AVIATION OCCURRENCE REPORT
A98H0002

LOSS OF SEPARATION

BETWEEN
AIR CANADA BOEING 747-400 C-GAGN
and
AIR FRANCE AIRBUS A340 F-GLZL
NORTH ATLANTIC, ST. JOHN'S, NEWFOUNDLAND 125nm S
20 JULY 1998

Aviation Occurrence Report

Loss of Separation

Between
Air Canada Boeing 747-400 C-GAGN
and
Air France Airbus A340 F-GLZL
North Atlantic, St. John's, Newfoundland 125 nm S
20 July 1998

Report Number A98H0002

Summary

Air France flight 033 (AFR033), an Airbus A340 aircraft, was en route from Houston, Texas, USA, to Paris, France, at flight level (FL) 370 with a routing of WHALE, BANCS, and latitude 46°N longitude 50°W (Oceanic Track "X"). Air Canada flight 870 (ACA870), a Boeing B747 aircraft, was en route from Montreal, Quebec, to Paris at FL 370 with a routing of MIILS, COLOR, and latitude 47°N longitude 50°W (Oceanic Track "W"). ACA870 was re-cleared from MIILS direct to latitude 45°N longitude 50°W (Oceanic Track "Y"). The new routing placed ACA870 on a converging track with AFR033. Approximately 30 miles west of the BANCS intersection, both aircraft received and responded to traffic avoidance and collision advisory system (TCAS) resolution advisories (RA). A loss of separation occurred at approximately 0213 Coordinated Universal Time (UTC) when the two aircraft closed to approximately 400 feet vertically and 1.9 miles horizontally. The required separation in the airspace for these aircraft is 5 miles horizontally or 1000 feet vertically.

Ce rapport est également disponible en français.

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1.0 Factual Information

1.1 History of the Flight

Air France flight 033 (AFR033)[1], an Airbus A340 aircraft, was en route from Houston to Paris at flight level (FL) 370 with a routing of WHALE, BANCS, and latitude 46°N longitude 50°W(Oceanic Track "X"). Air Canada flight 870 (ACA870), a Boeing B747 aircraft, was en route from Montreal to Paris at FL 370 with a routing of MIILS, COLOR, and latitude 47°N longitude 50°W (Oceanic Track "W"). ACA870 was re-cleared from MIILS direct to latitude 45°N longitude 50°W (Oceanic Track "Y"). The new routing placed ACA870 on a converging track with AFR033.

The two aircraft were being controlled by the Gander Area Control Centre (ACC) high domestic controllers responsible for the combined sector BANCS and south, the two south-easternmost sectors of the Gander domestic airspace, in which the coast-out points BANCS and RAFIN are located (see Appendix A, Figure 1). ACA870, with 265 passengers and a crew of 14, had been issued an amended oceanic clearance by clearance delivery prior to handoff to the BANCS radar controller. ACA870 contacted the radar controller at 0151:15[2], outside the geographic boundaries of the BANCS sector, and crossed the sector boundary at 0207. Position estimate information was provided by ACA870 to the radar controller indicating that the aircraft was level at FL 370 and estimating latitude 45°N longitude 50°W at 0227.

AFR033, with 235 passengers and a crew of 14, had received an oceanic clearance and had been handed off to the radar controller at 0158:32. AFR033, established on the route WHALE direct to BANCS, was level at FL 370, and estimating BANCS at 0217. The aircraft track during this portion of the flight was approximately 076° magnetic.

At approximately 0211, as ACA870 approached 40 nm west of the BANCS intersection en route to latitude 45°N longitude 50°W, the radar controller contacted ACA870 and advised that radar service would terminate at longitude 50°W and to contact Gander radio on frequency 126.9 megahertz. At this time, ACA870 was approximately 9 nm from AFR033 and converging on a track of 116° magnetic. No action was taken by the radar controller. Approximately one minute and thirty seconds later, at 0212:33, while the radar controller was communicating with another aircraft, ACA870 received a TCAS RA and attempted to make radio contact with the radar controller, but was cut off by another transmission. Seven seconds later, at 0212:40, ACA870 declared Pan, Pan, Pan. The radar controller issued a clearance to descend to FL 360. ACA870 replied that they were climbing as a result of the RA and that they were on a collision course. The radar controller advised ACA870 to follow the advisory.

