AVIATION OCCURRENCE REPORT

RISK OF COLLISION BETWEEN:

DELTA IR LINES
LOCKHEED L-1011 Nl739D and
CONTINENTAL AIRLINES
BOEING 747-200 N608PE
NORTH ATLANTIC 52°14'N 34°00'W
08 **JULY** 1987

REPORT NUMBER 87-A74947

SYNOPSIS

Delta Flight 37, a Lockheed L-1011 en route from London to Cincinnati at flight level 310, deviated south of its assigned track after passing 30 degrees west. The aircraft crossed the track of Continental Flight 25, a Boeing 747, flying from London to Newark, also maintaining flight level 310. The front half of Delta Flight 37 passed beneath the rear fuselage of Continental Flight 25 with less than 100 feet vertical separation.

The Canadian Aviation Safety Board determined that a navigation error resulting from a data input error led to the near collision. The error was not detected because the crew, who were relatively inexperienced with Atlantic crossings, did not perform adequate cross-checks of the INS. The company did not provide clear direction on the INS procedures to be followed. ATC did not query the error in the crew's estimated time of arrival over the next reporting point, nor was there a procedural requirement to do so at the time .

Ce rapport est egalement disponible en fran9ais.

15 February 1989

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1.0 **FACTUAL INFORMATION**

1.1 **History** of **the Flight**

Delta Flight 37, a Lockheed L-1011, departed London's Gatwick Airport on 08 July 1987 at 1334 Coordinated Universal Time (UTC)* on a scheduled international flight to Cincinnati, Ohio. Continental Flight 25, a Boeing 747-200, departed Gatwick Airport five minutes later at 1339 UTC on a scheduled international flig t to Newark, New Jersey.

As both aircraft approached the oceanic boundary, Shanwick Oceanic Control Centre assigned parallel routes, separated by 60 nautical miles, for the flight across the North Atlantic. Both aircraft were assigned a pressure altitude of 31,000 feet (flight level 310)**.

At 30 degrees west longitude, Delta 37 began deviating to the south of its assigned track and closed laterally with Continental 25 **(see** Figure 1.1.). Delta 37's deviation continued until the aircraft crossed the assigned track of Continental 25. As Delta 37 crossed the track of Continental 25, the front half of Delta 37 passed beneath the rear fuselage of Continental 25 with less than 100 feet of vertical separation. Neither crew saw the other aircraft in time to take evasive action.

The near collision occurred during the hours of daylight at 1625 UTC, over the North Atlantic at lat 52°45'N, long **33°12'W*****.

1.2 Injuries to Persons

1.2.1 Delta Flight 37

	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Serious	-	-	-	-
Minor/None	16	156	-	172
Total	16	156	-	172

* All times are UTC unless otherwise stated.
** Units are consistent with official manuals, documents, reports, and instructions used by or issued to the crew.
*** See Glossary for all abbreviations and acronyms.

