the wrong way. However, based on the following analysis, the investigating team finds it more probable that the Cessna crew in fact believed that they were cleared to taxi via the path they effectively followed, TWY R6, even though they had repeated the taxi clearance via TWY R5.

Furthermore current regulations in relation to the visibility conditions and the crew qualification, allowed the taxi out for departure, but did not allow to take off with visibility of less than 400 meters. The opportunity to taxi out with visibility lower than required for takeoff is sometimes adopted by crews when rapid improvement is registered but not when visibility readings are stable below takeoff minima (400 meters) as was the case on that day.

2.3.2.1. ATC/Cessna 525-A communications

The Cessna received a complete and correct taxi clearance that would have allowed the aircraft to reach RWY 36R holding position taxiing via TWY R5.

The read-back included the repetition of TWY R5 but lacked the wording *taxi north, stop bar*

and *runway extension*.

When taxi clearance was requested by the Cessna, the Boeing MD-87 had already switched to TWR frequency and therefore it was not possible for the Cessna crew to have any knowledge of the MD-87 position.

About 30 seconds after instructing the Cessna to taxi, the controller issued the same taxi clearance to LX-PRA parked on West apron near TWY R5 adding the instruction to give way and follow the Cessna. The clearance was given in Italian language and it is believed that it could not be understood by the pilots of the Cessna, if they were listening to the communication.

When checking the path followed by the Cessna and analyzing the decision to proceed towards TWY R6 (direction South-East instead of North) upon reaching the branching with the markings R5 and R6, it can be assumed, stemming from the assumption described in paragraph **2.3.2. Cessna 525-A**, that an expectation prevailed in both pilots mind; the expectation that the same path followed at their arrival would be offered to them for their departure. Upon their arrival at Linate, they had requested to back-track and taxied via TWY R6 and their request had been approved. In that circumstance, the denomination *Romeo Six* (R6) had occurred four times in their communications with the TWR; seemingly the exact position of TWY R6, in relation to West apron was very clear in their minds.

The existing visibility range at the branching R5-R6 is not known precisely. The first green centerline light of TWY R6 was positioned at about 80 meters from the branching; if in sight, it could have induced a decision towards the presumed correct path to follow. On the other hand the first green centerline light of TWY R5 would have been at a distance of 350 meters, well away of the visibility range for the actual visibility conditions reported and at a direction far to the left of the pilot sitting at the left hand seat (an angle of more than 90°). The absence of any vertical sign and the poor conditions of the markings visible on the tarmac, may have allowed (confirmed) a conscious behavior oriented by a previous determination.

A watchful evaluation of the Jeppesen charts by the Cessna pilots should have created the consciousness that reaching TWY R5 required taxiing towards the North through the entire length of the West apron, adjoining the parking stands. To reach TWY R6, the right direction pointed towards South-East and the distance to run was much shorter.

During their taxi, upon entering TWY R6, the green centerline lights switched on may have reaffirmed a false expectation in the pilots' mind: a confirmation that they were on the right path.

The spontaneous position report made by the Cessna pilot at *Sierra four*, which was not followed by warnings or negative comments from the controller, may have further confirmed the belief that they were on the right path.

Receiving the position report at *Sierra four*, the GND controller did not express doubts or other indications of not interpreting correctly the position report.

The next report from the Cessna, *Approaching the runway*, further confirms that the Cessna crew knew that they were taxiing on a taxiway heading towards the runway.

The GND controller, expecting that the Cessna was on TWY R5 may have interpreted the pilot reply *Approaching the runway* as an abbreviation of *Approaching the runway extension* and did not express doubts about the position report.

The following cognitive elements were not sufficient to raise doubt in the pilot's mind:

- the clearance received from the GND controller, explicitly inviting to enter the *Main apron*;
- the absence of a clear instruction to cross the runway;
- the fact that they were tuned on the GND frequency instead of being instructed to switch to the TWR frequency to cross the runway.

The firm belief that they were on the right track did not allow the perception of evident warnings. Furthermore, continuing on their taxi on TWY R6 along their path, the bar with red lights on was crossed, the *Stop* sign which was passed by, the ICAO pattern B, then the ICAO pattern A markings that were crossed in succession it is probable that the meaning of all these markings have been interpreted correctly by the crew and fitted with their belief to be on the right path and that they were cleared to enter the runway.

The GND controller had no possibility to switch ON and OFF the red light cross bar and all pilots were used to overrun it after ATC clearance. If that would have been possible, the switching ON and OFF of the red lights bar at TWY R5 and TWY R6 might have exposed the misunderstanding between the Cessna pilots and the GND controller and prevented them to enter the runway.

The visibility (RVR) at MID point (1.100 meters from threshold) had been reported to be 200 meters, twenty-two 22 seconds before collision. At runway intersection, while tuned on the GND frequency and following the lead-in lights, with a visibility of 200 meters available, it is assumed that the crew must have spotted three (characteristic) runway sideline lights (60 meters apart from each other) on the side of the runway and immediately after the runway centerline lights (15 meters apart from each other), definitely confirming that they were entering the runway.

While the Cessna taxied on the conjunction of TWY R6 and the runway, the MD-87 was being cleared for takeoff on the TWR frequency; the Cessna crew, still on GND frequency, could not have known.

2.3.3. Human factor elements prior to collision

This paragraph is based on a study conducted by aviation human factor experts on the wording used by pilots and controllers; it tries to describe the possible mental mechanism triggered and the subsequent induced behavior.

Communications flowed consistently with the meteorological situation and the number of aircraft involved; until 05.54:23 hrs it can only be pointed out that the phraseology used was sometimes questionable, implying familiarity with the airport facilities.

At 05.59:44 hrs the MD-87 was instructed to switch from GND to TWR frequency and at 06.01:24 hrs contact was made with the TWR; from that time the MD-87 became unable to hear instructions issued from GND to the Cessna. The Cessna requested his taxi clearance at 06.05:27 hrs and assumingly remained on GND frequency all through accident time, therefore unable to hear instructions issued from TWR frequency to the MD-87. The communication exchange between GND and the Cessna, the issuance of taxi clearance and its read-back, are believed to be crucial to interpret (understand) the subsequent conduct of the Cessna crew.

The clearance read:

DeltaVictorXray taxi North via RomeoFive QNH 1013 call me back at the stop bar of the... main runway extension

and was spelled out by the controller at the normal pace, but the word **North**, a short word when spoken by an Italian based speaker, inside and within a sequence of other words containing relevant information, may have not been perceived in all its relevance by the pilots. During taxi pilots are normally oriented towards interpretation of airport maps graphical description of the path to be followed and to correlate them with visual clues like tarmac and taxiway markings and signs (painted or lighted) instead of following instrument related information (North).

As a matter of fact the read-back by the pilot did not contain the word **North** and further lacked the repetition of other words, **stop bar** and **extension**, reducing the taxi clearance limit to a basic *...call you back before reaching main runway....*

As worded out, the read-back formally and substantially implied a clearance towards the takeoff runway.

The controller accepted the read back and did not object about the information missing.

Only hypothesis can be formulated to explain the omission:

- the difference between the clearance and the repetition was not perceived (a sign of diffused attention as opposite to focused attention);
- the difference was perceived (a phenomenon known as focused attention) but essential data

extraction **Romeo Five**, is considered to be sufficient;

- it is also possible that the trend adopted (and abundantly recorded in other parts of this report) by the Linate controllers to handle matters confidently when dealing with General Aviation pilots accredited with sufficient familiarity with airport layout and taxi procedures (a phenomenon described as complacency).

It is probable that the Cessna pilots devised an image for their next taxi (a phenomenon known as pre-operational phase of perception) based on recent arrival experience, when they went through TWY R6 towards the West apron.

It is to be noted that all through the time span analyzed, the controller seldom acknowledged the correctness of read-back by pilots. The circumstance was noted by the pilot of OS-222 who explicitly requested confirmation (at 06.00:50 hrs) for the correct read-back of the clearance received.

About seven seconds after the read-back by the Cessna, another communication was initiated by the GND to an aircraft parked on West apron. LX-PRA was cleared to taxi and was given the same clearance that had been issued to the Cessna, but the language used was Italian; this could have prevented the Cessna pilots to question or doubt their presumed intention.

GND communication to LX-PRA took place some 30 seconds after the Cessna received his clearance. LX-PRA was instructed (at 06.06:23 hrs) to follow:

...a Citation, registration marks DeltaIndiaEchoVictorXray, who is also taxiing on Romeo 5...

The Cessna presumably started taxiing at 06.06:00 hrs; LX-PRA was ready to move at 06.06:42 hrs but since he did not see the Cessna passing by, he did not move.

At 06.05:59 hrs the MD-87 was cleared to continue its taxi and, at 06.07:41 hrs cleared to line-up on runway 36R.

At 06.08:23 hrs, the Cessna pilot reported his position to GND with the following words, *...approaching Sierra Four*, a precise reference to the yellow marking visible on TWY R6, which the pilot viewed written upside down.

It is to be remembered that the Cessna had arrived at Linate at 04.59 hrs that morning and the landing runway 36R had been vacated on TWY R6 (at crew request), which leads to the assumption that the crew was conscious of their position and in coherence with the clearance received. Factually, the pilot read-back wording had been:

Roger, via Romeo Five and ...1013, and call you back before reaching the main runway...

and at that moment (position) they were effectively approaching runway 36R when they con-

firmed their position replying to the controller:

Approaching the runway, ..Sierra Four.

The controller's voice intonation asking confirmation of the aircraft's position leaves place to the assumption that part of the message was unclear to him. Probably the words ...*Sierra Four* did not match the controller's mental scheme, but possibly he may not have understood them. The unexpected report ...*Sierra Four* may have not matched his expectation of the Cessna position. Furthermore he may have interpreted the words *Approaching the runway* as an abbreviation of *Approaching the runway extension*.

There is evidence, from the sequence of previous communications and of the others that followed, that the controller was expecting the Cessna to be taxiing on TWY R5 as instructed. From the following communication, in the Italian language, it can be assumed that the controller was convinced about the position of the Cessna.

GND: *IndiaAlphaSierra stand by one, break, LimaRomeoAlpha are you confirming that you already are on Romeo 5?*

LX-PRA: *We were waiting to exit...to see the German coming out, we have not seen him, do you know where he is?*

GND: *He is on the main apron, I should say that you can go.*

LX-PRA: *I should say so, we move.*

In such cases, because of a prevalent mental scheme being formed, it is possible that contradictory messages take a lesser relevance and do not emerge duly (a phenomenon known as confirmation bias).

During that time the TWR controller was handling other communications and was objectively unable to follow what might have been said by the GND controller.

The instruction issued by the GND controller to maintain position at the *stop bar* may have appeared cautious enough since the presumed position of the Cessna on TWY R5. Stopping were instructed would have kept the Cessna on TWY R5 before the interception with RWY 36R extension and clear of what was beyond.

It is also to be pointed out that no mention was made on GND frequency of TWY R5 or TWY R6, in English, after the Cessna taxi clearance issuance and accident occurrence.

Among others, the hypothesis can be formulated that the Cessna crew, conscious of having been instructed to *proceed to the stop bar*, upon reaching the stop bar, had been puzzled by the crossing of S5 and S4 and the position report was seen as an expedient to obtain confirmation for the correctness of the path followed; furthermore, when approaching the stop bar a speedy clearance for its crossing was needed.

At 06.09:19 hrs the Cessna was cleared to continue taxi with the following:

...continue your taxi on the main apron, follow the Alpha line.

It can be assumed that the pilots were conscious of their position relative to RWY 18L/36R, which they had clearly declared.

There is no doubt that the Cessna pilots have seen the red lights when they crossed them and the green centerline lights of the taxiway when they entered the runway.

It is evident that the GND controller believed the Cessna to be at the lights bar across TWY R5; if ever a doubt had been raised in his mind when the words *Sierra Four* were aired, it had by now been suppressed by the succession of events unfolding and by the already mentioned confirmation bias phenomenon (a mental mechanism by which the mental image prevails over other contradictory perceptions -information- received), thus confirming the mental image devised. On the other hand the Cessna pilot replied correctly to the controller, further confirming the mental image perceived:

Roger continue the taxi in main apron, Alpha line the ...DeltaVictor Xray.