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[1] See Glossary for all abbreviations and acronyms.

[2] All times are Coordinated Universal Time (UTC) unless otherwise stated. (UTC equals Newfoundland daylight time plus 2 hours and 30 minutes).

Immediately thereafter, AFR033 declared Pan, Pan, Pan and advised the controller that the aircraft was descending as a result of a TCAS RA (see Appendix A, Figure 2). AFR033 received an initial TCAS traffic advisory (TA) at 0211:34 and an RA to descend at 0212:47. Recorded radar data of the occurrence shows AFR033's altitude to have been 36,900 feet at 0212:49, 36,700 feet at 0212:54, 36,700 feet at 0212:59, and 36,400 feet at 0213:03. (Valid recorded radar data may differ from aircraft-reported altitude by plus or minus 200 feet.) Aircraft data provided by Air France show the altitude of AFR033 as 36,788 feet at 0212:59 with a downward velocity of 1,790 feet per minute, and 36,384 feet at 0213:30. The time between the onset of the RA and initiation of descent with the autopilot off was two seconds.

On receiving the TCAS RA, ACA870 began an immediate climb to FL 380 and reached that altitude approximately 50 seconds after commencement of the climb. Seventeen seconds after the end of the AFR033 Pan, Pan, Pan transmission, ACA870 advised that they were directly overhead the Air France aircraft and that the two aircraft would have collided.

1.2 Injuries to Persons

There were no injuries.

1.3 Damage to Aircraft

There was no damage to either aircraft.

1.4 Other Damage

There was no other damage as a result of this occurrence.

1.5 Personnel Information

1.5.1 Air Traffic Controllers

Controller Position	Radar Controller
Age	36
Licence	ATC
Experience	
- as a Controller	8 years
- as an IFR Controller	8 years
- in Present Unit	8 years
Hours on Duty Prior to Occurrence	6

Controller Position	Radar Controller
Hours off Duty Prior to Work Period	58

Controller Position	Data Controller
Age	34
Licence	ATC
Experience	
- as a Controller	9 years
- as an IFR Controller	9 years
- in Present Unit	9 years
Hours on Duty Prior to Occurrence	3.75
Hours off Duty Prior to Work Period	38

1.5.1.1 Air Traffic Controllers' Experience

The sector in which the loss of separation occurred, BANCS, was staffed by a data controller and a radar controller in accordance with unit staffing requirements. The team supervisor, in keeping with normal practice, was working at another sector providing a relief break for a controller. The radar controller had eight years', and the data controller nine years', experience in air traffic control. Both controllers were appropriately licenced and qualified. The radar controller had been on duty for six hours, and the data controller three and three quarters hours, since the beginning of their shifts. The radar controller was on the first shift of his work cycle, having completed two days off. The data controller had been off the previous day but had reportedly worked 16 shifts in the previous 18 days, 7 of which had been overtime shifts. Such a schedule is within the terms of the collective agreement provided one day off is provided after nine consecutive days of work. The traffic volume at the time of the occurrence was described as moderate to heavy. All necessary equipment was serviceable and being used.

1.6 Aircraft Information

1.6.1 Air Canada Boeing 747 C-GAGN

Manufacturer	Boeing
Type and Model	747-400

Year of Manufacture	Not applicable
Serial Number	Not applicable
Engine Type (number of)	4

1.6.2 Air France Airbus A340 F-GLZL

Manufacturer	Airbus Industrie
Type and Model	A340
Year of Manufacture	Not applicable
Serial Number	Not applicable
Engine Type (number of)	4

1.7 Meteorological Information

The weather was clear in the vicinity of the occurrence.

1.8 Aids to Navigation

All navigation aids were reported to be operating normally.

1.9 Communications

Normal means of communication were serviceable.

1.10 Control Procedures - General

1.10.1 Flight Progress Strip Manipulation

Flight progress strips are maintained by controllers and contain written information on the status and intentions of aircraft passing through a sector. Directions for the marking and manipulation of flight progress strips are contained in the NAV CANADA *Air Traffic Control Manual of Operations* (ATC MANOPS), Part 9, and in the Gander ACC Operations Manual, High Level Domestic, Strip Writing Procedures.