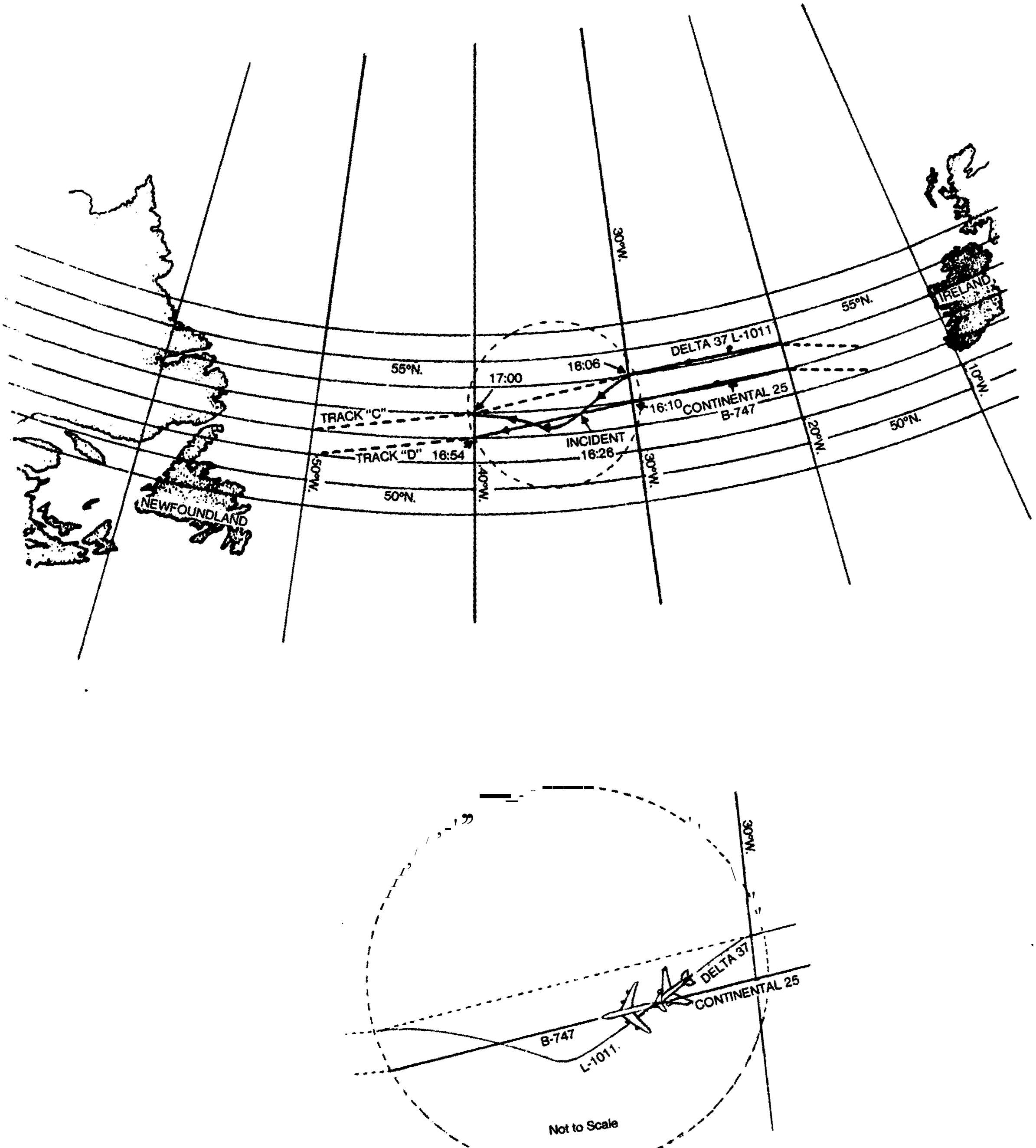

figure 1.1. fl19ht PathS - oetta 371eont1nental 25

1.2.2 Continental Flight 25

	Crew	Passengers	Others	Total
Fatal	-	-	-	-
Serious	-	-	-	-
Minor/None	20	397	-	417
Total	20	397	-	417

1.3 **Damage** to Aircraft

There was no damage to either aircraft.

1.4 Other Damage

- Nil -

1.5 Personnel Information

1.5.1 Delta Flight 37

	Captain	First Officer	Second Officer
Age	56	44	37
Pilot Licence	Airline Transport **Pilot (USA)**	Airline Transport **Pilot (USA)**	**Flight** Engineer **(USA)**
Medical Expiry Date	30/11/87	30/11/87	30/11/87
Total Flying Time	24,000 hr	12,000 hr	3,000 hr
Total on Type	4,200 hr	1,000 hr	850 hr
Total Last 90 Days	210 hr	110 hr	103 hr
Total on Type Last 90 Days	210 hr	110 hr	103 hr
Hours on Duty Prior to Occurrence	5 hr	5 hr	5 hr
Hours off Duty Prior to Work Period	27 hr	27 hr	27 hr

All three Delta Flight 37 deck crew members were trained and qualified to conduct the flight. The captain was occupying the left seat and was on his twelfth North Atlantic crossing. The first officer, who was flying, and the second officer were on their sixth North Atlantic crossing. The flight crew rest time exceeded the minimum required by regulation.

1.5.2 Continental Flight 25

	Captain	First Officer	Second Officer
Age	N/A	N/A	N/A
Pilot Licence	Airline Transport Pilot (USA)	Airline Transport Pilot (USA)	Commercial (USA)
Medical Expiry Date	N/A	N/A	N/A
Total Flying Time	5,800 hr	3,800 hr	1,150 hr
Total on Type	1,400 hr	1,700 hr	450 hr
Total Last 90 Days	N/A	N/A	N/A
Total on Type Last 90 Days	N/A	N/A	N/A
Hours on Duty Prior to Occurrence	4.5 hr	4.5 hr	4.5 hr
Hours off Duty Prior to Work Period	27 hr	27 hr	27 hr

All three Continental Flight 25 pilot crew members were trained and qualified to conduct the flight.

1.6 Aircraft Information

1.6.1 Delta Flight 37

Manufacturer	Lockheed Corporation
Type	L-1011-250
Certificate of Airworthiness	Valid
Total Airframe Time	Unknown
Engine Type (3)	Rolls Royce RB211-524
Maximum Allowable Take-off Weight	510,000 lb
Recommended Fuel Type	Jet B

The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. The aircraft navigation equipment exceeded the minimum standard for the flight.

1.6.2 Continental Flight 25

Manufacturer	Boeing Aircraft Co.
Type	B747-200
Certificate of Airworthiness	Valid
Total Airframe Time	47,706 hr
Engine Type (4)	Pratt & Whitney JT9-7f-7J.
Maximum Allowable Take-off Weight	785,000 lb
Recommended Fuel Type	Jet B

The aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. The aircraft's navigation equipment exceeded the minimum standard for the flight.

1.7 Meteorological Information

Both aircraft were flying in visual meteorological conditions over an undercast cloud layer.

1.8 Aids to Navigation

1.8.1 The North Atlantic Organized Track System

The high-level air traffic on the North Atlantic consists primarily of two unidirectional flows: westbound during the day and eastbound during the night. Because of the large number of high-level aircraft which cross the North Atlantic each day, a North Atlantic Organized Track System (NAT-OTS) is in place. This airspace usually consists of five tracks, each assigned with alphabetic designators and laterally separated by 60 nautical miles. The positions of these tracks change daily and are based on the wind-related minimum time track between New York and London.

1.8.2 Minimum Navigation Performance Specifications

Minimum Navigation Performance Specifications (MNPS) Airspace is that airspace within which users must meet certain minimum navigation equipment and flight crew requirements. The NAT-OTS is always within MNPS airspace.

1.8.3 North Atlantic Navigation within MNPS

The navigation systems used by individual aircraft are based upon self-contained airborne navigation capability. The **MNPS** airborne navigation equipment standard and the operating procedures are established by an international committee of North Atlantic airspace users. This committee is known as the North Atlantic Systems Planning Group (NATSPG) and works under the auspices of the International Civil Aviation Organization (ICAO). NATSPG makes its recommendations known to the ICAO contracting states through the ICAO publication North Atlantic MNPS Airspace Operations Manual. It is the responsibility of the State of Registry to ensure that the procedures contained in the manual will be complied with by its carriers before certifying aircraft, navigation equipment, and flight crews for operation in MNPS.