At this stage the pilots apparently do not realize the inconsistency between the clearance received and their actual position.

The following hypothesis can be advanced:

- superficial listening attention and stereotyped answer, formally correct but implying partial understanding of a complex message; only the information *continue taxi...* was apparently understood, detached from the full significance of the rest of the instruction: *...continue your taxi on the main apron, follow the Alpha line;*
- belief that by abiding to the instruction they would enter the North apron (a consequence of failure to consult airport chart for lack of perceived ambiguity in the clearance received): *Roger continue the taxi in main apron, Alpha Line the...DeltaVictorXray*, to which the controller replied with a confirmatory: *This is correct and please call me back entering the main taxiway;*

- the immediate response by the pilot is typical of a busy traffic situation, where if any doubt subsisted about **Alpha line** there would be time to clarify later on, after crossing the runway which was perceived as the primary task to abide the clearance. This a habit often developed by pilots during their training, by which the attention is focused towards immediate compliance with a perceived primary task and the deferral of complementary information understanding (clarification) to subsequent analysis;
- the usage by the controller of the words **main taxiway** in lieu of **main apron** could have been interpreted by the pilots as a miss spelling of a word; here again the same psychological mechanism that censors and negates contradictory signals (albeit multiple) when a strong drive towards the perceived object is the leading parameter (a phenomenon known as exclusive orientation to an objective). As absurd as this may be a similar mental attitude is to be recognized widely in accidents where human factor is found to be a contributory factor. As for the **Alpha line**, the pilots could expect to reach it after crossing the runway; however the **Alpha line** as such was not identified in AIP Italy but only on Jeppesen chart 20-9B with an “A” which marked the initial part of the taxiway parallel to the runway south of North apron between the apron and the intersection at TWY R2.
- as for the **Alpha line**, the crew could expect to reach it after crossing the runway; incidentally it was not shown on any AIP Italy documentation; Jeppesen Parking chart 20-9B denotes an “A” on the segment of the parallel taxiway between R1 and R2 leading to RWY 36R holding position (the portion between North apron and TWY R2); however, the “alpha line” referenced by the controller, was the parking stands line West of the North apron which was not reported on AIP Italy;
- the wording **main taxiway** was not referenced as such for the taxiway parallel to the RWY 18L/36R in the AIP Italy charts (there was no denomination for the taxiway). Consequently SAS Flight Support charts, used by the MD-87 crew and Jeppesen charts used by the Cessna crew, both did not show a denomination for the taxiway;
- moreover the next instruction issued by the controller, to call back when on **main taxiway**, may have created in the pilots mind the persuasion that they had to cross rapidly the runway to reach the **Alpha line**, on the **main taxiway**:

GND: *That is correct and please call me back entering the main taxiway.*

D-IEVX: *I'll call you on the main taxiway.*

On the other hand the clearance to continue taxi and the presence of green center line lights continuing at the end of the taxiway, beyond the red lights cross bar, were elements that could leave place to no doubt.

During that time the MD-87 was cleared for takeoff by TWR (while the Cessna crew was in contact with GND).

This was happening while both the TWR and the GND controllers, between 06.10:06 hrs and 06.10:15 hrs, (while the MD-87 was accelerating for take-off) were busy handling traffic calls in rapid succession with other aircrafts and therefore unable to focus on other than their primary task, inhibiting cross check or monitoring with each other. In particular, it has been determined that the TWR controller was required to repeat (again and again) visibility readings to a calling aircraft who had misread the information received, for which he presumably had to repetitiously consult the meteorological monitor. This sequence of events is reported meticulously here to indicate that operations were probably regarded as being normal by ATC controllers and not warranting a special attention.

At 06.10:21 hrs the MD-87 and the Cessna collided as described in other parts of this report. The ELT of the MD-87 was recorded on GND and TWR recording channels and on the CVR of the same aircraft. The signal should have been heard at ATC stations (GND/TWR) as listen watch is mandatory for 121.5 MHz emergency frequency. The signal was received, but hearing a signal does not automatically trigger the understanding of its significance and the initiation of a response. Controllers declared that such ELT signals were often received and were generally the result of unwanted activation or equipment malfunction, which may have induced a lower alertness to the signal activation.

As a matter of fact a number of ATC controllers present submitted that the signal went unheard. If it was heard no reaction was triggered.

From successive communications appraisal, it is understood that the GND controller did not have immediate cognition of what might have happened, at least until 06.10:48 hrs (and well beyond as determined by complete communications analysis reported elsewhere in this report). At 06.10:48 hrs, asked by LX-PRA about the Cessna's position (LX-PRA was supposed to follow the Cessna for taxi), the controller replied: ***He is on the Main apron....*** This information was issued promptly without any hesitation, definitely indicating that the controller was and had always been convinced that the Cessna had taxied on TWY R5.

2.3.4. Other aircraft involved

Other aircraft were involved in the event because of their proximity or for other ATC related concern, LX-PRA and I-LUBI.

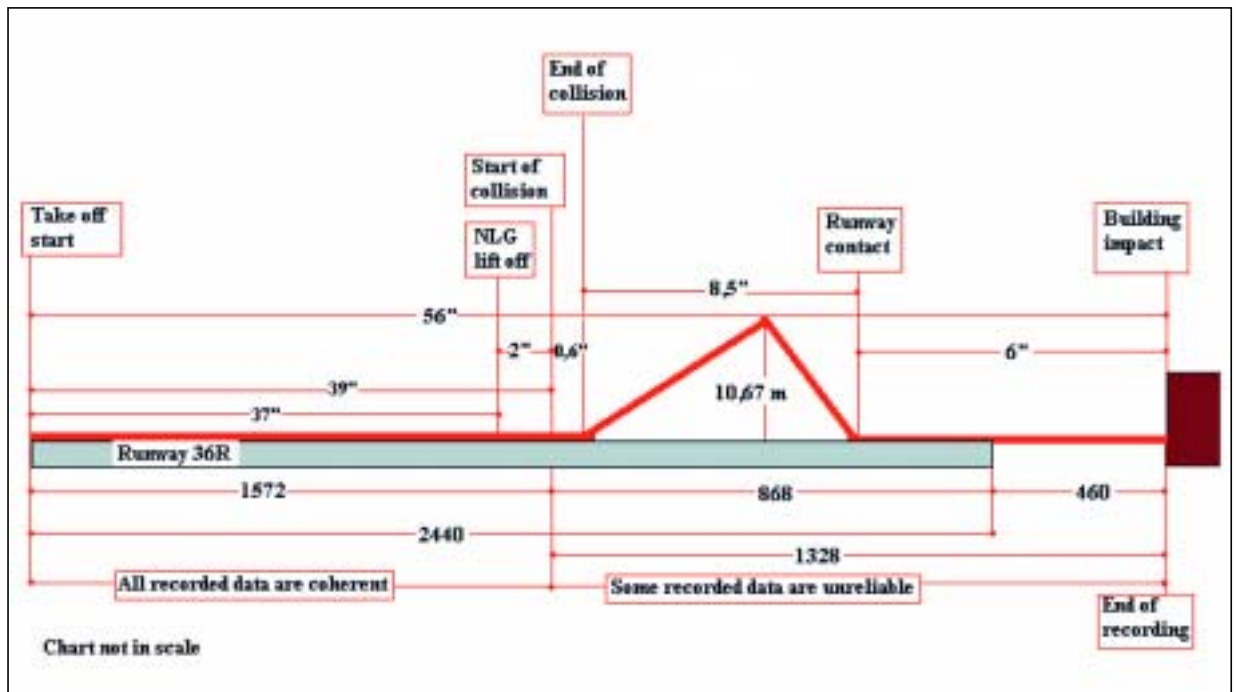
LX-PRA had received a taxi clearance including a taxi instruction via R5 and to follow the Cessna. A while after receiving his clearance, the pilot having not seen the Cessna passing in front of him, called GND; this call from the LX-PRA did not raise suspicion or concern to the controller.

I-LUBI had been cleared to line up on RWY 36R after the MD-87 departure.

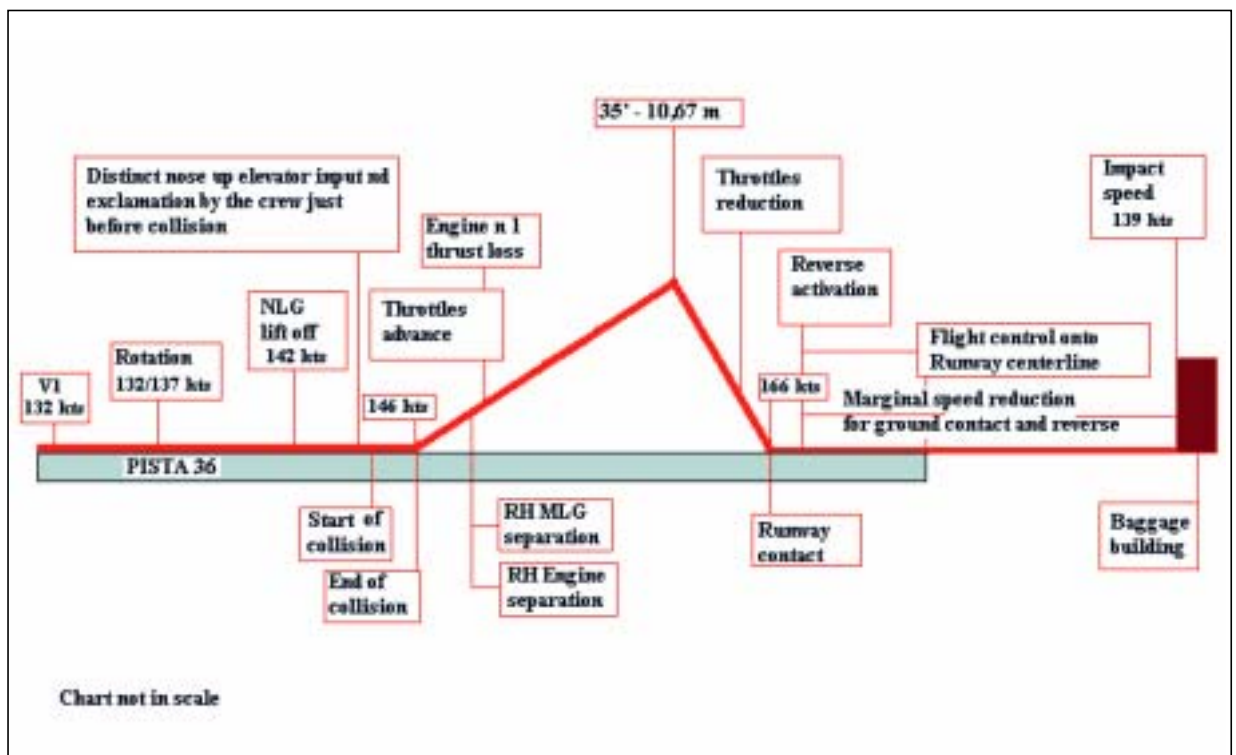
2.4. FLIGHT RECORDERS

Data recovered from the Boeing MD-87 recorders permitted a valuable reconstruction of the take off run, the collision with the Cessna and the final impact with the baggage building. The data allowed the drafting of the following graphs.

2.4.1. Chart with time-distance / IAS-pilot maneuvers



Timing and distances run (distances expressed in meters).



Speeds and pilot maneuvers.

2.4.2. DFDR of the Boeing MD-87 - Collision and impact reconstruction

a) First point of contact

From DFDR data reading and wreckage analysis it is possible to confirm that at first impact, the aircraft had started a normal takeoff rotation, with NLG having left the ground while MLG was still on the ground with its shock absorbers partially extended during lift off.

The recorded attitude was 10.3 degrees Nose Up (DFDR data) or very close to that figure, since the rotation attitude maximum was 13,5 degrees Nose Up has not been reached (tail-skid was found untouched).