The original flight planned routing for ACA870 was from North American route N49A to MIILS direct to COLOR and then to latitude 47°N longitude 50°W (Oceanic Track "W")
(see Appendix A, Figure 1). The original flight progress strip, designated D1 for ACA870, was posted under the COLOR header in the flight progress board of the appropriate sector. When the oceanic clearance was

changed necessitating a reroute, the D1 strip was amended by the data controller in the COLOR sector by stroking out the fix identifier COL (COLOR) and writing in the new fix identifier, RFN (RAFIN), which is the fix associated with latitude 45°N longitude 50°W. In accordance with the Gander ACC Operations Manual, article 4.1.6.2, the strip was then passed to the affected sector, BANCS. Subsequently, a new oceanic clearance strip was printed at 0138 together with an amended sector strip designated D2 and passed to the BANCS sector for posting under the RAFIN header. There was no traffic on the route from RAFIN to latitude 45°N longitude 50°W at FL 370 which conflicted with ACA870.
ACA870, now rerouted and known locally as a cutter, crossed several other active tracks, including the WHALE-to- BANCS track which was very active on the night of the occurrence, from the northwest to the southeast. ACA870 passed approximately 13 nm abeam BANCS, while its closest approach to RAFIN was approximately 28 nm. There was no flight progress strip printed for posting under the BANCS header. There is no requirement for such a posting in local procedures, and there is no provision for the printing of an extra strip for this purpose. Aircraft joining southern oceanic tracks from the North American Midwest generally cut southeast-bound across other established tracks, and are a relatively common occurrence for Gander controllers.

The flight route of AFR033 took it directly over BANCS and on to latitude 46°N longitude 50°W to follow Oceanic Track "X". The flight progress strip for AFR033 was posted under the BANCS header.

The Gander ACC Operations Manual, High Level Domestic, Strip Writing Procedures, article 2.6, directs that "When aircraft are cleared direct and this results in the aircraft going abeam a fix, the fix shall have "A/" written to the upper left of the affected fix ...." The flight progress strip used by the BANCS and south sector for ACA870 was not marked with the "A/" to the upper left of the fix indicator, RFN, on either the D1 or D2 strips. Article 2.4 specifies that "If a particular route requires attention: ... the fixes to the right of the aircraft ident shall have a box placed around them on all strips." No box was placed around the fixes to the right of the aircraft identification on either the D1 or D2 flight progress strips of ACA870. Article 8.3.2 directs that "If there is a radar confliction also include fix under which the traffic is posted." There were no other fixes indicated on the flight progress strips of ACA870 to indicate that there might be a radar conflict with traffic on the BANCS track.

1.10.2 Duties of Controllers

The Gander ACC Operations Manual, Part 4, High Domestic Sector Procedures, specifies the responsibilities of controllers as follows:

> 4.1.2 Sector controller(s) is/are responsible for all IFR aircraft operating within the airspace assigned to their sectors.
>
> 4.1.4 When a Radar and Data controller are assigned to the same sector, the radar controller is primarily responsible for the flow of sector traffic. The sector workplan and the overall strategy shall be determined jointly. It is recognized that during some traffic situations one controller may not be immediately aware of all actions initiated by the other - in this case each controller is responsible for his actions.
>
> 4.1.6 When assigned to a Sector, the data controller's primary role is to facilitate the flow of flight data between Radar sectors.

Prior to the occurrence, the data controller was fully occupied facilitating the flow of flight data between sectors, and he was not aware of activities as they unfolded on the radar controller's radar indicator module (IM). The flight progress strips of the two aircraft were posted under different coast-out fixes, and because the data controller's primary responsibility was to facilitate the flow of flight data between Radar sectors, he was not specifically aware of the proximity of AFR033 and ACA870 at the same altitude as they approached BANCS. The radar controller was primarily responsible for the flow of sector traffic, and other than keeping flight progress strips updated by checking altitudes and estimates, he performed his separation function using only the IM. Supervisors, even when not otherwise occupied performing relief duties for other controllers, are not expected to provide close inspection and quality control of controllers in these circumstances, because it is not possible for the supervisor to be cognizant of the control actions taken by controllers in all the sectors of a specialty.