Delta 37 was equipped with three Carousel IV Inertial Navigation Systems (INS) for long-range navigation. In addition, a flight management system (FMS) was used. INS navigation equipment, as well as other self-contained navigation systems, is different from ground-based navigation systems because of the requirement to input navigation data. A unique aspect of North Atlantic navigation is the daily changing of the organized track structure; therefore, waypoint latitude and longitude data cannot be stored and must be manually entered for each flight. To ensure that an airplane is on the correct track, there must be proper data input and continuous monitoring of the navigation system by use of navigation cross-check procedures.

On Delta 37, the captain and first officer each have a control and display unit (CDU). The captain's CDU was located on the lower right side of the captain's flight instrument panel. The first officer's CDU was located on the lower left side of the first officer's flight instrument panel. The first officer in this case loaded the FMS computer through his CDU. Delta's procedure required that the captain confirm the data entered using his COU. The FMS automatically supplies the information to the captain's and first officer's INS units. The second officer entered the waypoints directly into his INS independently of the FMS.

1.9 ColDDlunications

1.9.1 Progress Reporting and Communication Monitoring

Aircraft flying across the North Atlantic beyond ground-based very high frequency (VHF) reception range use high frequency (HF) radio for communication. All communications are made through a flight service station (FSS) located on one side or the other of the Atlantic. In Gander, a co-located FSS handles the HF communications relaying information between the air traffic controllers and the pilots. There is no direct pilot/controller communication capability. Pilots continuously monitor a common VHF frequency in case of the need for emergency communications between aircraft. Pilots do not continuously listen to HF because of noise and static, but a selective call system generates a cockpit tone when some agency, such as an FSS, is calling an aircraft.

The HF communication facilities were operating normally on 08 July 1987 but were subject to the usual difficulties associated with HF communication, including busy frequencies and signal propagation problems. These difficulties, plus the use of FSS as an intermediary in pilot/controller communications, can cause a time delay of up to 20 minutes before a controller records or acts on transmissions from aircraft.

1.9.2 Air Traffic Control (ATC) Clearances

A westbound transatlantic flight receives its air traffic control clearances in three stages: domestic departure clearance, oceanic clearance approaching the ocean, and North American route clearance approaching landfall.

The domestic and oceanic clearances issued by Shanwick ATC to both Delta 37 and Continental 25 were correct and met separation standards.

Delta 37 was cleared via NAT Track "C", and Continental 25 was cleared via NAT Track "D".

On 08 July the coordinates of Track C were:
53N 15W, 54N 20W, 54N 30W, 53N 40W, 52N SOW.

on 08 July the coordinates of Track D were:
52N 15W, 53N 20W, 53N 30W, 52N 40W, 51N SOW.

Because of congestion on HF radio, Delta Flight 37 received its oceanic clearance later than expected, but this did not cause any flight delays or changes in the flight-planned track.

1.9.3 Progress Reports

For westbound flights, aircraft are required to make progress reports when crossing the following positions:

Coast-out point (the point where aircraft enter oceanic airspace) 15 west, 20 west, 30 west, 40 west, 50 west; and coast-in point (the point where they enter North American domestic airspace).

All progress reports for both aircraft were normal except for the Delta 37 report at 30 degrees west. This report stated that Delta 37 arrived at 54N 30W at 1606 UTC and estimated arriving at 53N 40W at 1707 UTC (elapsed time 61 minutes).

The controller estimated that Delta 37 would arrive at 53N 40W at 1651 UTC (elapsed time 45 minutes).

If a discrepancy exists between pilot and controller estimates and separation could be affected, the ATC Manual of Operations (MANOPS) states that the controller is required to:

a) check the accuracy of the ATC estimate;
b) if necessary, request that the pilot check his estimate; and
c) if a discrepancy remains, take any action necessary to ensure that an appropriate separation minimum will be maintained.

The controller did not bring the discrepancy of 16 minutes to the attention of the Delta 37 crew.

Some years ago, ATC MANOPS had required controllers to confirm estimates that differed by three minutes *in* domestic airspace and five minutes in oceanic airspace.

1.10 Aerodrome Information

Not applicable.

1.11 Flight Recorders

1.11.1 Cockpit Voice Recorders (CVR)

The CVRs operated on a 30-minute continuous-loop tape. Both CVRs continued to operate after the near collision, and therefore all information regarding the occurrence was lost.

1.11.2 Digital Flight Data Recorders (DFDR)

The DFDRs from both aircraft were analysed by the National Research Council of Canada Recorder Playback Centre and the CASB Engineering Laboratory in Ottawa, Canada. The geographic track and altitudes of both aircraft were determined. There was no INS information recorded by the DFDR of either aircraft. However, geographical tracks and relative positions were determined by correlation of times, headings, tracks, airspeeds, aircraft bank angles, winds, and pressure altitude changes. The recorders confirmed that Delta 37 deviated off course to the south and Continental 25 maintained its assigned track. Both aircraft maintained their assigned flight level of 310. Delta 37 passed beneath Continental 25 with less than 100 feet vertical separation. This was confirmed by a dip in the pressure altitude recorded by the Delta 37 DFDR as Delta passed through the wake turbulence of Continental 25 immediately after their paths crossed.

