

**CANADIAN FORCES
FLIGHT SAFETY INVESTIGATION REPORT (FSIR)**

FINAL REPORT

FILE NUMBER: 1010-CT114172

DATE OF REPORT: 07 June, 2001

AIRCRAFT TYPE: CT114172-CT114006 Tutor

DATE/TIME: 1530 EST. 04 September 2000

LOCATION: 5 NM East of Pearson International Airport, Toronto, Ontario

CATEGORY: "C" Category Accident

**This report was produced under authority of the Minister of National Defence (MND) pursuant to Section 4.2 of the Aeronautics Act (AA), and in accordance with A-GA-135-001/AA-001,
Flight Safety for the Canadian Forces.**

With the exception of Part 1 – Factual Information, the contents of this report shall only be used for the purpose of accident prevention. This report was released to the public under the authority of the Director of Flight Safety, National Defence Headquarters, pursuant to powers delegated to him by the MND as the Airworthiness Investigative Authority (AIA) of the Canadian Forces.

SYNOPSIS

Both of the involved aircraft were part of a nine-plane formation taking off from Pearson International Airport (PIA) in Toronto in preparation for an air demonstration at the Canadian National Exhibition. While joining on the lead aircraft of the formation, aircraft #4 overshot his position and subsequently contacted the lead aircraft while trying to regain position in the formation. Both aircraft sustained "C" category damage and both recovered at PIA without further incident. There were no injuries.

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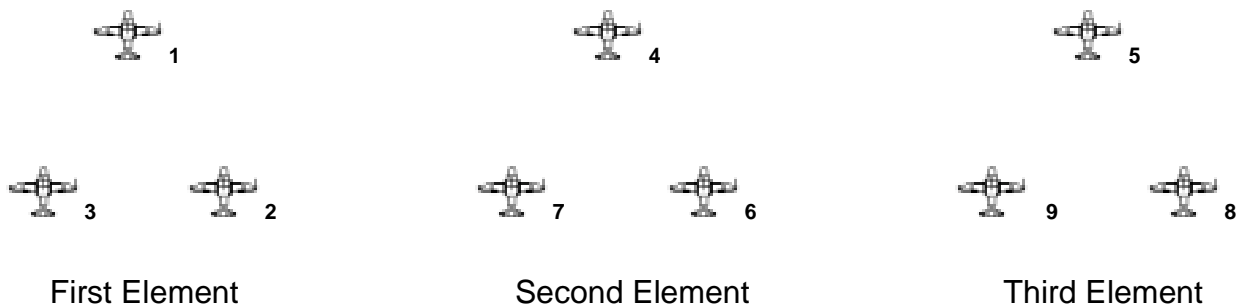
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1. FACTUAL INFORMATION

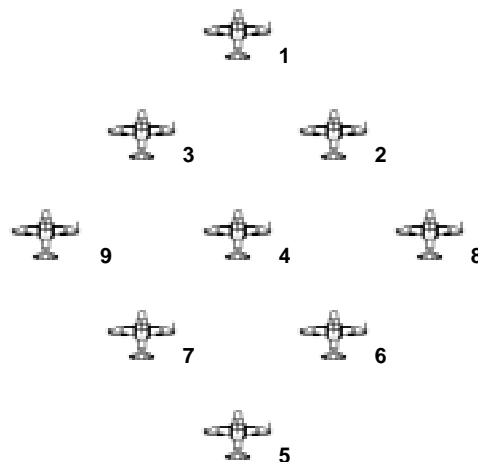
1.1. History of the Flight

(For ease of understanding throughout this report, pilots and aircraft will be referred to with reference to their positions within the formation. ie. “pilot #4” and “aircraft #4”).

Both of the accident aircraft were part of a nine-plane formation taking off from Pearson International Airport (PIA) in Toronto in preparation for an air demonstration at the Canadian National Exhibition. Departure was conducted as three separate elements of three aircraft, each in “Vic” formation. Aircraft #1 (CT 114006), was the lead aircraft of the entire formation and the lead aircraft of the first “Vic” element (#1, #2, #3). Aircraft #4, (CT 114172), was the lead aircraft of the second “Vic” element (#4, #6, #7). Aircraft #5 was the lead aircraft of the third “Vic” element (#5, #8, #9).

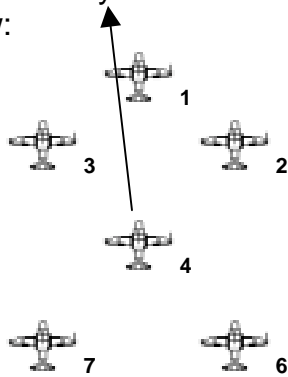


It was intended that all aircraft would join up in the 9-plane “Big Diamond” formation. This formation is used to transit to the air show site.



9-Plane Big Diamond

Rejoin was to be completed shortly after take-off with the first two elements rejoining as depicted below:



As the second element was positioning for rejoin, pilot #1 called a speed reduction and 'easing right' into the turn. On rejoin, aircraft #4 overshot aircraft #1 as depicted by the arrow in the diagram above.