Based on the above; the lowermost point of the MD-87 NLG was approximately 11-12 feet (3,35-3,66 m) above ground level at the aircraft's attitude during rotation. The uppermost surface of the Cessna fuselage was approximately 8.5 feet (2,85 m) above ground level. Wings were significantly lower. Thus the MD-87 NLG passed clear of the Cessna fuselage, wings and the LH engine, and it probably struck the Cessna's stabilizers (horizontal). Examination of the Cessna wreckage revealed that the LH side and the outboard portion of the RH side of the horizontal stabilizer sustained extensive damage (see attachment AT).

The MD-87 NLG LH Wheel and spray deflector most likely caused the Cessna LH horizontal stabilizer damage. MD-87 spray deflector was most probably broken off at time of contact; the spray deflector debris has not been identified. The LH wheel of the NLG shows evident damage, but not the RH wheel. Looking at the geometry of the MD-87 and the NLG position, it is probable that this was the first point of contact between the two aircraft (see attachment AT).

b) Second point of contact

Following the MD-87 LH Main Gear wheels hitting ("snagging") the Cessna RH wing outboard portion, lower surface. The Cessna RH wing leading edge/front spar was found broken and this damage corresponds to MD 87 LH Main Landing Gear strut diameter. There is clear evidence of tire marks on lower surface of Cessna RH wing and aileron. Outboard section of wing was found damaged, and the severely bent aileron had become detached from the wing. The angle of the tire skid marks on the lower part of the Cessna RH wing gives the relative angle of the two aircraft. The force of impact with MD87 LH MLG strut is insignificant and leaves no clear sign of damage on the wing, however a clockwise pivotal of the Citation was initiated (see attachment AT).

c) Third point of contact

Next contact was the MD-87 RH MLG wheel hitting the Cessna RH wing leading edge, inboard section; a very high force contact, which damaged both aircraft severely.

The MD-87 MLG wheel n.3 has extensive compression force marks whereas wheel n.4 does not carry the same signature. This evidence confirms the longitudinal position (and the relative motion angle) of the two aircraft. The high force of impact broke the MD-87 RH MLG strut just above the hydraulic retraction cylinder, causing the separation of the lower part piston (including wheels and brake units). This breaking point matches a MLG strut extension of approximately 20 centimeters indicating that the MD-87 main wheels had a firm ground contact (see attachment AT).

At this point several impacts took place within a very short time frame, which correlates generally with the second noise peak of the CVR sound analysis, which covers the highest sound peak in the collision sequence. The MD-87 LH wing inboard slat fairing then probably hit Cessna RH horizontal stabilizer, the MD-87 RH MLG door (fuselage mounted, in closed position) and MD-87 RH hydraulic service panel were struck by Cessna vertical stabilizer. Parts (fragments) of MD-87 wing fillet were found inside Cessna vertical stabilizer (see attachment AT).

Then the MD-87 RH MLG strut (cylinder) cut through the center part of the Cessna fuselage. The RH MLG lower part piston (including wheels and brake units) which had separated broke off and was forced aft. Assisted by the rotational energy the wheel assembly rolled upward damaging the RH inboard flaps.

MD-87 RH main wheel assembly then became jammed between MD-87 RH engine front, at six o'clock position, and the Cessna fuselage (see attachment AT).

The MD-87 engine was severely damaged by the impact and the subsequent sudden seizure of the engine rotors; multiple electrical failures were also generated.

MD-87 RH wing inboard flap hinge penetrated diagonally through the Cessna fuselage and struck the Cessna LH engine.

The two aircraft separated from each other.

The combined collision forces on the MD-87 RH engine resulted in failure of engine mounts and the engine separation from the pylon, approximately one second later. At this moment the aircraft was airborne and the separated engine landed approximately 180 meters down-field from point of collision, as indicated by extensive runway surface damage then the engine slid down the runway coming to a rest near TWY R1.

d) Trajectory of the Boeing MD-87 – Impact with airport baggage building

After the collision the pilot flying (PF) continued takeoff; the MD-87 became airborne but severely damaged. From that moment DFDR recorded a limited number of parameters (in conjunction with the mentioned electrical failures) and many of them were found to be inconsistent. DFDR reading shows that throttles were advanced gradually; for the LH engine now the only available, fuel flow and EGT increased, but no thrust increase was obtained and the EPR set at takeoff (1.91) decreased to 1.20-1.55. This may have been caused by ingestion of unspecified frame parts and debris originated during the previous multiple clashes.

The MD-87, with the LH engine severely damaged and without the RH engine which had separated from the fuselage, suffered an instant thrust loss and unbalance of the center of gravity (CG) which moved forward by about 12%. It has been calculated that CG was then outside the acceptable forward limit, putting the aircraft in an untrimmed stabilizer condition.

DFDR data continue to show manual control and motion of rudder, elevator and aileron, indicating that the pilot tried to maintain directional control of the aircraft.

The simultaneous LH engine impending thrust loss combined with the energy loss from the collision, adding to other structural damage, did not allow the aircraft other than reaching an estimated height of thirty five feet above the runway before becoming non-flyable as it touched down after about twelve seconds, prior to end of runway and at high speed.

Due to damage (including electrical) to airplane systems at collision with the Cessna and the separation of the right engine, the actual speed at touchdown was not recorded by the DFDR. Aircraft speed after collision could only be calculated, which was done by factoring the speed data available with the data of the acceleration recorded (see attachment AU).

The last recorded speed being 146 kts before collision, it has been calculated that considering the acceleration data available the speed was 166 kts at touch down. FDR data indicates that the MD-87 touched down on the runway about 10 seconds after the collision. Immediately after ground contact, deceleration was minimal for the first 3,5 seconds, then becoming more sensible further reducing the calculated speed to 142 kts. The calculation was based on the distance covered from a point intersecting the runway centerline with the conjunction line between TWY R6 and TWY R2 and the final impact point on airport baggage building (approximately 1.328 meters). The calculated speed was further reduced to consider the yaw displacement. The resulting figure is 139 kts at impact with the building.

Due to the missing RH MLG the RH wing tip came in contact with the runway surface. Initial tracks are parallel and marks on the runway surface indicate that RH wing flap hinges were in contact with the ground and probably also LH MLG door (extended for lack of

hydraulic pressure).

The crew had deployed the reverse thrust levers (recorded by the FDR and factually evidenced by reverse lever position and reverse buckets deployment). Manual braking was applied but not obtained due to loss of hydraulic pressure.

Such attempts were only partially successful due to the altered geometry and balance of the aircraft and the residual effectiveness of flight controls in combination with the RH wingtip dragging the grass.

Skidding on the runway the MD-87 started swiveling with RH wing tip as pivotal point. The aircraft slid sideways, with its longitudinal axes reaching approximately 45 degrees to the right of the aircraft initial direction of movement, till impact with baggage building occurred; instant stoppage was inevitable (see attachment AT).

Documentation available attributes a high professional standard to the PIC and an above average standard to the co-pilot.

The professional performance of the crew during the few seconds from aircraft collision to final stop shows a consistent and correct control of the crippled aircraft trajectory and path which may have averted a higher proportion disaster (this is confirmed by DFDR data analysis). Containment of the trajectory deviation possibly safeguarded near by airport main building and other aircraft parked on the North apron.

2.4.3. QAR of the Boeing MD-87

Available parameters analysis indicated coherence with the DFDR data.

2.4.4. CVR of the Boeing MD-87

CVR recorded data has been matched to the official time of the TWR, to which the time of the accident has been related. Accuracy of the transcripts has been evaluated to be within 3 seconds. The transcripts of the Boeing MD-87 CVR are limited to communications involving the pilots; the greater part of other communications has been transcribed (see attachment AU).

The recording of the line up and take off sequence is brief, less than one minute; the rest of the recording is related to the flight preparation and taxi out.

Track n. 1: Captain to cabin announcements were recorded; no other cockpit to cabin communications were recorded.

- Track n. 2: all radio communications between the Boeing MD-87 and ATC through RH radio panel were recorded.
- Track n. 3: all radio communications occurred through the LH radio panel were recorded.
- Track n. 4: all radio communications are recorded, the conversation between the pilots and local (ambient) sounds.

Comment: communications recorded on tracks 2 and 3 are downstream of pilot VHF control panels.

The recording starts at 05.39:55 hrs and confirms the recording available from TWR and GND communications. The recording of the crew communications are heavily scrambled and difficult to understand because the pilots did not make use of headsets with microphone and because of ambient high volume noise.

Sound analysis confirms that:

- takeoff clearance was received at 06.09:24 hrs;
- *Vee one* call was recorded between 7 and 5,7 seconds before impact;
- *Rotate* call 4,8 seconds before impact,
- about 3 seconds before impact the characteristic NLG noise leaving the ground is clearly identified;
- collision occurred at 06.10:21 hrs, 57 seconds after take off clearance issuance.

No other intelligible communication is recorded, only a brief duration noise (0,5 second) an indistinctly spelled word suggesting the possibility of the start of a call prior to impact.

Possibly an instinctive warning by one of the pilots who may have spotted an obstacle or the anti-collision light of the Cessna.

Analysis of collision noise, lasting 0,4 second and other findings, made it possible to understand the dynamics of the collision. The loudness of the first impact noise is due to the proximity of the NLG with the area microphone located in the cockpit.

Then other noise was recorded for the duration of the collision, providing foundation for the reconstruction of the succession of impacts as reported in paragraph 2.4.2.

Total recording lasts 30 minutes and 26 seconds and was interrupted at 06.10:21 (see attachment AU).

The CVR was powered by the right generator AC bus and became un-powered when the right engine generator or associated power feeder cables were damaged during the collision. This

damage prevented the cross-tie relay from closing, thereby preventing the left engine generator from powering both busses.

Providing for independent (or back up) CVR powering would have prevented the loss of important data useful for accident analysis.

2.4.5. The Cessna 525-A recorders

There was no recording system installed on the Cessna for flight data (CVR/FDR) as it is not required for aircraft with a maximum takeoff mass of less than 5.700 Kg (see JAR-OPS 1.720, page 1-K-9).

2.4.6. ACARS Boeing MD-87

ACARS (Aircraft Communications Addressing and Reporting System) automatically transmits certain technical information to Airline base: block off time, takeoff time and other aircraft system information useful for operational scheduling of aircraft and for maintenance purposes.

At 06.10:18 hrs the ACARS transmitted takeoff time to the Copenhagen SAS base, at full shock absorber extension of the NLG.

2.4.7. ELT equipment

At collision time, the ELT equipment fitted on the MD-87 started to transmit on frequency 121.5 MHz and the signal was recorded on the TWR recording tapes (for both frequencies 121.5 MHz and GND 121.8 MHz). The recording of the signal lasts 18,6 seconds (presumably the time difference between aircraft collision and MD-87 impact with baggage building).

The signal was also recorded on the CVR of the MD-87 (see attachment AU).

The TWR recordings did not show trace of the Cessna's emergency broadcast equipment.

An acoustic sound, coming from the Cessna and heard by rescuers for a few hours after the accident, was probably generated by an emergency broadcast equipment (ARTEX), which should have transmitted a signal on frequency 121.5 MHz. The reasons for the absence of such signal on the recorded tapes are unknown. The magistrate did not allow ANSV to make specific tests on that equipment. Such information has been requested by this Agency but to the date of publication of this Final Report, it has not been obtained.

2.5. AFTER IMPACT EVENTS

The emergency rescue equipment used by the firemen, as described in paragraph 1.14. FIRE, were in conformity with ICAO provisions. The shifting of personnel on duty occurred at 06.00:00 hrs; this may have had some negative repercussion on initial intervention of the emergency team. The vehicles that were ready for emergency purposes as prescribed by CAT II/III conditions had been activated for their daily test, and were ready to move swiftly.

The localization of the MD-87 occurred quickly in spite of the prevailing poor visibility conditions. Recovery of bodies has been made difficult by the fire that embraced the area and by the collapse of the 16-ton concrete rafter over the fuselage wreckage.