1.11.3 Other Recorders

A number of aircraft in the vicinity became involved in assisting Delta 37 to return to its assigned track. This involved a number of VHF radio transmissions outside the area of ground-based VHF coverage. The conversations that took place also involved a discussion about whether the incident should be reported. Part of these conversations was recorded on a CVR which was preserved by the crew of one aircraft. A copy of this CVR was submitted to the CASB.

1.12 Wreckage and Impact Information

Not applicable.

1.13 **Medical Information**

There was no evidence that incapacitation, physiological, or psychological factors affected the crews' performance.

1.14 **Fire**

Not applicable.

1.15 **Survival Aspects**

Not applicable.

1.16 Tests and Research

Nil.

1.17 **Additional Information**

1.17.1 **Navigation** Error - Delta Flight 37

When Delta 37 passed 30 degrees west, the aircraft turned left through 26 degrees. The flight log indicated that a 10-degree turn was required to maintain the desired track. The flight log also specified an elapsed time of 45 minutes for Delta 37 to fly from 30 west to 40 west. The captain used the FMS information to pass the position report at 30 degrees west. Based on this information, the estimated elapsed time to reach 40 degrees west was 61 minutes. No one in the cockpit detected the time and heading discrepancies.

Immediately after the occurrence, the captain turned his attention to regaining the correct track and reprogrammed the current "to" waypoint for 40 degrees west. By completing this procedure, the previously programmed waypoint data for 40 degrees west was erased. As a result, the captain could not confirm whether the INS had been programmed incorrectly or if it was malfunctioning.

After crossing Track D, Delta 37 continued to deviate another 20 nautical miles south before turning to regain the assigned track. The Delta crew received assistance from other aircraft crews in the area who had them in sight. Delta 37 descended 500 feet before recrossing Track O. The aircraft was back on its assigned track, Track C, just before reaching 40 degrees west.

1.17.2 The Aircraft's INS Equipment

The INS functioned normally after the occurrence. At Cincinnati, the captain entered a snag on the performance of the INS, which resulted in electronic maintenance personnel checking the equipment immediately before dispatching the aircraft. There was an ongoing check of the aircraft's INS system for several weeks after the occurrence; during this period, the equipment operated satisfactorily without any reported malfunction.

1.17.3 Gross **Navigation** Errors Using Self-Contained Equipment

A gross navigation error is defined as a deviation of more than 25 nautical miles from the prescribed track. An examination of previous occurrences involving gross navigation errors over the North Atlantic indicates that data input errors are a factor in the majority of cases, in particular those errors involving the use of INS.

1.17.4 Navigation Error Reporting

The ICAO North Atlantic MNPS Airspace Operations Manual makes several references to dealing with navigation difficulties. Regardless of origin of the difficulty, the manual states "ATC should be contacted" whenever navigation degradation is suspected or known.

A Federal Aviation Administration (FAA) Advisory Circular (AC 90-79 dated 7/14/80), entitled Recommended Practices and Procedures for the Use of Electronic Long-Range Navigation Equipment, states that ATC should be informed when a flight is experiencing navigation difficulty.

Delta's MNPS navigation error reporting procedures were contained in the Pilot's Operating Manual and were identical to those published in the ICAO North Atlantic MNPS Airspace Operations Manual. The Pilot's Operating Manual was required to be carried in the cockpit by the second officer for reference as necessary. The Jeppesen International Manual is carried in the cockpit and contains airways information and other pertinent information for international flight. Delta inserted special pages into their Jeppesen International Manual, outlining Delta's company procedures for using self-dontained navigation systems, but no reference is made to MNPS navigation difficulty reporting procedures.

The navigation difficulty was not reported to ATC by either Delta 37 or Continental 25 flight crew or by any one of more than 20 flight crews who were aware of the occurrence. The crew of Continental 25, however, reported the incident to company dispatch as they approached New York.

1.17.5 Delta's International Training

The FAA-approved Delta international training included instruction on INS operation and cross-check procedures for transoceanic operations. Delta requires that all crew members receive this training before flying transoceanic flights. The captain and first officer must fly a return jump-seat familiarization flight. The captain must then fly a return trip with a line check airman. Both the captain and first officer had successfully completed this training program.

1.17.6 Flight Planning Documents

In London, the pilots received their flight-planning documents from Gatwick Handling Limited, the company's ground-handling agent in London. All material provided to the crew was found to be accurate and complete.

1.17.7 Cross-check Procedures

A summary of the recommended cross-check procedures contained in the ICAO MNPS Operations Manual is as follows:

1. Plot the waypoints entered into the navigation system on a map or chart in the area to be traversed;

2. Data entered by one crew member to be verified by another crew member;

3. Match predicted distance between inserted waypoints, against predicted distances on the aircraft's flight plan;

4. Match navigation system present position against the coordinates of known ground-based NAVAIDS before crossing the outbound gateway;

5. Match the coordinates of waypoints against the flight plan, both when crossing the waypoint and approximately 10 minutes following the waypoint;

6. Match estimated time and distance between waypoints against those parameters predicted on the flight plan; and

7. Plot actual position on a chart, 10 minutes after waypoint passage, to compare actual position with required position.

The following cross-check procedures are extracted from the Jeppesen International Manual, Delta special pages:

1. The waypoint log must be verified by a pilot other than the one making the original list;

2. Waypoint entry will be verified using the challenge/response method;

3. At last NAVAID position compare INS position with known position and perform a compass deviation check;

4. Approaching a waypoint verify the following waypoint coordinates;

5. Over a waypoint compare the three INS sets for reasonableness;

6. After waypoint passage verify heading, course, and miles to next waypoint.

In addition to these cross-checks, the company policy states that the crew members shall normally leave their cousin the following display modes: the captain's in present position; the first officer's in next waypoint position; and the second officer's in cross-track error.