1.10.3 Radar Control Methods

The NAV CANADA ATC MANOPS, article 471.1, directs controllers to apply separation by consistent reference to, and use of three elements fundamental to effective control: plan separation, execute the selected plan, and monitor progress to ensure continued applicability of the plan.

To assist in the identification of potential aircraft conflicts, the radar controller has at his or her disposal a tool known as the Predict Track Line (PTL). This electronic device displays a line on the IM showing a predicted direction and expected travel distance of an aircraft present position symbol based on the time in minutes entered by the controller. It was the radar controller's habit to use this tool on a regular basis to detect traffic conflicts. On the night of the occurrence, the radar controller had used the PTL regularly prior to the approach of the occurrence aircraft, but did not detect the intersecting flight paths of ACA870 and AFR033.

1.10.4 Radar Monitoring Methods

In TSB Occurrence No. A96A0138, an altered routing put two aircraft that were under radar control, a Boeing 747 and a Boeing 767 with a total of 502 persons on board, on converging courses at the same altitude until they were about three miles apart. At that time, the crews of both aircraft received and reacted to TCAS RAs and manoeuvred to avoid collision. The radar controller was unable to explain why he was unaware of the conflict between the two aircraft.

In TSB Occurrence No. A97H0007, two aircraft, a Boeing 727 and a Canadair CL-600, approaching head-on under radar control on direct off-airway routes, were involved in a risk of collision. In this instance, only one of the aircraft was fitted with TCAS. The RA and subsequent declaration by the crew of their avoidance action were the only warnings provided.

In TSB Occurrence No. A97C0144, a Boeing 737 under radar control was given permission to deviate north of the flight planned route to avoid weather. The actual position of the aircraft did not correspond with that indicated by the positioning of the aircraft's flight progress strip and the radar controller, occupied in resolving a problem on another part of the IM, did not detect the imminent conflict with an opposite-direction DC-9 during his monitoring of the IM. The Boeing 737 received a TCAS RA and manoeuvred to avoid the other aircraft approaching
head-on.

In TSB Occurrence No. A99H0001 (investigation in progress), two opposite-direction Boeing 767 aircraft under radar control, with a total of 206 persons on board, were involved in an air proximity occurrence when the radar controller cleared one aircraft to climb through the other's altitude. Both aircraft received TCAS RAs.

In each of the above occurrences, the aircraft were being provided with radar monitoring and the radar controller had spoken to one of the involved aircraft shortly before the conflict, and in each instance the radar controllers were unable to explain why they had not detected the approaching conflict. Controller fatigue or exceptional distractions, other than normal traffic conflicts, were not identified as findings in any of the completed investigations.

NAV CANADA Functional Goal Number 1 encourages controllers to provide full-time attentive flight monitoring and flight information services. Effective scanning techniques as required in ATC MANOPS, article 901.8, are covered in the recently inaugurated Situational Awareness Module training package, which has been administered to approximately 80 percent of air traffic control units. Gander controllers had not yet received this training at the time of the occurrence. There is no formal lesson plan in basic or regional air traffic control training designed to teach controllers specific radar monitoring techniques or best practices. During basic radar simulation training, however, instructors are directed to include as teaching points information to avoid concentrating too long on one situation during radar scanning, because other situations may require attention as well.

1.10.5 Conflict Alerting Tool

The original performance specifications for the ATC radar data processing system (RDPS) software included provisions for aircraft conflict detection and alerting. During testing in the late 1980s and early 1990s, the RDPS conflict alert function was found to have several faults and was not considered acceptable for operational use. This function is still not in operational use today. The Canadian Aviation Safety Board (CASB), the TSB's predecessor, recommended in 1990 that,

> The Department of Transport accelerate all technical initiatives with a potential for providing controllers with automated conflict prediction and alerting.
>
> CASB 90-36