Pilot #4 then attempted to rejoin into the proper position by moving his aircraft backwards and underneath aircraft #1 where he made contact with aircraft #1. The aircraft were approximately 5 NM East of PIA when the collision occurred.

Pilot #4 immediately broke his aircraft out of the formation and recovered at PIA. Pilot #1 co-ordinated the recovery of the remaining aircraft of the formation and all recovered at PIA without further incident.

1.2. Injuries to Personnel

	Crew
Fatalities	0
Major injury	0
Minor injury	0

1.3. Damage to Aircraft

Aircraft #1, CT 114006, sustained "C" category damage in that the left leading edge was dented and torn requiring replacement. Aircraft #4, CT 114172, sustained "C" category damage to the top and left side of the T-tail, requiring replacement. (Annex A)

1.4. Collateral Damage

There was no collateral damage.

1.5. Personnel Information

	Pilot #1	Pilot #4
Rank	Maj	Capt
Medical Category validity	valid	valid
Total flying time	4900 hrs	3200 hrs
Flying hours on type	1600	1745
Flying hours last 30 days	41	30
Flying hours last 48 hours	0	0
Flying hours on day of Occurrence	0.3	0.3

1.6. Aircraft Information

Both aircraft were serviceable before contact. The centres of gravity and aircraft weights were within prescribed limits.

1.7. Meteorological Information

The forecast weather for the time of the occurrence was:

CYYZ 041747Z 041818 02015KT P6SM SKC

The actual weather for flight planning (1900Z) and at the time of the incident (2000Z) was:

CYYZ 041900Z 01016G21KT 15SM FEW 042 FEW090 19/07 A3011 RMK
CU1AC1 AC TR SLP196

CYYZ 042000Z 01015KT 15SM FEW 042 FEW090 19/06 A3012 RMK
CF1AC1 SLP200

1.8. Aid to Navigation

Not applicable.

1.9. Communications

Normal air show communication between the formation is accomplished on discrete frequencies, using one of two on-board radios. When departures occur at an airport not situated at the air show site, as at PIA, pilot #1 co-ordinates with Air Traffic Control (ATC) using one radio to establish and maintain radio contact. Pilot #1 manages ATC clearances and makes requests on behalf of the formation. He passes on relevant information to the formation on the second radio. Prior to arriving at the air show site, pilot #1 switches the first radio over to the formation frequency and communicates with the Snowbird co-ordinator who is present at the air show site. The Snowbird co-ordinator is then responsible for

ATC clearances for the team during the show. This allows the formation to perform without monitoring extraneous radio communication, which could interfere with formation radio calls. During the transit from the departure airport to the air show site, Snowbird team members may elect to monitor ATC in addition to their own formation frequency. Most of the Snowbird team, including pilot #4, do not monitor ATC during this phase because it can be distracting and it is not a requirement for safe flight.

During a formation rejoin, the procedure for an aircraft that overshoots his position is to advise the lead aircraft with an “overshooting” call on the primary formation frequency.

1.10. Aerodrome/Alighting Area Information

Not applicable.

1.11. Flight Recorders

The Operational Load Monitoring (OLM) data was extracted from both aircraft. This data was used to corroborate witness testimony. There is no Flight Data Recorder (FDR) or Cockpit Voice Recorder (CVR) installed on the CT114 Tutor. A CVR would have provided valuable information to the investigation.

1.12. Wreckage and Impact Information

Not applicable.

1.13. Medical

Toxicology samples were taken in accordance with orders and sent for analysis. Toxicology results were negative.

1.14. Fire, Explosives Devices, and Munitions

Not applicable.

1.14.1. Fire

Not applicable.

1.14.2. Explosive Devices

Not applicable.

1.14.3. Munitions

There were no munitions on these aircraft.

1.15. Survival Aspects

Not applicable.

1.15.1. Crash Survivability

Not applicable.

1.16. Test and Research Activities

Not applicable.

2. ANALYSIS

2.1. General

The mission was properly authorized, briefed and operationally required. All aircrew involved in the mishap were fit for flying duty.

2.2. The Aircraft

Both aircraft, CT 114006 and CT 114172, were serviceable prior to the accident. There were no maintenance or aircraft handling anomalies identified that contributed to the accident.

2.3. Impact Marks

Aircraft #1's left leading edge showed denting, rub marks and two areas of tears outboard of the landing light for approximately four feet (Annex A, photo #1). Aircraft #1 also had dents on the left smoke tank. Aircraft #4's tail, top and left elevator, showed torn and dented surfaces including deformation approximately four inches downwards of the left elevator (Annex A, photo #2). Comparison of these damaged areas shows that aircraft #4's 'T' tail impacted both the smoke tank and leading edge of aircraft #1.