It became immediately evident that no rescue was possible that could have affected the survivability of the occupants.

Seat and seat belts of occupants (both passengers and crew) were torn off from their fixing position. Bodies of passengers and crew of the left side of the cabin were piled crushed under the heavy rafter, while the others were amassed on the front end of the fuselage near the cockpit.

The localization of the Cessna occurred at 06.36:50 hrs (26:29 minutes after collision).

2.5.1. The alarm

The TWR started the multi recipient alarm signal approximately between 06.13:00 and 06.13:30 hrs when a State Police officer at the Operations Centre of the airport Police station forwarded to FSCC a request for a fire squad intervention. The exact time of the calls and the alarm activation were not automatically recorded; the timing has been deducted from analysis of radio (R/T) and phone calls that were recorded. Dispatching of fire squads occurred in two distinct moments.

When the call was received from the Police Operations centre, two vehicles were sent. Approximately two minutes later FSCC dispatched all available vehicles (this is evidenced by a service radio call recorded at 06.13:51 hrs). Analysis of radio communications shows that the latter equipment dispatch was not in connection with the activation of the alarm by the TWR, but most probably following a telephone call from a *Guardia di Finanza* officer, signaling an accident involving an aircraft at the baggage building. All other parties involved in the published airport emergency plan (EAP) and associated procedures were activated by the multi recipient alarm issued by the TWR.

2.5.2. Communications

Radio and telephone communications between organizations mentioned in the airport emergency plan were not conducted in a steady and orderly way.

Contacts between the FSCC and TWR were not orderly. Many requests issued by TWR remained unanswered. Initial information issued missed important elements of appraisal (location of the accident, type of aircraft, fuel quantity contained, crew complement, number of passengers, nature and placement of cargo load and other significant elements of information).

No progress reports were issued that should have contained systematic update and relevant or additional information; updates and new elements of information flowed randomly rather than consequential and orderly.

It is probable that the communication flow through the service radio of the FSCC and fire squads have been sufficient for an effective fire fighting and containment at the baggage building but none were relayed to the TWR who remained unaware of the actions being taken and of the overall situation. Repeatedly the TWR had to insist to obtain information regarding the position of the various fire squads and in request of their assessment of the situation. Many times the information requested by the TWR could not be provided because the personnel involved were busy replenishing extinguishing agent tanks.

There is a clear perception that there was no coordination acting as such. TWR personnel has been unduly loaded with the burden of answering unnecessary phone calls dealing with futile requests; a source of unwanted loss of attention.

2.5.2.1. Human factor elements in after impact communications

This paragraph is based on a study conducted by aviation human factor experts on the wording used by pilots and controllers; it tries to describe the possible mental mechanism triggered and subsequent induced behavior. The analysis focuses on radio and telephone communications which could not be mentioned in **CHAPTER I - GENERAL INFORMATION**, but they are contained in the attachments.

At **06.10:21** hrs the ELT signal from the MD-87 was recorded on both 121.8 MHz and 121.5 MHz frequencies. Albeit the sound was audible in the TWR it did not raise the attention of any of the controllers present, who continued their normal activity dealing with other traffic movements.

A possible explanation for the missed attention to the ELT sound signal can be found in the daily practice of checking the equipment installed on aircraft under maintenance, usually occurring at that time of the day. The inadvertence can therefore be explained with a kind of **perceptive deafness** generated by the repetitiveness of the occurrence.

At 06.10:54 hrs the usual radio checks were started by the fire station operators (usual operation after personnel shifting); it was initiated by Victor 10 (FSCC). The radio checks continued for just over one minute and a half, with Victor 2 and Victor 9 responding; the call to Victor 1 remained unanswered.

Over the next minutes a number of communications were initiated by various operators:

- an airport Police officer servicing at airport Gate n. 5 called his Operations Centre informing that there was a *heavy fire* at the baggage building; the call was not taped, therefore the time of occurrence is not available;
- the airport Police Operations center called the fire station informing about a fire in the baggage building; again this call was not taped;
- TWR received (by phone) confirmation from ACC that the MD-87 did not make radio contact and did not appear on their radar screens;
- phone and radio reports to TWR about sound of explosions that were heard at UCT:
...a number of bangs... and from AZ 2023: ...three bangs in sequence...;
- when the UCT officer called TWR to enquire about the bangs, he was reassured; the TWR controller attitude can be interpreted as an attempt to negate an alarming evidence;
- the call to TWR from AZ 2023 further contained the information that a ramp agent had reported having observed *...a red streak of fire...;*
- background comments from TWR controllers, audible and recorded through the live microphone, openly mentioned *...therefore it was the Scandinavian...;*
- the vocal characteristics of the TWR controller attempting to make contact with the MD-87 seem to indicate a state of anxiety and apprehension (there is a significant pressing request, presumably from another controller who was present, recorded and heard in the background which said: *...continue...).*

Then, at a time between 06.13:00 hrs and 06.13:30 hrs, the alarm was activated by TWR (this

could be determined from the call from DCA to TWR at 06.13:35 hrs).

At 06.13:51 hrs, Victor 10 ordered dispatch of their equipment through the service radio. Since the communication made explicit reference to proceed to airport Gate n. 5, ...*you have to go near gate 5...*, whilst no previously recorded communication made mention of Gate n. 5, it is possible to infer that the decision to dispatch fire fighting equipment was not subsequent to the TWR alarm activation but possibly in response to some other information received (and not recorded). At that stage, the TWR must have been short of essential information and this is evidenced by a call originated by the TWR to the fire station asking if they had heard the alarm, at 06.14:45 hrs. The response from the fire station was hurried and did not contain essential information about the location and nature of their intervention or the type and number of equipment used. More so, when the answer from the fire station operator was ...*they have left...*, the TWR controller did not ask “where” they had been sent, which would have been the logical assumption; the lack of essential information inhibited the TWR from assuring the necessary co-ordination and further originated other misunderstandings. There is evidence that TWR controllers did not act with the necessary rationality, even when doubts started to surface about the seriousness of the situation. Nevertheless the TWR issued the alarm signal starting the emergency procedure.

Meanwhile, the GND controller continued on the attempt to contact the Cessna; he did so for about eight minutes after the accident. However the position and the fate of the Cessna were still unknown to ATC.

During that time the ATC were unable to receive the most basic information on what had happened and what was going on. The starting point of the confusion can be found in the unquestioning manner the previous information given to the TWR when they were told by the fire station that the firemen were at work...they had been dispatched: ...*they have left...* This may have induced the fire station operators to believe (erroneously) that the TWR knew more than what they effectively knew about the situation.

From the conversation between GND and LX-PRA initiated by the latter at 06.14:59 hrs ending at 06.15:24 hrs, it can be assumed that the controller firmly believed that the Cessna had taxied via TWY R5 and (at accident time) was somewhere on the North apron.

At 06.15:25 hrs the TWR called Victor 10 to authorize firemen to enter the runway (18L/36R), to cover the whole length and report ...*and report along the whole length...* in particular ...*watch what is on the runway...* since ...*an aircraft is missing...*

TWR: *Victor you can enter the runway, from this moment the runway is clear, you may*

enter the runway. Report us over its whole length. There is an aircraft missing which should have taken off but at this stage it is not in flight any more then report on what may be on the runway.

The wording used by the controller implied a precise request of inspection of the runway and a report. The instructions issued by the FSCC to all Victor, nearly forty seconds later, did not contain the recommendation (request) and were merely the information that it was now possible to use the runway.

Victor 10: *For all Victor from station you can use the runway too... for now it is closed.*

In other words the communication channel from all parties involved was open to ambiguities and misunderstandings and often cut short essential information. The request by the TWR was not interpreted as a request but merely as an authorization to use the runway, possibly to facilitate their activity.

The words used by the TWR, *...you can enter the runway...* was not interpreted correctly as a specific request or an order to do a specific action, but as a clearance to use the runway as the case may be for the displacement of Victor equipment. The information *...there is an aircraft missing...* was not regarded in all its importance, since the fire station had already found the MD-87.

To summarize, the overall picture seemed to be confused at that stage:

- firemen were concentrating their efforts on a fire signaled by the airport Police Station;
- firemen ignored the runway inspection and associated report request, they simply did not enter the runway;
- the thinking inside the TWR was contradictory, some controller thought that the MD-87 may have overrun the runway which was therefore now free of obstructions, thence the clearance to I-LUBI to taxi along the runway;
- the position of the Cessna was unknown and attempts were made by TWR to find the aircraft through SIRIO 0051 (by means of a mobile phone) who was about to start taxiing and who knew one of the Cessna passengers;
- the DCA informed the TWR that an aircraft had penetrated the “toboga” (denomination indicating the baggage clearing area, the baggage conveyor belt area, commonly used by some airport operators) *...this airplane entered the toboga...*, but when the TWR transferred the information to the fire station, the information was translated into *...the toboga entered the run-*

way..., to which the fire station operator replied ...*roger*..., seemingly unaware of the inconsistency contained in the information received (*toboga*, clearly unfamiliar to the controller). There is clear evidence of confusion between the organizations or simply between the various operators. In particular between the various controllers present inside the TWR in their relations with others and between them; the isolation of the TWR may have been a factor, considering the poor visibility conditions and the lack of efficient ground movement radar or other electronic protective device.

The first positive information to the TWR that the MD-87 was involved in an accident came from a doctor servicing the First Aid unit adjacent to the baggage building. The doctor supposedly witnessed the post impact fire and used his service radio (frequency 440.450 MHz) at 06.16:03 hrs giving a succinct appraisal, but still not informing the TWR about the location of the accident or the extent of the disaster.

This investigation has determined that the communications shortcomings were compounded by the avoidance of the usage of the prescribed grid provided in the emergency procedures booklet to facilitate the localization of airport sites in case of emergency.

At 06.16:21 hrs, Victor 1 called the TWR on service frequency 440.450 MHz requesting: ...*did you localize the aircraft?*, leaving room to the assumption that the crew of Victor 1 did not participate to the emergency operation in progress and had no precise notion of the happenings.

After about one minute, at 06.17:37 hrs, Victor 1 called (summoned) all other rescuers: ...*all Victor must come here*....

In all evidence, Victor 1 was assuming that the recipients of the call knew where to go, but all other interested parties in the emergency plan activation (FSCC, TWR, etc,...) could not have been able to use the information and indeed the TWR was still out of the loop and ignoring that important information. The following two considerations can be formulated from evidence gathered:

- at 06.18:46 hrs the GND controller had an information exchange with AZ 2010 during which he said with an upset voice: ...*probably a Scandinavian and a private*..., which indicates that inside the TWR the hypothesis of the involvement of two aircrafts, was already present;
- at 06.18:43 hrs the TWR specifically asked to Victor 1 to be informed on ...*the position of the aircraft on fire*..., indicating the need for TWR to know more details about the position of the fire, previously indicated as being ...*near the First Aid unit*.... Victor 1 did not reply.

There is evidence that TWR continued repetitiously but unsuccessfully with attempts to make contact with Victor 1 from 06.18:52 hrs to 06.22:30 hrs.

All of the above gives a clear picture of the poor level of coordination by all parties activated by the alarm originated by the TWR. Many obstructive factors can be considered: objective difficulties, poor visibility, tasks overlap, flow of unspecific information, overload of essential communication channel, operators' emotional stress build up; all of these may have obstructed a steady, orderly and correct information flow and spread, but most probably the source of the shortcomings rested within the weakness of the procedures to be followed.

After many attempts, at 06.21:34 hrs, TWR finally obtained the required information from the FSCC that Victor 1 was in charge for co-ordination of contacts between the firemen squads on the field; this was in reply to a direct questioning:

... *what is the vehicle that handles contacts...*

The reply was: "One"

This essential information should have been specified in the airport emergency plan procedures, but it was not. The TWR continued to call insistently Victor 1, according to the indication received by telephone from the FSCC.

Eventually, radio contact was established between TWR and Victor 1 at 06.22:30 hrs and two specific questions were asked by TWR:

- the precise position of the accident scene where firemen were operating;
- the situation on the runway and how many vehicles were involved in the survey on the runway.