During the occurrence flight, the crew completed the following cross-check procedures:

1. Data entered by one crew member was verified by another crew member;

2. A compass deviation check was completed at the coast-out point.

At the time of the occurrence, the captain's CDU was selected to present position mode, the first officer's was selected to time and distance, and the second officer's to wind.

1.17.8 Re-creation of Flight Paths

A re-creation of the relative flight paths demonstrated that the crossing angles of the two aircraft made a visual sighting from either flight deck unlikely•

On Delta 37, the captain was the only flight crew member who was in a position to see Continental 25; to do so he would have had to be looking to his extreme left. In fact, the captain was looking to his right, discussing flight business with another crew member. As a movie was in progress, none of the Delta 37 passengers saw the occurrence.

On Continental Flight 25, the first officer was the only flight crew member who was in a position to see Delta 37; to do so he would have had to be looking to his extreme right. However, at the time of the occurrence, he was looking straight ahead until approximately three seconds before the two aircraft crossed, when he looked to his right and caught a glimpse of Delta 37. Several passengers aboard Continental Flight 25 saw Delta 37 moments before the two aircraft crossed; one passenger **was able** to photograph the Delta Lockheed L-1011 (see Figure 1.2.).

1.17.9 Satellite Navigation and Communication

In the absence of radar coverage over extensive oceanic and certain land areas, air traffic control has been based on position reports by pilots. Thus, ICAO is currently studying the feasibility of using satellite navigation and communication systems for North Atlantic air traffic operations. The concept of Automatic Dependent Surveillance (ADS), incorporating direct two-way pilot/controller communications, whereby aircraft-derived positional reports would be transmitted automatically or on request to ATC units at frequent intervals is being examined. The technical capability of satellite communications to support ADS and other ATC-related air-ground communications exists and has been demonstrated.

The United States is establishing a satellite navigation system. The Global Positioning System (GPS) will be operational in the 1990s, providing users with a world-wide three-dimensional navigation system.

1.17.10 Incident Reporting

When the crew of Continental 25 indicated that they would have to report the occurrence, they were discouraged from doing so by some other pilots in the vicinity. The wisdom of reporting the occurrence was questioned, and they were told that, since the aircraft was outside radar coverage, the error would not be detected. It was also suggested that only a few pilots knew about it and it did not have to be reported. One pilot suggested to Delta 37 that a report to the National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System **(ASRS)** by registered mail within nine days would preclude the possibility of regulatory action.

1.17.11 Second Incident

About 1.5 hours after regaining track and as the aircraft entered radar coverage, Delta 37 was involved in a second incident during which a loss of instrument flight rules (IFR) separation occurred.