Transport Canada accepted the recommendation and advised that "Minimum Safe Altitude Warning/Conflict Alert would be implemented as the Radar Data Processing Systems are brought online with the introduction of the Radar Modernization project beginning in June 1990." In early 1997 NAV CANADA advised that the unavailability of the conflict alert feature of RDPS was an on-going issue. The conflict alert feature of RDPS was still under development, and it was hoped that it would be available with the 700 version of RDPS software then scheduled for release in the fall of 1997. NAV CANADA advised in early 1998 that software testing of this functionality was under way and on-site test was planned for the fall of 1998. Operational acceptance was expected to be lengthy. Software testing of the conflict alert functionality is still under way but is expected to be completed in 1999, followed by site testing in Toronto, Ontario, and Edmonton, Alberta. The Minimum Safe Altitude Warning (MSAW) portion is not expected to be included in this site test procedure. NAV CANADA, in its Corporate Safety Plan 1998/99, stated that it is committed to "the national installation of Minimum Sector Altitude Warning Systems/Conflict Alert (MSAW/CA) on existing surveillance systems."

1.11 Flight Recorders

Flight recorder information was provided by Air Canada and Air France to determine aircraft responses on receipt of the respective TCAS RAs. That information was included in section 1.1 above.

2.0 Analysis

2.1 General

The radar controller was aware, at least from ACA870's radio position reports if not from the information contained on the flight progress strip, that this aircraft was what is known as a "cutter", and that the flight path of the aircraft would cut across the tracks of other aircraft proceeding eastbound to the ocean. This situation was described as being relatively common for controllers in southern sectors of the Gander airspace. As well, the radar controller communicated with ACA870 one minute and twenty seconds prior to the Pan, Pan, Pan call by the crew. At the time of the communication, the two aircraft were approximately 9 nm apart and on a converging course. The radar controller should have detected and resolved the conflict between AFR033 and ACA870 well before the risk of collision occurred.

2.2 Conflict Detection

2.2.1 Information Exchange

Some of the factors which actively contributed to the radar controller not detecting the approaching conflict include the following:

- There was no strip posted at BANCS for ACA870, and there is no provision for the automatic printing of such a strip in the flight progress strip processing software in use in Gander.

- Notwithstanding the direction in Gander ACC Operations Manual, article 4.1.4, that the sector workplan and the overall strategy shall be determined jointly, there appears to be no procedure which encourages team planning and problem solving.

- The division of work and the very different work focus of the radar controller and the data controller encourage independent work. This is acknowledged in the Gander ACC Operations Manual, article 4.1.4, where controllers are reminded that "It is recognized that during some traffic situations one controller may not be immediately aware of all actions initiated by the other ...." The next reminder emphasizing that "each controller is responsible for his actions" is an accepted philosophy; however, it contributes little to enhancing safety.

2.2.2 Attentive Flight Monitoring

The TSB investigations noted in section 1.10.4 bear resemblances to this occurrence in that in each referenced occurrence, the radar controller did not detect aircraft conflicts displayed on the IM. While strip scanning for potential traffic conflicts is necessary, the increasing prevalence of direct off-airway routes, which do not lend themselves to the relatively structured environment for which flight progress strips were designed, puts a premium on the necessity to actively and constantly monitor the IM. While NAV CANADA does provide direction to all controllers on scanning techniques, that subject matter is more oriented to flight progress strip scanning procedures than to definable techniques associated with how to maintain full-time attentive radar flight monitoring. In this occurrence, the radar controller's full-time attentive flight

monitoring procedure did not meet the level of attentiveness required to provide an adequate level of safety to the aircraft under his control, and, as a result, the radar controller did not recognize the conflict and did not provide air traffic control radar separation between the two aircraft.

2.2.3 Conflict Resolution

Devising a specific separation plan is predicated on recognizing that a situation exists that requires specific action. The benefits of adding specific markings to strips in accordance with articles 2.4 and 8.3.2 of the Gander ACC Operations Manual are restricted to their use as memory aids in that the use of the warnings presupposes that potential conflicts have been recognized. If no conflict is identified, no warning markings are added. Review of the flight progress board for conflicting traffic at common points and full-time attentive flight monitoring of the IM are often the triggering events that enable radar controllers to recognize potential conflicts and to begin the action planning process. Where there is no obvious conflict indicated on the flight progress board (the two aircraft were not posted under a common point and none of the required markings were on either of the flight progress strips), or where the conflict is overlooked during the monitoring process, the radar controller may not devise a specific separation plan and thus may perform no specific separation actions. Where task design does not encourage effective team problem solving, the necessary team planning step may not be accomplished, and the radar controller in his or her tactical control decisions becomes the single, ground-based point of defence against airborne collisions. That defence broke down when the radar controller did not identify the conflict during his monitoring of the tactical situation on the IM. The team supervisor was unable to intervene as a final level of quality control because he was occupied controlling in another sector, and, in any case, his duties preclude detailed knowledge of the control actions of all the controllers in all the sectors of the specialty. There was no procedural or technological defence in the design of this air traffic control process to contain this situation once the radar controller missed the developing conflict.