The first question was not answered usefully; Victor 1 replied *...near the infirmary...* (the First Aid unit), adding nothing to what TWR had already told Victor 1.

From the response to the second question, the TWR learned that none of the firemen vehicles (squads) had inspected the runway. That information, however, did not elicit any particular reaction from the TWR until after 06.30 hrs, when I-LUBI will signal that they were observing wreckage pieces and a fire on runway 36R; then, three more minutes will be needed to TWR to clarify to firemen the absolute need to inspect the runway and report, as will be described further on.

It appears that inside the TWR, the notion of the localization of the MD-87 had been acquired, but probably it had not spread to all that were present. A contributory confusion factor had been the usage of colloquial and barely descriptive words to indicate airport positions instead of resorting to the prescribed official localization system (grid), which would have facilitated the understanding of all airport operators.

In this respect, the following four communications are indicative.

- At 06.15:41 hrs, the phone call from DCA to the TWR informing that: ...*seemingly the aircraft entered the toboga...*, and was soon after followed at 06.16:18 hrs, by the explanation of what the *toboga* meant.
- At 06.16:28 hrs, Victor 1, answering a request from the TWR on the service radio, had replied that ...*it is a Scandinavian Airlines aircraft against the toboga...*
- At 06.17:58 hrs, the DCA had advised the TWR that they should request the firemen to operate ...*at runway end at the toboga.*
- At 06.19:10 hrs, a TWR controller had explained to a colleague, phone call to internal number 231, that the SAS aircraft ...*collided with the toboga...*

In the meanwhile, more confused and uncertain communications were traded:

- it is peculiar to note that at 06.24:08 hrs, the FSCC (Victor 10) asked TWR in a phone call: ...*are there persons involved?* While firemen had been operating around the MD-87 since about ten minutes;
- subsequently, at 06.25:04 hrs, the FSCC (Victor 10) asked the same question to Victor 1: ...*are there persons involved?* Again this a clear evidence of a lack of co-ordination and centralized flow of information, adding to the tense emotional atmosphere build up; there was no answer from Victor 1.

At the same time, another phone conversation sheds light on the level of uncertainty prevailing inside the TWR, at least according to the controller speaking; at 06.24:02 hrs, a TWR controller speaking to ARO, states that the SAS aircraft had not been able to take off ...*for his own problems...*, this meant:

- that the controller was not contemplating the possibility of an aircraft collision;
- consequently, the speaker was presumably satisfied about the position of all other aircraft on the movement area, including the Cessna that was unaccounted and was not responding to calls (numerous attempts had been made by GND).

Meanwhile, at 06.24:36 hrs, another controller had instructed I-LUBI to return to the West apron taxiing along RWY 36R but exercising caution since: ...*there could be debris...*

The TWR instruction to I-LUBI to taxi along the runway must have been based on the inadvertence or unconsciousness which prevailed inside the TWR about the course of events. This fur-

ther confirms what had emerged in a phone conversation between TWR and ARO, in essence the TWR belief that the accident to the MD-87 was attributable to an aircraft problem occurred during take off, which led to an aborted take off and subsequent runway overrun.

On the other hand it could be assumed that until confirmation by Victor 1, received at 06.21:50 hrs, that no firemen vehicle had inspected the runway, the TWR having requested the inspection at 06.15:25 hrs, could have considered that the runway had been inspected and nothing warranted a report.

It is possible that at that stage TWR was realizing that the Cessna might have been involved in the accident; therefore ATA was contacted requesting if the aircraft had returned to West apron. Having received a negative response, in a subsequent phone call to KLM, at 06.27:51 hrs, it was for the first time admitted that *...a private aircraft is also unaccounted...* but confusingly stating that the Cessna was *...taxiing along Romeo 5...* The Cessna had been on RWY 36R since eighteen minutes now but the runway had not been inspected.

TWR called repeatedly Victor 1 enquiring about a second aircraft possibly being involved in baggage building fire along with the MD-87, but no valuable answer was obtained since he replied, at 06.29:43 hrs, that it *...was busy replenishing water tanks...*

From that request from TWR, it can be assumed that it was suspected that the Cessna might have been involved when transiting on TWY R5 towards the North apron and dragged into the accident place at the baggage building.

After the last communication exchange between TWR and Victor 1, at **06.30:09** hrs came the call from I-LUBI with the revealing message: *...there is fire on the runway...* at TWY R6 intersection.

It is possible that the next report from I-LUBI, at 06.30:23 hrs, *...there are objects burning, debris in flames...* were still interpreted at TWR as if the debris may have belonged to the MD-87 or maybe be part of the technical problem originating the runway overrun and the crash.

The mental scenario that may have prevailed would be typical of a realistic data distortion in confirmation of a previous persuasion (confirmation bias).

The mental image that prevailed in the controller's minds must have been well rooted and persistent. TWR did not react to the information received from I-LUBI. No enquiry or fact finding attempt is evidenced on TWR frequency, but GND controller became apparently doubtful about the sequence of events. At 06.32:41 hrs the GND controller asked specifically to LX-PRA if he had seen the Cessna passing in front of him before he taxied towards TWY R5 (LX-PRA had started its taxi, as instructed, around 06.10:50 hrs, approximately half a minute after the ELT activa-

tion). From the ensuing conversation between GND controller and LX-PRA there is evidence that inside TWR some realized at last that the Cessna was not where it was believed to have been. After receiving the information from I-LUBI about the debris and the flames presence on the runway, TWR did not relay it to the FSCC.

At 06.33:14 hrs, TWR called FSCC on the direct phone and specifically asked *...did the firemen enter the runway or not so far now...* and finally discovering that the firemen had not yet done so.

By that time communications on frequency 440.450 MHz had become chaotic and excited. In addition to the unanswered calls from TWR, the firemen were calling each other and their Control centre. This indicates that relevant difficulties were encountered fighting the fire at the baggage building. The FSCC had no knowledge about the presence of an aircraft on the runway.

At 06.32:53 hrs, TWR was queried by Delta 2 on the service radio about the request made *...we need that the runway be entered (inspected)...a private aircraft is missing...*; after a brief exchange at 06.33:41 hrs, Delta 2 announced that *...we will try to enter the runway...* (we, had been used because there were two UCT officers on duty and both were observing the scene near the baggage building).

The crucial and final discovery occurred at **06.36:50** hrs when Delta 2 shouted *... there is an aircraft on the runway...the remains of an aircraft...*

The call, which has been recorded on various frequencies and recorded phone lines, finally removed uncertainty and also clarified the exact nature of the event, nearly twenty seven minutes after the collision. It is probable that from that moment the controllers start wondering about their involvement in the sequence of events.

TWR then called rescue vehicles through service radio and when Victor 1 responded he was instructed to proceed to the runway. Victor 1 answered at 06.37:28 hrs: *copied...we are going right away...*; from other service radio calls from Delta 2, we know that Victor 1 arrived at the Cessna wreckage area around 06.39:00 hrs.

At 06.41:58 hrs Delta 2 informed that: *here the fire has been extinguished*

A further request of informations from TWR to Victor 1 about the state of rescue operations on the runway came, but the firemen were busy and Victor 1 replied that the fire had been extinguished at the Cessna wreckage. TWR continued to be isolated and kept outside of the informations loop, in spite of the evidence of the situations.

Delta 2 came in offering to relay informations as required, but it was rebutted and suggested to use another communication channel since the service radio had to be used by firemen for their operations.

During that time span, starting from accident time, TWR and GND had also been dealing with all other airport traffic movement taxiing to and from aprons. Radio black out (silence) was never ordered.

This chapter dealt with the analysis of human factor elements in after impact communications. It can conclusively be said that the emergency operations have been significantly hampered and delayed by low visibility, faulty communications procedures and pressing emotional behavior. All parties involved have somehow missed to implement a steady and meaningful flow of information; published procedures, when adhered to, did not produce the expected results and the primary importance of their implementation seems to have not been fully understood by operators. Modality of concise information, usage of clear and unambiguous phraseology, hierarchical and coordinated and constant flow of essential information, challenge/respond technique essential to all vital information dissemination, all seem to have been neglected and were overridden by stress related, fatigue and emotional behavior. This widespread behavior has been instrumental in determining anxiety, omission, oversight and negligence along with organizational and procedural shortage.

2.5.3. Airport Emergency Plan handling

Comparison of the Airport Emergency Plan - AEP with the actual handling of the emergency, it can be assumed that the plan has been enforced only partially. The following factors concurred to the obstruction of its deployment:

- poor visibility has hampered a visual and immediate appraisal of the situation;
- the abnormal start and activation of the emergency state (the call from a Airport Police to FSCC, reporting a generic fire), has initially hampered from the beginning the information and communication flow between TWR, UCT and firemen;
- the automatic (challenge/respond) alarm system has reached FSCC when fire-fighting equipment had already been ordered out, creating misunderstanding;
- the failure to implement and activate an emergency command team has “de facto” hampered the enforcement of the AEP;
- failure from FSCC to inform about the state of fire-fighting units (vehicles and extinguishers) may have left a number of aircraft taxiing along the airport without adequate fire protection.

Individual initiatives (often producing valuable contributions) have prevailed over the resort to planned procedures, to the detriment of coherent actions as it would have been necessary in the circumstances.

The two exercises that had been conducted (before the event) after the promulgation of the AEP had indicated that significant shortcomings existed in the emergency plan.

The first exercise showed that:

- a) the co-ordination and command team gathered some twenty minutes after the emergency declaration;
- b) UCT had been considered to be unsuitable for that role.

The second exercise had indicated that:

- a) a mobile coordination post was missed (needed);
- b) UCT location was not suitable;
- c) co-ordination and command team had been widely unattended.

There is enough evidence to recognize that since the inefficiencies that had already emerged had not been addressed and corrected, the same inefficiencies surfaced the day of the accident producing significant negative consequences. The failure to implement the AEP, the lack of co-ordination, the failure to set up a functioning command team, all concurred in determining that the shortcomings already highlighted by the exercises conducted were still well rooted and henceforth inevitably surfaced again.

2.6. THE ITALIAN LEGISLATION

Italy has ratified the *Convention on International Civil Aviation* with Legislative Decree n. 616/1948. Subsequently, with Law n. 213/1983 which modified the Navigation Code, it identified the instrument by which the ICAO Annexes could be adopted by national regulations. Many requirements contained in the Annexes were adopted with instruments other than Law n. 213/1983 and not necessarily with the same format.

Law n. 166/2002, adopted recently, has modified the previous adoption scheme of ICAO Annexes envisaged by Law n. 213/1983, so as to simplify and speed up the transposition of ICAO Annexes requirements within national regulation. It was found that for a number of

Annexes Italy had notified to ICAO differences between national regulation and the Annexes. However, this technical investigation has evidenced that Milano Linate airport did not conform with ICAO Annex 14 requirements.

As for the conformity with Annex 13, which deals with technical accident investigation, the following can be said:

- a) the principles contained in Annex 13 were enforced in national legislation through the adoption of EC Directive 94/56/CE of November 21, 1994;
- b) national law requires that ANSV conducts technical investigation in abidance of Annex 13;
- c) Annex 13 makes provision for technical investigation conduct, while it cannot influence the course of other investigation under the magistrate's authority competence.

2.7. RUNWAY INCURSIONS - A GLOBAL PROBLEM

Runway Incursions has been identified as one of the major risk-factors in the aviation transport system. The problem seems to be applicable to many international aerodromes and in different countries all over the world. This is an unacceptable situation and global measures need to be taken to solve the problem.

The basis for the aerodrome flight safety is stated in the requirements as specified in ICAO Annex 14. Unfortunately many aerodromes still do not meet these requirements, even though pertinent local authorities and managements claim so. The discipline to implement and follow the requirements varies widely. The many discrepancies and deviations from ICAO Annex 14 found in this investigation at Milano Linate aerodrome is one example of this, but certainly far from the only. The reasons for this may be many; complex aerodrome management organization, lack of safety management system, unclear responsibility structure, weak safety culture, high traffic flow/intensity and physical expansion of aerodromes, etc.