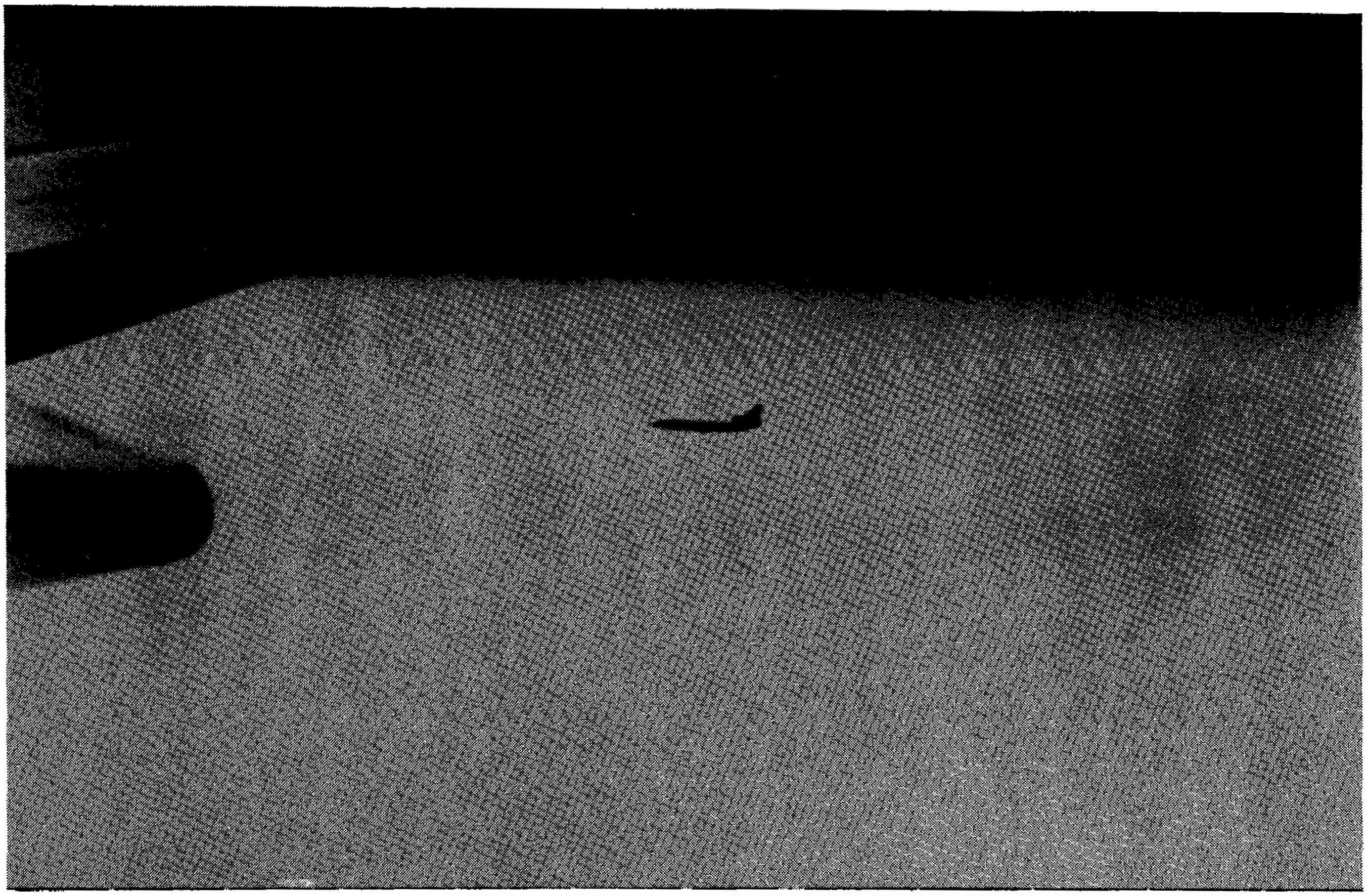

Figure 1.2. Photograph of Delta 37 Taken by Passenger On Board Continental 25

As Delta 37 approached the Dotty Intersection, the captain contacted the Gander Domestic controller and requested a clearance to climb to flight level 370. The Gander Domestic controller issued Delta 37 a domestic clearance via Dotty Intersection direct Heath Point and en route to Cincinnati. To accommodate the captain's request and to provide necessary separation with nearby traffic, the Gander Domestic controller instructed Delta 37 to turn 30 degrees to the right. When separation was established with the pertinent traffic, the Gander Domestic controller cleared Delta 37 to climb to flight level 370. When the aircraft were established on parallel courses 10 miles apart, the Gander Domestic controller recleared Delta 37 present position direct to Heath Point which would parallel the other aircraft, thus maintaining radar separation. This new clearance would have taken Delta 37 to a position north of the Dotty Intersection. The Domestic controller instructed Delta 37 to resume normal navigation, and the aircraft commenced a 90-degree left turn back toward the Dotty Intersection, on a converging course with the other aircraft. The Domestic controller detected the error and redirected Delta 37 back toward Heath Point; during this incident, the required 10-mile spacing was reduced to 7 miles. Separation was then re-established, and the flight of Delta 37 continued without further anomalies.

The second loss of separation occurred at lat 51°00'N, long 55°00'W at 1807 UTC during the hours of daylight.

2.0 ANALYSIS

2.1 Introduction

On 08 July 1987, Delta 37 flew within 100 feet of Continental 25. Both aircraft were westbound across the North Atlantic at flight level 310. The incident occurred in airspace controlled by Gander Oceanic Area Control Centre. Delta 37, which had been assigned North Atlantic Track C, 60 nautical miles to the north of Track D, departed its track, crossed Track D, and continued to a point about 80 miles south of course before the crew began to correct back to the assigned track.

The analysis will discuss the reasons for the navigation error and why it remained undetected. This will include a discussion of crew and air traffic control procedures. Finally, the manner in which the incident was reported will be addressed.

2.2 The Navigation Error

The requirement to manually insert latitudes and longitudes on self-contained navigation systems makes such systems prone to input error. On many routes this problem is alleviated by using preset points which have been previously programmed into the sets. These preset points greatly simplify the data input process by decreasing and simplifying digit input, thus reducing the possibility of input error. Preset points are not viable for NAT-OTS navigation because of the daily track changes.

At the time of the occurrence, both the captain's and the first officer's INS units showed the aircraft on the programmed track, even though the aircraft was deviating from the flight-planned track. The second officer's unit appeared to be programmed for the correct desired track. The captain's and first officer's INS units were being automatically supplied with the active navigating waypoints by the FMS computer which had been programmed using the first officer's CDU and which had been cross-checked by the captain; the second officer inputted his INS independently. This sequence, coupled with the accurate performance of the aircraft's INS equipment subsequent to the occurrence, indicates that a data input error was made by the crew.

Because data input errors can easily occur when using self-contained navigation systems, there is a well-documented procedure of checks and cross-checks to detect and prevent such errors.

2.3 Crew Procedures

The Delta ground school syllabus covered INS navigation and cross-check procedures. Course testing and examination were carried out, and the captain was route-checked by a company check airman. In addition, this training and testing package was FAA approved. There was no indication that the material covered did not provide adequate information to the crew about the appropriate navigation procedures. The two manuals available to the crew were examined. The Pilot's Operatina Manual restated the recommended procedures contalne In the ICAO North Atlantic MNPS Airspace Operations Manual. Although the ICAO procedures gave detailed guidance on the equipment operation, they gave the impression that the cross-check procedures were recommended when in fact they were essential. The Delta special pages of the Jeppesen International Manual, which is normally accessible on the flight deck, contained a step-by-step guide to the operation of the INS equipment. Although there was no ambiguity as to the procedures to be followed, the Jeppesen manual did not make clear the importance of operating the INS displays so as to facilitate error detection, nor did it emphasize the importance of the various cross-check procedures interspersed throughout the other procedures.

The crew followed established data entry procedures by ensuring the data entered was verified by another crew member; however, an input error still resulted. Subsequently, the crew did not follow established cross-check procedures, thus allowing the error to go unnoticed until the near collision occurred. Despite the fact that the crew had undergone ground school training, route familiarization, and route checks, they did not appear to be sufficiently aware of the importance of adhering to the required INS procedures. The three crew members' inexperience with Atlantic crossings would have contributed to their lack of awareness of the importance of cross-check procedures.