3.0 Conclusions

3.1 Findings

4. The controllers involved in this occurrence were qualified and current.

5. All equipment available to the controllers was serviceable and being used.

6. Staffing in the sector met unit standards. The supervisor was working in another sector at the time of the occurrence.

7. The workload was assessed as heavy.

8. The radar controller did not devise an active separation action plan because he did not recognize the need for one.

9. The flight progress strips for ACA870 were not marked with the various symbols specified in the Gander ACC Operations Manual indicating that the flight required special attention.

10. The sector controllers' performance of their duties, seemingly in conformance with the directives and the task design in the Gander ACC Operations Manual, did not lend itself to effective sector team problem solving and separation planning, which resulted in the loss of an effective defence.

11. The placement of the two flight progress strips under two separate fixes did not overtly warn the radar controller that the two aircraft at the same altitude would be in close proximity in the vicinity of one of those fixes.

12. There was no rigorous training on radar monitoring methods provided to these controllers in basic air traffic control training or during refresher or specialty training after initial qualification.

13. The TCAS RAs received by the crews of ACA870 and AFR033 provided the only warning and successful resolution to the traffic conflict.

14. Though planned for implementation to meet traffic needs in the early 1990s, a functioning automated conflict alert tool was not available.

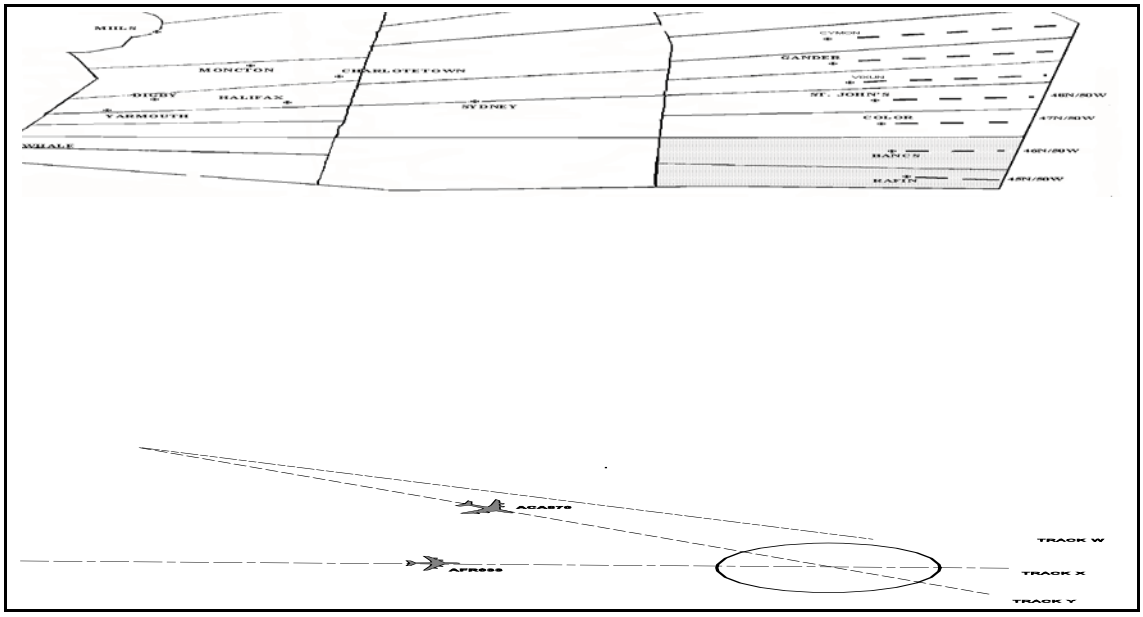
15. The Canadian Aviation Safety Board (CASB), the predecessor to the TSB, in 1990, recommended that the air traffic service provider accelerate all initiatives with a potential for providing controllers with automated conflict prediction and alerting.