One further reason may be that many aerodromes originally were designed and constructed for a limited traffic volume. Through the years the traffic volume has increased dramatically, new runways, ramp areas, hangars etc. have been build. This means that the operational situation at many aerodromes has became more and more complex for all parties involved. Many aerodromes in the world are more or less under a constant construction and expansion phase. Also the procedures for LVO has became more and more sophisticated. Today many airports can operate under ILS CAT II and ILS CAT III with RVR minima for take-off and landing down to a minimum of 75 meters RVR. The technical and operational requirements on those aerodromes

has increased consistently. For aerodrome safety managers it is a very demanding task to assess all changes from a safety view-point so that all requirements are met during and after major aerodrome lay-out changes and higher operational standards.

Besides this, many aerodromes frequently have to suffer from a traffic overload before necessary physical expansions have been accomplished which can end up in different types of critical and hazardous unsafe situations.

The European Action Plan for prevention of runway incursion is one of many positive and very comprehensive initiatives seeking to solve this problem. Experts have focused on a number of critical items to be improved. The Action plan has a total of 37 different recommendations in the following areas: General principles, Aerodrome and Aircraft Operator Issues, Communications, Air Navigation Service Provider Issues and Regulatory Issues. See paragraph **1.18.5. The European Action plan for prevention of runway incursions, the recommendations.**

These recommendations represent a very comprehensive "Action-plan" for a general improvement of aerodromes flight safety. Therefore a most important issue for politicians, regulators, aerodrome managers, operators, etc... is to ensure that all these recommendations are taken care of and fulfilled. Not as a one-time action but as a long term action plan to improve and secure aerodrome safety.

In this respect it is also important that the "aerodrome customers", i.e. airlines, passengers, service organizations, media etc. becomes aware of the widely differing flight safety standards at various aerodromes and that the key to solve this unacceptable situation in fact is available to all. The recommendations require that all Civil Aviation operators and users should take the necessary steps in order to secure aerodrome flight safety.

As Accident Investigation Boards continue to monitor statistics and issue recommendations worldwide with the aim of reducing runway incursion risk, ANSV has instituted a dedicated runway incursion internal investigating panel (August 2001). The ANSV panel has focused its attention on the following:

- airport signage;
- operational procedures;
- crews and air traffic controllers training;
- airport air-side personnel training;
- airport and ATC update to state-of-the-art technology.

The findings of the ANSV panel, when finalized, will be relayed to all national interested Organizations for the consequent determinations.

CHAPTER III

CONCLUSIONS

3. CONCLUSIONS

Runway incursion phenomenon, the Milano Linate accident being a clear example, represents a growing concern to the Civil Aviation community. The event investigated here is a runway incursion which had devastating effects (the most serious accident suffered by Italian Civil Aviation and the second most dramatic of this kind in Air Transport history). Consequently and in an effort to avoid similar occurrences in the future all institutions, airport operators, airport management agencies and airlines should be called to implement ICAO requirements, as detailed in the Annexes, and in particular Annex 14, for a safer conduct of airport operations.

In conclusion of this investigation of the Milano Linate accident of October 8, 2001, the following findings were obtained.

3.1 FINDINGS

3.1.1. Operational conditions prior to the accident

- 1) The management and operational situation at Milano/Linate Aerodrome was complicated and involved three major organizations, ENAC, ENAV SpA and SEA.
- 2) No effective performance agreements did exist between involved organizations regarding safety matters.
- 3) No functional Safety Management System was in operation.
- 4) The aerodrome standard did not comply with ICAO Annex 14.
- 5) No recurrent training program for ATC personnel had been provided.
- 6) No Aerodrome Operations Manual was established.
- 7) No Quality System was established for all activity sectors.
- 8) No well functioning deviation reporting system was in operation.

- 9) The aerodrome did not meet the requirements for LVP under ILS CAT III B conditions.
- 10) The aerodrome was operating according to DOP 2/97 document for *Visibility 2 conditions*.
- 11) DOP 2/97 document did not conform to ICAO DOC 9476, whilst recalling it.
- 12) The punitive environment that existed and the fear of sanctions discouraged the self-reporting of incidents and individual mistakes.

3.1.2. Before collision-impact findings

- 1) The flight plan faxed by the Cessna crew to ARO (Air Traffic Reporting Office) of Köln (Germany) and forwarded to all pertinent offices, reported that the qualification of the crew was limited to ILS CAT 1 approaches (a minimum visibility 550 meters was required).
- 2) The Cessna flight was filed as a private flight, but according to documented evidence it had to be considered as of commercial nature.
- 3) At 04.59 hrs, nearly one hour before the accident, the Cessna landed at Milano Linate airport while the following weather conditions were reported: wind calm, visibility 100 meters, fog, ceiling at 100 meters, RVR 175, 200, 225 meters. During the approach the crew was not notified of the instrument landing type of operations in progress, but the current weather conditions warranted ILS CAT III operations to be implemented.
- 4) Up to 05.24 hrs the ATIS of Milano Linate did not state that ILS CAT III operation were in progress, while existing weather conditions warranted their implementation.
- 5) The pilots of the Cessna were not qualified and certified to land in such weather conditions as were actually present.
- 6) The Cessna was not equipped with FDR and/or CVR.
- 7) After landing on RWY 36R the Cessna vacated the runway on TWY R6 after a short back-track on the runway.
- 8) Milano Linate UCT did not check the consistency of the Cessna aircraft and crew qualification against the allowed weather minima; the aircraft landed in visibility lower than what was stated in the FPL.
- 9) Current regulations in relation to the visibility conditions and the crew qualification allowed the taxi out for departure, but did not allow take off with visibility of less than 400 meters.

- 10) The MD-87 crew was qualified for the intended flight.
- 11) The MD-87 aircraft was certified for LVO take off and ILS CAT III-A approach minima.
- 12) The Cessna 525-A was certified for ILS CAT I approach minima.
- 13) The nature of the flight may have exerted a certain pressure on the Cessna crew to commence the flight despite the prevailing weather conditions.
- 14) AIP Italy published information was found not consistent with the current (at accident time) Milano Linate airport layout.
- 15) Jeppesen and AIP Italy documentation were not consistent with the airport layout. In addition, Jeppesen charts deviated from the published AIP Italy as follows: Airport Diagram 20-9 did not label the fire station, Parking chart 20-9B contained an “A” denoting a segment of the northern end of the main taxiway and chart 20-9A did not contain a notation *that aircraft on TWY R5 ...must request and obtain specific ATC clearance to cross the RWY 36R extension.*
- 16) SAS Flight Support documentation was also found not consistent with the airport layout, similarly to AIP Italy. In addition it further differed partially from the latter published information in that the Parking chart showed TWY R6 in a different position than the official maps, the Aerodrome chart did not report the position of the Fire station building nor its denomination, the North apron the chart showed taxi lines (A, B, C and D) which were not reported on the official maps.
- 17) According to ICAO recommendations, taxiways should have been denominated following a clockwise logic: R1, R2, R3, R4, R5, R6 starting from the North; to the contrary the airport set up was R1, R2, R3, R4, **R6, R5**.
- 18) West apron markings were not in conformity with ICAO recommendations and were further found to be insufficient.
- 19) In total deviation from ICAO recommendations, West apron missed signage altogether.
- 20) TWY R6 lacked markings (pavement surface markings to reinforce messages to flight crew) and signs and those present were found to deviate from ICAO recommendations.
- 21) Markings that currently existed on TWY R6, indicating S4 and S5 positions and on TWY R5 indicating S1 and S2 positions and a further marking entering the North apron from TWY R5 indicating an S5 position, were not duly reported on AIP Italy. Consequently this was not reflected in Jeppesen and SAS Flight Support documentation.

- 22) Controllers servicing the aerodrome Tower have declared that they ignored the existence of such markings S1, S2, S4, S5 and S5.
- 23) ASMI radar was reportedly out of service since November 29, 1999.
- 24) Installed equipment for prevention of runway incursions, positioned at TWY R6 intersection with RWY 18L/36R, had been deactivated for several years.
- 25) White flashing lights, positioned at TWY R6 intersection with RWY 18L/36R, described on AIP Italy official charts (“white alternate flash light indicators”) had been deactivated in 1992 and substituted by unidirectional alternate green/yellow (code color lead-on in lights) lead lights to guide exit from RWY 36R and entrance to TWY R6 (while the green taxiway lights exiting from TWY R6 towards RWY 18L/36R were not affected by this implementation and remained unchanged). Official documentation showed none of these changes.
- 26) The GND controller had no possibility to switch ON and OFF the light cross bars on TWY R5 and R6 and could not select taxiway centerline lights in coherence with taxi instructions.
- 27) Phraseology widely used by controllers and pilots was not in conformity with ICAO recommended practices; radio-telephony communication was conducted alternating Italian and English language.
- 28) The taxi clearance issued by the GND controller to the Cessna at 06.05:44 hrs, contained all necessary instructions to correctly identify the route to be followed. The phraseology adopted by the controller in these circumstances, was found to be correct and conforming to the rules: *DeltaVictorXray taxi north via Romeo 5, QNH 1013, call me back at the stop bar of the...main runway extension.*
- 29) At 06.05:56 hrs, the pilot of the Cessna, when reading back the clearance just received, omitted the repetition of the word *North*, the part of the instruction concerning the *stop bar* and further omitted the word *extension* qualifying the concept contained in *runway extension* present in the instruction received: *Roger via Romeo 5 and...1013 and call you back before reaching main runway.* The controller did not notice (and did not respond to) the omissions and did not request a correct read-back.
- 30) Twenty seven seconds after clearing the Cessna, the GND controller issued the following taxi clearance to LX-PRA who was also parked at West apron using the Italian language: *OK RomeoAlpha taxi North Romeo 5, QNH 1013, you must follow a Citation registration marks DeltaIndiaEcoVictorXray who is taxiing on Romeo5.*

- 31) The Cessna, parked at West apron in front of the ATA hangar, taxied following the yellow line and upon reaching the fork at R5/R6, instead of following the line leading North and towards TWY R5, the aircraft followed the line (that was interrupted for a short distance) leading South-East towards TWY R6 entrance.
- 32) The air traffic controllers have not consistently enforced the prescribed read back procedure.
- 33) The pilot of the Cessna spontaneously reported his position when he was approaching the **S4** marking (reading the inscription upside down as he was coming from the opposite direction).
- 34) The GND controller request confirmation of the Cessna position:
DeltaVictorXray confirm ... your position.
- 35) The next call from the Cessna contained the following wording, with the repetition of the previous communication: *Approaching the runway...Sierra 4.*
- 36) The GND controller did not notify to the pilot that he was not aware of the position reported in *Approaching the runway...Sierra 4*; neither did he state that he did not understand the meaning of the position report.
- 37) The GND controller did not identify the actual Cessna position through the radio messages exchanged.
- 38) The Cessna pilot made a further position report: *Approaching the runway...Sierra 4*; the reply from GND: *DeltaVictorXray Roger, maintain Stop Bar, I call you back.*
- 39) After receiving twice the position report of the Cessna crew indicating position **S4**, the controller, although he did not understand the meaning of the position report, issued the following taxi instruction to the Cessna, after having checked the position of another aircraft taxiing on North apron:
GND: *D-IEVX continue your taxi on the main apron, follow the Alpha line.*
- 40) GND controller was positively certain that the Cessna was taxiing on TWY R5.
- 41) The Cessna pilot read back, subsequent to the next taxi instruction received, was correct:
GND: *DeltaVictorXray continue your taxi on the main apron, follow the Alpha line.*
D-IEVX: *Roger continue the taxi in main apron, Alpha line the... DeltaVictorXray.*
- 42) The GND controller gave the Cessna a correct clearance based on the assumption that the Cessna was on TWY R5.