2.4 Air Traffic Control

The captain, in making his 30 west progress report, read his information directly from the FMS. The captain's forward estimate of 61 minutes was 16 minutes more than the controller's estimate of 45 minutes. ATC MANOPS requires that the controller check the accuracy of the ATC estimate and, if necessary, request the pilot to check his estimate should a discrepancy exist for the same reporting point and if separation could be affected. In this case, the controller did not query the difference because he judged that aircraft separation would not be affected by the difference in the estimates. Had he queried the difference, it is possible that it would have alerted the crew of Delta 37 to the fact that the incorrect waypoint was inserted into the INS.

In the past, ATC MANOPS required controllers to confirm estimates that differed by three minutes in domestic airspace and five minutes in oceanic airspace. Had this instruction been in effect, it is likely that the controller would have requested the pilot to recheck his estimate. Since air traffic control on the North Atlantic is based on position reports from pilots, monitoring time discrepancies between crew and controller estimates is the primary means of detecting significant navigation errors.

The delays associated with HF communication at Gander could have made any controller's request to recheck the estimate too late to have affected the outcome of the occurrence. In the absence of more direct controller/ pilot communications, significant delays in HF radio communications will continue.

2.5 Reporting

Neither Delta 37 nor Continental 25 attempted to report the incident to ATC by radio in accordance with ICAO requirements. Because the incident was not reported, Gander Oceanic Control Centre was unaware of the navigation error and could not gu de Delta 37 to a safe position on a track free of conflicting traffic. When Delta 37 returned to Track C, the crew was unaware of the location of other aircraft on the "track and, as a result, could have created an additional hazard to other aircraft.

The captain of Delta 37 stated that he was too preoccupied immediately after the occurrence in analysing the problem and ensuring the safety of the aircraft to make an immediate report to ATC. A radio discussion on VHF among several aircraft crews took place shortly after the occurrence. The conversation centred around whether the occurrence had to be reported and, if so, by whom and by what method. The discussion contained many unprofessional remarks, and it was evident that several crews were content to leave the occurrence unreported. Some crews also suggested that the crew of Continental 25 not report the occurrence. The end result was that the occurrence was not reported to ATC in a timely manner for safety purposes.

3.0 CONCLUSIONS

3.1 Findings

1. The near collision resulted from an INS data input error by the Delta Flight 37 crew.

2. Delta Flight 37's crew did not follow established INS cross-checks.

3. Delta Flight 37, while at flight level 310, deviated 80 nautical miles south of its assigned track after passing 30 west.

4. Delta Flight 37 crossed the track of Continental Flight 25 which was also at flight level 310.

5. Neither aircraft crew saw the other aircraft in time to take evasive action, and the angle of closure made a visual sighting unlikely.

6. The forward fuselage of Delta Flight 37 passed beneath the rear fuselage of Continental Flight 25 with less than 100 feet of vertical separation.

7. Continental Flight 25 was maintaining its assigned track.

8. Delta 37's flight crew had limited experience in North Atlantic flying, with no crew member having more than six return trips.

9. Although cross-check procedures were contained in explicit detail in the manuals used by the crew, they were set out in such terms and format that a mandatory requirement to cross-check at each and every waypoint may not have been clearly conveyed to aircrew.

10. The ATC clearances received and acknowledged by both aircraft were correct and, if followed, would not have resulted in a loss of separation.

11. The occurrence was not reported to ATC in a timely manner by the involved flight crews, in accordance with ICAO requirements.

12. Continental Flight 25 reported the occurrence to company dispatch, as it approached New York.

13. The estimate for Delta Flight 37 at 40 west showing a difference of 16 minutes was not challenged by ATC, nor was it required to be in the circumstances of this incident.

14. There is no direct pilot/controller communication on transatlantic flights.

15. HF communications on transatlantic flights may be subject to significant time delays.

16. About 1.5 hours after the first occurrence, the crew of Delta Flight 37 misinterpreted an ATC clearance, and the aircraft was involved in a technical loss of separation with another aircraft.

17. The Delta 37 flight crew was certified and qualified for the flight in accordance with existing regulations.

18. The Delta 37 aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures.

19. No evidence was found that would indicate the Delta 37 INS was malfunctioning prior to or during the flight.

3.2 Causes

A navigation error resulting from an INS data input error led to the near collision. The error was not detected because the crew, who were relatively inexperienced with Atlantic crossings, did not perform adequate cross-checks of the INS. The company did not provide clear direction on the INS procedures to be followed. ATC did not query the error in the crew's estimated time of arrival over the next reporting point, nor was there a procedural requirement to do so at the time.

4.0 SAFETY ACTION

4.1 Action Taken

On 03 September 1987, the Canadian Aviation Safety Board issued two interim recommendations to the Minister of Transport proposing that:

> The Department of Transport ensure that all Canadian operators engaged in long-range flights dependent upon on-board area navigation systems carry out a prescriBed series of pre-taxi and en route procedural cross-checks to provide redundant protection against gross navigational errors; and

CASB 87-48

> The Department of Transport seek international agreement concerning adequate cross-check procedures of area **navigation** equipment to reduce the possibility of gross navigational errors during long-range intercontinental flights, particularly over the North Atlantic.

CASB 87-49

Transport Canada has replied to these two recommendations in a positive manner.