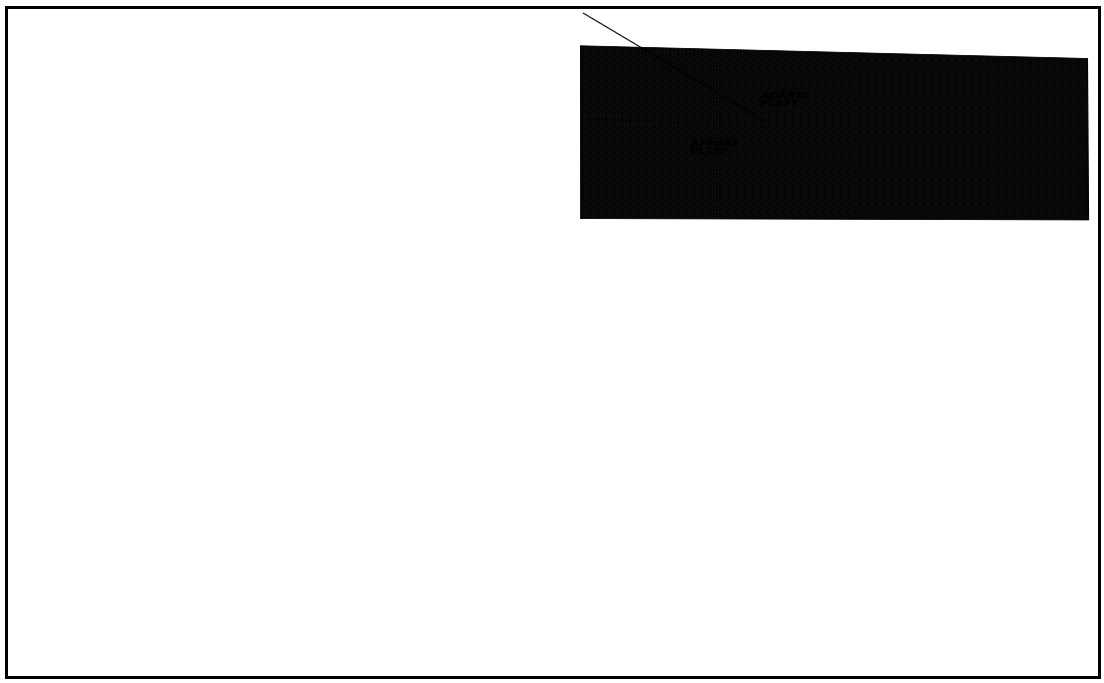
3.2 Causes

The radar controller did not recognize the traffic conflict between ACA870 and AFR033, and, as a result, did not apply the required radar separation criteria between the two aircraft. The fact that the flight progress strip procedures did not provide a flight progress strip for posting at the fix nearest the point of conflict; there was no basic or follow-on training provided to the radar controller in effective radar monitoring techniques; there was no realistic human back-up to the radar controller's activities; and there was no technological back-up in the form of an automated conflict alert tool contributed to this occurrence.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 29 September 1999.

Appendix A - Track Diagrams





Appendix B - Glossary

ACA870	Air Canada flight 870
ACC	Area Control Centre
AFR033	Air France flight 033
ATC	air traffic control
CASB	Canadian Aviation Safety Board
COL	COLOR (fix)
FL	flight level
IFR	instrument flight rules
IM	radar indicator module
MANOPS	Manual of Operations
MSAW	Minimum Safe Altitude Warning
MSAW/CA	Minimum Sector Altitude Warning Systems/Conflict Alert
N	north
nm	nautical mile
PTL	Predict Track Line
RA	resolution advisory
RDPS	radar data processing system
RFN	RAFIN
S	south
TA	traffic advisory
TCAS	traffic avoidance and collision advisory system
TSB	Transportation Safety Board of Canada
UTC	Coordinated Universal Time
W	west
°	degree