- 43) The D-IEVX crew was not aided properly with correct publications, lights and signs to enhance their positional awareness.
- 44) Before entering the runway, the Cessna crossed a white **STOP** marking, an ICAO type B holding position marking, a bar of red lights, an ICAO type A holding marking, and then he followed the green taxiway centerline lights, without any further radio communication.
- 45) The Cessna entered the runway without receiving the prescribed clearance.
- 46) At about the same time the MD-87 was cleared for take off:
Scandinavian 686 Linate clear for take off 36, the wind is calm, report rolling, when airborne squawk ident.
- 47) Twenty two seconds before collision, the reported visibility on RWY 36R was 225, 200 and 175 meters respectively at TDZ, MID and STOP END.
- 48) At 06.10:21 hrs the two aircraft collided.
- 49) The Cessna broke in three parts which remained on the runway.
- 50) At about 06.10:36 hrs the Boeing MD-87 impacted the airport baggage building.

3.1.3. Post impact findings

- 1) The position and dimension of the baggage building, where the MD-87 finally crashed, while consistent with current regulations, were instrumental in the catastrophic sudden and violent stoppage of the aircraft.
- 2) After the impact, TWR controller, frequency 118.1 MHz, called 5 times **SAS 686**, the MD-87, without receiving an answer from 06.11:26 to 06.13:00 hrs.
- 3) After the impact, GND controller, frequency 121.8 MHz, called 8 times **D-IEVX** without receiving an answer from 06.12:17 to 06.17:52 hrs.
- 4) The first two fire fighting firemen squads left the FSCC following a phone call from the Airport Police station; the phone call was not recorded.
- 5) There is no recording of Airport Police station informing the TWR or the UCT of the call made to FSCC.

6) FSCC (Victor 10) did not inform TWR about the fire notice received by the Airport Police and therefore did not inform about the dispatch of the two squads towards the baggage building.

7) From a phone call recorded at 06.13:35 hrs (00.03:14), TWR calling DCA, it can be assumed that TWR issued the emergency alarm signal just prior to that call:

DCA: *Yes tell me, has the alarm been called?*

TWR: *Hm...yes...we have the Scandinavian...we do not find him.*

8) The emergency alarm issued by TWR was activated while the first two fire squads were already on their way.

9) At 06.13:51 hrs (00.03:30) the FSCC (Victor 10) ordered out all available squads towards airport Gate n. 5:

Victor 10: *To all Victor, proceed towards gate number five, all Victor go near gate number five.*

All equipment followed the airport peripheral route (going around the North apron).

10) FSCC did not inform TWR, neither via service radio (440.450 MHz) nor by phone, of the nature of the fire at the baggage building and the type of intervention in progress (no information forwarded on aircraft type involved).

11) TWR and DCA did not forward timely to FSCC relevant and essential information, such as: aircraft type, number of passengers, fuel embarked or information about the nature of cargo contained.

12) At 06.16:21 hrs (00.06:00), Victor 1 made the first contact with TWR only to enquire about the position of the aircraft (for which the emergency alarm had been activated); *...did you localize the aircraft?*

13) At 06.17:37 hrs (00.07:16), Victor 1 made the following call on service radio frequency 440.450 MHz: *All Victor must come here, I want them Victor here;* that call gives evidence that not all Victor sent at time 06.13:51 had reached the impact area (baggage building).

14) FSCC did not inform TWR about the number of fire fighting equipment (vehicles and extinguishers) available for assistance to other traffic still moving around the airport on taxiways and aprons (at 06.40 hrs LX-PRA, I-DEAS, I-LUBI, AZ 2021 and AP 937 were still with their engines running).

- 15) The AEP did not mention the service radio call sign of the fire fighting mobile station (Victor 1) in charge of firemen coordination with TWR.
- 16) TWR ignored the service radio call sign of fire fighting mobile station (Victor1) in charge of firemen coordination; at 06.21:31 hrs, TWR asked FSCC on the direct phone line for that call sign and the reply received was: *ONE*.
- 17) During the early stages of the emergency, TWR received too many unnecessary phone calls.
- 18) AEP had not been updated and has not been implemented (adhered to) coherently.
- 19) Working shifts (end of duty/start of duty) of DCA, TWR and FSCC personnel all coincided at 06.00 hrs.
- 20) The removal of part of the wreckage before arrival of the Investigator-in charge and completion of important on site investigation, resulted in loss of factual information useful to the investigation.

3.2. CAUSES

After analysis of evidence available and information gathered, it can be assumed that the immediate cause for the accident has been the runway incursion in the active runway by the Cessna. The obvious consideration is that the human factor related action of the Cessna crew – during low visibility conditions - must be weighted against the scenario that allowed the course of events that led to the fatal collision; equally it can be stated that the system in place at Milano Linate airport was not geared to trap misunderstandings, let alone inadequate procedures, blatant human errors and faulty airport layout.

The following list highlights immediate and systemic causes that led to the accident:

- the visibility was low, between 50 and 100 meters;
- the traffic volume was high;
- the lack of adequate visual aids;
- the Cessna crew used the wrong taxiway and entered the runway without specific clearance;
- the failure to check the Cessna crew qualification;
- the nature of the flight might have exerted a certain pressure on the Cessna crew to commence the flight despite the prevailing weather conditions;

- the Cessna crew was not aided properly with correct publications (AIP Italy – Jeppesen), lights (red bar lights and taxiway lights), markings (in deformity with standard format and unpublished, S4) and signs (non existing, TWY R6) to enhance their situational awareness;
- official documentation failing to report the presence of unpublished markings (S4, S5, etc) that were unknown to air traffic controllers, thus preventing the ATC controller from interpreting the unambiguous information from the Cessna crew, a position report mentioning S4;
- operational procedures allowing high traffic volume (high number of ground movements) in weather conditions as were current the day of the accident (reduced visibility) and in the absence of technical aids;
- radio communications were not performed using standard phraseology (read back) or were not consistently adhered to (resulting in untraced misunderstandings in relevant radio communications);
- radio communications were performed in Italian and English language;
- Air Traffic Control (ATC) personnel did not realize that Cessna was on taxiway R6;
- the ground controller issued a taxi clearance towards *Main apron* although the reported position **S4** did not have any meaning to him;
- instructions, training and the prevailing environmental situation prevented the ATC personnel from having full control over the aircraft movements on ground.

Furthermore:

- the aerodrome standard did not comply with ICAO Annex 14; required markings, lights and signs did either not exist (TWY R6) or were in dismal order and were hard to recognize especially under low visibility conditions (R5-R6), other markings were unknown to operators (S4);
- no functional Safety Management System was in operation;
- the competence maintenance and requirements for recent experience for ATC personnel did not fully comply with ICAO Annex 1;
- the LVO implementation by ENAV (DOP 2/97) did not conform with the requirements provided in the corresponding and referenced ICAO DOC 4976.

The combined effect of these factors, contemporaneously present on the 8th of October 2001 at Milano Linate, have neutralized any possible error corrective action and therefore allowed the accident.

CHAPTER IV

SAFETY RECOMMENDATIONS AND ALERT MESSAGES

4. SAFETY RECOMMENDATIONS AND ALERT MESSAGES

4.1. ANSV RECOMMENDATIONS ISSUED WITH THE SECOND INTERIM REPORT - 9TH OF JULY 2002

4.1.1. Recommendation ANSV-17/113-1/A/02

Subject: Usage of the English language in Air/GND communications - Read-back

Addressed to: ENAC and ENAV SpA

Text: With reference to analysis of Air/GND communications of this accident, ANSV recommends mandate that the ICAO requirements regarding the usage of the English language shall be enforced and that its abidance shall be monitored. It is also felt necessary that standard read back procedures are enforced (ICAO Annex 10, paragraph 5.2.1.8 - Exchange of communications 5.2.1.8.2.2 PANS).

Similarly, ANSV calls for the enforcement by Air Transport Authority, of the new ICAO recommended procedure that calls for explicit clearance to be issued when “runways crossings” are involved and containing explicit mention of the runway denomination of the runway to be engaged. ICAO DOC 4444 and Doc 9432-An/925 “Manual of Radiotelephony”.

Exceptions should be confined to situations that emanate from a typical domestic only traffic and/or that the usage of the domestic language would facilitate handling of an emergency situation.

4.1.1.1. ENAC response letter of October 3, 2002

Extract from ENAC response letter:

ENAC acknowledges the content of the above mentioned recommendation for the part concerning its competence and requests to all Operators to make pilots aware of the need to use the English language, moreover highlighting the need of read-back (Annex 10-par 5.2.1.8 Exchange of communications 5.2.1.8.2). It is further requested to all Operators to invite all pilots to observe the obligation to request an explicit clearance to cross the runway (Doc 4444 and Doc-AN/925) and to follow the clearance received.

A special care is requested from Flight Schools and Training Centers so that starting from the training phase students be made aware of the importance of the use of the English language, the read-back and the observance of pertinent ICAO procedures and their implementation.

(See attachment AV)

4.1.2. Recommendation ANSV-18/113-2/A/02

Subject: Consistency of Aerodrome approved and published information with International Standard and correspondence between the information published and the physical state of airports - Follow-up to ANSV Safety Alert message, reference N 1238/INV/113-14/01 of Oct 10, 2001. (see attachment AV)

Addressed to: ENAC

Text: With reference to alert message n. 1238 and to findings obtained during this investigation, ANSV recommends that the state of airport Visual Aids of all domestic airports as well as the published taxi procedures shall be checked and found to be in accordance to published AIP.

All information shall be unequivocal and in conformity with Internationally adopted standards (ICAO Annex 14); furthermore such correspondence shall be reflected in Operators documentation.

4.1.3. Recommendation ANSV-19/113-3/A/02

Subject: Reporting and registration by ATC of abnormal Operational Safety events

Addressed to: ENAC and ENAV SpA

Text: With reference to findings obtained in this investigation, ANSV recommends that procedures shall be adopted to systematically report any incident or abnormal operation in breach of Safety. Registration of such events should be monitored by ENAC with a view to update and enhance the quality of procedures and their compliance by all concerned, to achieve and maintain adequate Operational Safety.

4.1.4. Recommendation ANSV-20/113-4/A/02

Subject: Professional qualification proficiency and recurrence of training for Air Traffic Controllers

Addressed to: ENAC and ENAV SpA

Text: With reference to findings obtained in this investigation, ANSV recommends to mandate for increased training and recurrent training of all Air Traffic Controllers, necessary to validate individual continuing proficiency for the task required for ATC.

4.1.5. Recommendation ANSV-21/113-5/A/02

Subject: Criteria for Aircrafts GND Movement routing - Follow-up to ANSV Safety Alert message, reference N 1336/INV/113-35/01 of Nov 6, 2001. (see attachment AV)

Addressed to: ENAC and ENAV SpA

Text: With reference to findings obtained in this investigation and to safety alert message 1336 issued on Nov 6, 2001, ANSV recommends the adoption of the model clearly defined in the ICAO Aerodrome Design Manual for the denomination of all elements of the airport movement area. Such model shall

allow the implementation of “standard taxi routings” containing all necessary information to air crews (denomination, routing, compulsory stop points). Such model should be adoptable by all airports. ANSV further recommends that Stop bar lights must be controlled by GND Controllers (On/Off control function), as described in ICAO Annex 14.

4.1.6. Recommendation ANSV-22/113-6/A/02

Subject: Applicability of Mandatory Low Visibility Procedures

Addressed to: ENAC and ENAV SpA

Text: With reference to findings obtained in this investigation, ANSV recommends the application of the same regulations, now compulsory for Commercial aircrafts, to all aircrafts involved in Low Visibility Operations (LVO-CAT II-III, LVTO).

4.1.6.1. ENAC response letter of July 26, 2002

Extract from ENAC response letter:

...with reference to evidence gathered during the investigation of the Linate accident of the 8th of October 2001 ANSV has recommended to extend the regulations applicable to low visibility (LVO-CAT II-III, LVTO) now compulsory for all commercial aircrafts, to all aircraft operating in the same meteorological conditions.

In this respect ENAC hereby gives notice of the intention to acknowledge by the recommendation...