The Board notes that the United States National Transportation Safety Board (NTSB) concurrently issued similar recommendations in the United States. The NTSB proposed that flight crews of U.S. operators who engage in transoceanic transport employ at least two initial and three en route verification techniques to guard against the use of incorrect navigation information, and that FAA inspectors emphasize to operators the rules that apply to transoceanic operations in a non-radar environment. In addition, Delta Air Lines conducted an internal review of their international operations and subsequently revised several sections of the Pilot's Operating Manual that relate to navigational and cross-check procedures. Delta's Transoceanic Flight Crew Bulletins 87-5 through 87-10 refer.

On 13 May 1988, the CASB issued a third recommendation to the Minister of Transport proposing that:

> The Department of Transport modify Air Traffic Control procedures to ensure that any discrepancies of five minutes or more between pilot and ATC estimates on the North Atlantic be challenged by the controller at once to verify the estimate.

CASB 88-03

This recommendation has been adopted in Canadian controlled airspace. Further, Transport Canada has advised other North Atlantic Track Provider States of CASB 88-03 and has recommended similar action to the North Atlantic Systems Planning Group .

4.2 Action Required

4.2.1 Surveillance and Communications

The potential consequences of the gross navigation error of this occurrence were exacerbated by an antiquated system of flight-following by air traffic services (ATS) using data strips, without benefit of direct pilot/controller communications. currently, beyond the 200 nautical mile range of present day radars, there is no system of direct air traffic surveillance, and pilot/controller communications are dependent upon often unreliable HF radio contact.

Air traffic on the North Atlantic air routes is expected to increase over the next few years. Canada is one of the major contributors to an ICAO special committee on Future Air Navigation Systems (FANS), which is charged with developing the operational and equipment standards for an international communication, navigation, and surveillance (CNS) system. Several countries are developing global satellite communication and navigation systems. Once in place, these systems will facilitate the safe and efficient control of this increasing air traffic on the North Atlantic.

One of the principal concepts under development by the !CAO FANS Committee is known as Automatic Dependent Surveillance (ADS). With ADS, aircraft will automatically transmit positional data derived from their on-board **area** navigation system to air traffic control facilities via an air-ground data link, thereby providing controllers with the necessary surveillance system to monitor the flow of air traffic, as cleared. Satellite communications systems will facilitate the direct pilot/controller communications to effect necessary changes in routing to maintain safe separation between aircraft. The ADS concept is promising, and the Board encourages the Department of Transport in its ongoing efforts to reach international agreement for the early implementation of such a system. Optimistically, however, several more years will be required for the development and implementation of ADS into full operational service on the North Atlantic.

In the near term, the problem of direct pilot/controller communication in the Gander Oceanic Control Area persists. Currently, a co-located FSS actually handles the HF communications, relaying pilots' estimates for each waypoint to the air traffic controller who updates his **data** strips and cross-checks the pilots' estimates. Should a discrepancy arise which affects the safe **separation** of aircraft, the controller then physically has to go to the FSS operator and attempt to contact the pilot on HF to confirm the accuracy of the estimate. This cumbersome, time-consuming process results in delays that could affect aircraft separation. Because of current problems arising from the lack of direct communication between pilots and air traffic controllers in the Gander Oceanic Control Area and because the potential of **ADS** remains a longer term proposition, the CASB recommends that:

> The Department of Transport take immediate steps to provide more timely and reliable controller/pilot communications in the Gander Oceanic Control Area.

CASB 89-06

4.3 Safety Concern

4.3.1 Failure to Report a Near Mid-Air Collision

The Board is concerned that a number of professional aircrew from several countries gave advice to the Delta crew to avoid or delay reporting this incident of a near mid-air collision to air traffic controllers. This represents a significant departure from the traditional operating philosophy of pilots who, through their strong motivation towards accident prevention, have promptly reported their in-flight problems or errors, without fear of career implications. In this case, failure to report the track deviation put many people at risk for a longer than necessary time period while the aircraft manoeuvred to regain the lost track without the assistance of air traffic control. While the Board believes that most aircrew would not deliberately attempt to cover up a near mid-air collision, it is very concerned by the attitude of the various flight crews in the in-flight discussions immediately after this incident. The Board is seeking the support of the major professional pilot associations, air transport associations, and government regulators of the aviation industry in a cooperative effort to help ensure the continued willingness of flight crews to report safety-related matters.

This report and the safety action therein has been adopted by the Chairman, K.J. Thorneycroft, and Board Members:

W. MacEachern
A. Portelance
r. Thurston

Board Members N. Bobbitt, L. Filotas, and R. Stevenson dissented.

GLOSSARY

AC	Advisory Circular
ADS	Automatic Dependent Surveillance
ASRS	Aviation Safety Reporting System
ATC	air traffic control
ATS	air traffic services
CASB	Canadian Aviation Safety Board
CDU	control and display unit
CNS	communication, navigation and surveillance
CVR	cockpit voice recorder
DFDR	digital flight data recorder
FAA	Federal Aviation Administration
FANS	Future Air Navigation Systems
FMS	flight management system
FSS	flight service station
GPS	Global Positioning System
HF	high frequency
hr	hour(s)
ICAO	International Civil Aviation Organization
IFR	instrument flight rules
INS	Inertial Navigation System
lat	latitude
lb	pound(s)
long	longitude
MANOPS	Manual of Operations
MNPS	Minimum Navigation Performance Specifications
N	north
NASA	National Aeronautics and Space Administration
NAT-OTS	North Atlantic Organized Track System
NAT-SPG	North Atlantic Systems Planning Group
NTSB	National Transportation Safety Board
VHF	very high frequency
UTC	Coordinated Universal Time
W	west
°	degree(s)
'	minute(s)