(See attachment AV)

4.2. RECOMMENDATIONS ISSUED WITH THE FINAL REPORT - 20TH OF JANUARY 2004

4.2.1. Recommendation ANSV-1/113-7/A/04

Subject: Runway Incursion

Addressed to: Ministry of Infrastructure and Transport

Text: With reference to findings obtained in this investigation, ANSV recommends the national competent Authority to work in the international air transport organizations a full and quick implementation of the European Action Plan for Prevention of Runway Incursions.

4.2.2. Recommendation ANSV-1/113-8/A/04

Subject: ICAO Annex 14

Addressed to: Ministry of Infrastructure and Transport and ENAC

Text: With reference to findings obtained in this investigation, ANSV recommends the national competent Authority, to ensure that the design and operation of all Aerodromes are in compliance with the safety standards as specified in ICAO Annex 14.

4.2.3. Recommendation ANSV-1/113-9/A/04

Subject: Safety Management System

Addressed to: Ministry of Infrastructure and Transport and ENAC

Text: With reference to findings obtained in this investigation, ANSV recommends the national competent Authority, to ensure that all Aerodromes in Italy have a functional Safety Management System, according to ICAO Annex 14, vol. 1 paragraph 1.3.4.

4.2.4. Recommendation ANSV-1/113-10/A/04

Subject: ICAO Annex 1

Addressed to: Ministry of Infrastructure and Transport, ENAC and ENAV SpA

Text: With reference to findings obtained in this investigation, ANSV recommends the national competent Authority, to ensure that competence, maintenance and requirements for recent experience for ATC personnel fully comply with ICAO Annex 1 Standards.

4.2.5. Recommendation ANSV-1/113-11/A/04

Subject: AIP Italy

Addressed to: ENAC and ENAV SpA

Text: With reference to findings obtained in this investigation, ANSV recommends the national competent Authority, to ensure that all required information to operate safely are contained in the AIP Italy and updated as needed.

4.2.6. Recommendation ANSV-1/113-12/A/04

Subject: Cockpit Voice Recorder

Addressed to: Ministry of Infrastructure and Transport and ENAC

Text: With reference to findings obtained in this investigation, ANSV recommends that the national competent Authority forward proposals to ICAO regarding mandatory installation of Cockpit Voice Recorder equipment in aircraft operated under an AOC or equivalent approvals.

4.2.7. Recommendation ANSV-1/113-13/A/04

Subject: Eurocontrol Safety Regulatory Requirement - ESARR 5

Addressed to: Ministry of Infrastructure and Transport and ENAC

Text: With reference to findings obtained in this investigation, ANSV recommends the national competent Authority, in the international air transport organizations, work for that European Civil Aviation Conference - ECAC States shall collectively introduce the additional requirements in ESARR 5, SRC DOC 5, to the ICAO Council with the objective to have the ICAO Council adopt the changes to ICAO Annex 1 as proposed in ESARR 5, SRC DOC 5.

4.2.8. Recommendation ANSV-1/113-14/A/04

Subject: European Civil Aviation Conference (ECAC)

Addressed to: Ministry of Infrastructure and Transport and ENAC

Text: With reference to findings obtained in this investigation, ANSV recommends the national competent Authority present in the international air transport organizations, work for that European Civil Aviation Conference (ECAC) States shall establish standardization teams which on behalf of the Member States perform checks of air traffic management units similar to the established functions of the JAA standardization teams.

4.2.9. Recommendation ANSV-1/113-15/A/04

Subject: Airport norms and procedures for emergency and accident

Addressed to: Ministry of Internal Affairs and ENAC

Text: With reference to evidence gathered during this investigation, ANSV recommends the national competent Authority to evaluate the need to design the airport emergency plans applicable to all Italian airports in accordance with the ICAO (Annex 14 paragraph 9.1.12.) provisions and to establish guidelines applicable to all Italian airports, paying a special attention to the following requirements:

- a) The plan shall cater for an immediate dissemination of all necessary information (aircraft type, dangerous goods, fuel, persons on board) so as to allow correct rescue and fire fighting procedures to be followed.
- b) Reference maps shall contain the official denomination of key positions (locations) and made public.
- c) The plan shall be updated, made public and verified with periodic limited exercises (regarding communication and vehicle movement), full exercises (regarding also Fire Station crews intervention). They should be conducted without prior notice; exercises results shall be conducive to implementation of corrective measures, when needed.
- d) Fire Station crews shall inform duly the TWR for the necessary coordination.
- e) The plan shall make provision for priority radio and telephone links and a mandatory coded information flow between control centers of organizations.
- f) The plan shall require that a specific telephone line will be dedicated to non operational information flow to avoid overloading essential communication.
- g) The plan shall contain guidelines to participating organizations for other important aspects to be taken into account, such as the continuing alertness by all involved (organizational aspects like personnel shifting times, new recruits training, etc.).

4.2.10. Recommendation ANSV-1/113-16/A/04

Subject: ATC equipment and procedures

Addressed to: ENAV SpA and ENAC

Text: With reference to evidence gathered during the investigation, ANSV recommends the national competent Authority the following for evaluation:

- a) TWR personnel shall be invited to on site periodic recognition of existing markings, lightings and signs of airport maneuver area;

- b) the TWR airport emergency signal equipment shall be recorded and time stamped;
- c) the emergency frequency speaker system shall be positioned so as to be audible from all controller of the TWR control room;
- d) to add visual recognition capability (light source) to the ELT activation signal;
- e) to install the necessary equipment (radio and frequency) to allow TWR to monitor firemen service communications, when needed;
- f) TWR shall have immediate access the necessary information to be made available to rescue personnel prior to their intervention on accident site (persons on board, fuel, dangerous goods, etc,...).

4.2.11. Recommendation ANSV-1/113-17/A/04

Subject: Airport fire station organization

Addressed to: Ministry of Internal Affairs and ENAC

Text: With reference to available evidence gathered during this investigation, ANSV recommends the national competent Authority the following for evaluation:

- a) in case of accident the essential information should be shared by TWR and fire station using the dedicated communication equipment provided;
- b) the Fire Station Control Center should have immediately available the necessary information (number of passengers, fuel, dangerous goods, etc,...) to adopt the appropriate intervention technique;
- c) all communication lines of the fire station shall be recorded and time stamped;
- d) the internal alarm signal of the fire station shall be connected directly to the TWR signal;
- e) the number of fixed replenishing tanks shall guarantee that many equipment (vehicles) can be serviced at the same time;

4.2.12. Recommendation ANSV-1/113-18/A/04

Subject: Documental control for commercial and private pilots.

Addressed to: ENAC

Text: With reference to available evidence gathered during this investigation, ANSV recommends the national competent Authority to request all DCA that in low visibility condition operations, the random rate checking of aircraft documental certification and of the licenses and qualifications of the pilots, should be increased. With the objective of verifying the coherence of such documental check with the actual meteorological conditions.

4.3. ALERT MESSAGES

For alert messages issued by ANSV on the 10th of October 2001 and the 6th of November 2001 (see attachment AV).

APPENDIX

The following comments to this Final Report by States who have participated to the investigation are appended, at their request, in abidance of ICAO Annex 13 paragraph 6.3

- a) Denmark (State of operator SAS) : Nil
- b) Germany (State of registration of D-IEVX): Comment to Paragraph **2.1.4.**
The planned flight from Milano to Paris and back was, according the information given to our authority, a private flight. The BFU thinks that the assumption that it was a commercial flight has not been proven.
- c) Norway (State of operator SAS): Nil
- d) Sweden (State of operator SAS): Nil
- e) USA (State of manufacture and design of aircrafts involved): Nil

LIST OF ATTACHMENTS

- Attachment A:** AIP Italy documentation and audit of the Milano Linate Airport.
- Attachment B:** EDDK-LIML Flight plan and LIML-LFPB telex.
- Attachment C:** statement from ATA concerning Cessna departure from gate.
- Attachment D:** STOP sign, two photos.
- Attachment E:** taxiway markings pattern A and B.
- Attachment F:** CAT III sign photo.
- Attachment G:** airport map displaying firemen path from fire station to accident site.
- Attachment H:** NOTAMs.
- Attachment I:** Status of Cessna D-IEVX flight to Paris Le Bourget.
- Attachment J:** MD-87 load sheet.
- Attachment K:** maintenance transaction report (CESCOM).
- Attachment L:** METAR (Linate, Malpensa, Bergamo)-ATIS-RVR (Linate)- SIGMET- TAF.
- Attachment M:** transcripts of GND communication, from 05.00:55 to 06.12:27 hours of October 8, 2001.
- Attachment N:** transcripts of GND communication, 7th and 8th of October 2001 from 08.15:15 to 06.06:20 hours, grouped by flight call sign.
- Attachment O:** transcripts of GND communication, only taxi clearances via R5/R6.
- Attachment P:** transcripts of TWR communication on the 8th of October from 03.55:48 to 06.36:45 hours.
- Attachment Q:** telephone call transcripts between TWR and other selected operators on the 8th of October 2001 from 05.02:08 to 06.59:15 hrs.
- Attachment R:** transcripts of service radio communication on frequency 440.45 MHz from 05.10:57 to 06.51:32 on the 8th of October 2001.
- Attachment S:** transcripts of all communication, chronologically ordered, from 06.02:34 to 06.59.15 hours on the 8th of October 2001.
- Attachment T:** year sixties aerial photographs of Linate airport.
- Attachment U:** West apron map.
- Attachment V:** meeting report SEA/airport operators on West apron parking bays, March 3, 1996.
- Attachment W:** controllers declaration on meeting report discovery (March 13, 1996).
- Attachment X:** air traffic controllers statement concerning signs S1-S5.
- Attachment Y:** statistical data, RVR and traffic at Milano Linate.
- Attachment Z:** installation of lead-in green-yellow lights at RWY 18L/36R and TWY R6 intersection.

- Attachment AA:** red bar control deactivation.
- Attachment AB:** North apron taxi lines denomination, AIP Aerodrome chart (version 1997) with lines A,B,C.
- Attachment AC:** Jeppesen charts.
- Attachment AD:** SAS Flight Support charts.
- Attachment AE:** DGAC letter on new SMGC Radar antenna positioning.
- Attachment AF:** airport emergency plan amendment documents (DCA letter of 8/89).
- Attachment AG:** wo DCA reports (comments) on emergency exercises.
- Attachment AH:** UCT (DCA), D-IEVX control form.
- Attachment AI:** MD-87 DFDR data plotting and tabular.
- Attachment AJ:** declarations about the Cessna radio beacon sound.
- Attachment AK:** firemen vehicles technical data sheets.
- Attachment AL:** declaration from “Guardia di Finanza” officer.
- Attachment AM:** airport map displaying gate n. 5, First Aid Center and taxi parking area (outside of airport perimeter).
- Attachment AN:** declaration from doctor in charge of “First Aid” station.
- Attachment AO:** airport users committee “CASO” minutes.
- Attachment AP:** other documented runway incursion at Milano Linate.
- Attachment AQ:** aircraft reconstruction photographs.
- Attachment AR:** SAS station manager declaration.
- Attachment AS:** TWR controller declaration on CSO controller presence at accident time.
- Attachment AT:** aircraft collision pattern plan.
- Attachment AU:** After collision speed calculation; MD-87 CVR transcription and analysis.
- Attachment AV:** alert messages issued by ANSV;
ENAC response letter of 26th of July 2002 on Recommendation 22/113-6/A02;
ENAC response letter of 3rd of October 2002 on Recommendation 17/113-1/A02.

The attachments are copies of original documents made available to and kept by ANSV. In these documents the privacy of all individuals involved in the event and those who have provided evidence have been safeguarded, as indicated in Legislative Decree of February the 25th 1999, number 66, article 12, 3.

The CD to be found in the cover sleeve of this printed version contains the files of the Final Report text in the Italian and English language, the complete set of attachments listed above and videos showing animations of the accident dynamics. The animations, showing the accident scenario from various viewpoints and in different visibility conditions, were obtained from the data extracted from the DFDR of the MD-87 using a dedicated software and were synchronized with other findings and data available.