2.4. The Accident

Normal briefings and procedures were conducted prior to take-off. On the taxi out, pilot #1 briefed that the climb would be slightly slower at 220kts vice the usual 240kts. While in the climb, pilot #1 radioed that he would be further reducing airspeed to 200kts. These speed reductions were heard by pilot #4. Rejoins at a slower airspeed had occurred on numerous prior occasions, however, the formation was usually established in a turn, which makes the rejoin less demanding. The rejoin in this instance was attempted while the formation was directionally straight ahead and not in a turn. The human visual limitations when doing this type of straight-in rejoin made it difficult for pilot #4 to accurately judge closure rate. When pilot #4 selected speed brakes, slightly late, to reduce his speed and rate of closure on the first element, there was insufficient time to slow down and aircraft #4 overshot aircraft #1 by going slightly below and approximately fifty feet forward of aircraft #1. The speed brakes, which are utilised to reduce speed, become less effective at slower speeds. The element-to-element rejoin may have limited pilot #4's option to be more aggressive with the controls. Pilot #4 attempted to regain position by moving backwards and underneath aircraft #1. To maintain the visual cues necessary for this manoeuvre pilot #4 was required to swivel his body and turn his head completely to the rear, right side, and upwards to see aircraft #1 which was directly behind and above him. At this point, pilot #1, unaware of the overshooting aircraft #4,

called "easing right" into a turn. It is probable that in the twisting of his body to maintain visual cues, pilot #4 applied slight backpressure to the control stick. This unintentional backpressure on the stick caused upward movement of aircraft #4 and subsequent contact with aircraft #1. While craning his neck and turning his body to maintain binocular vision, pilot #4 was, at the same time, reducing his proprioceptive cues; flying in this body position makes it difficult to recognize inadvertent control inputs, especially aft control column movement. Pilots #6, #7, #8 and #9 all anticipated the upcoming contact as they could see both aircraft and the convergence between them. Pilots #6 and #7 had moved their aircraft outboard of the normal formation distances because of this.

2.5. Active Factors

2.5.1. Overshoot Procedure

Overshoot procedures are briefed in the course of normal training. These procedures are outlined in the Tutor "How to Fly" manual. The Snowbird flying emphasis, however, is placed on escape routes for the various flight formations. Generally, overshoots are covered only in pre-flight briefings or as debriefs if one should occur in a given flight. Specific overshoot procedures were not clearly defined in the Snowbird Standard Operating Procedures (SOP's). However, all aircrew were aware of the procedures involved with overshooting another aircraft. Prior to this accident pilot #4 had only experienced or flown a line astern overshoot while aircraft #1 was in a turn. Pilot #4 also felt that while he was out of position, he anticipated regaining his formation position more quickly by flying a non standard rejoin, rather than completing the standard overshoot and rejoin. The standard overshoot and rejoin would entail continuing the overshoot of aircraft #1 while moving down and away from the lead element. After well clear of the lead element, pilot #4 would then reposition his aircraft behind the lead element and conduct another rejoin attempt.

It is, therefore, concluded that aircraft #4 collided with aircraft #1 while pilot #4 attempted to salvage an overshoot with a non-standard manoeuvre.

2.6. Latent Factors

2.6.1. Radio Procedure

As the formation was still on departure from PIA at the time of the accident, their radios were configured as described at para 1.9. Pilot #4 was only monitoring the primary formation frequency while pilot #1 was monitoring both the primary formation frequency and ATC.

Normal overshoot procedure requires the overshooting aircraft to advise the lead aircraft with an overshooting call on the primary formation frequency. Although pilot #4 was aware of the associated radio procedures during an overshoot, he

felt that in this instance the call might interfere with pilot #1's communication with ATC on the second radio and did not, therefore, make this standard radio transmission. While radio discipline is extremely important when flying formation, the formation lead must also know when aircraft are not in their formation positions. As pilot #1 may not be able to maintain visual contact with all of the formation aircraft, full situational awareness may come only through timely radio calls. Knowing the dynamics of the formation, which pilot #1 cannot see, allows him to best fly a profile that helps reduce the potential for contact/interference between aircraft. It may also help to assist in the rejoin of an overshooting aircraft.

Just prior to contact, pilot #3 and pilot #9 attempted to advise pilot #1 on the radio to pull up. These calls were not heard by pilot #1 as they were made simultaneously and interfered with each other.

2.6.2. Formation Rejoin Culture

Snowbird cultural ethos expected formation rejoins to be accomplished very quickly. This is due, in part, to the expectation that they meet air show timings. With the "triple Vic" take-off, pilots #8 and #9, who rejoin individually, are able to position themselves just outside their normal positions prior to the second "Vic" formation, led by pilot #4, completing his section rejoin. This pressure pushes pilot #4 to expedite his rejoin. Formation aircraft should rejoin in the proper sequence to ensure spacing is not reduced beyond a safe distance. Specifically, the solo aircraft should wait until aircraft #4 (first line astern), aircraft #6 and #7 (outer) and aircraft #5 (second line astern) have reached their positions in the formation prior to moving into or close to their own respective ideal positions.

2.6.3. Rejoin spacing

Normally, following a triple Vic take-off, rejoins are to the 9-Plane "Big Diamond" formation. Normal rejoin spacing is to a position the Snowbirds refer to as "route", which provides approximately 10 feet of nose-tail clearance. This is done, prior to compressing into close formation, to reduce the probability of collision within the formation, but is still tight enough for significant risk. In this case, it is felt that the relative closeness during rejoin to this "route" position contributed, along with the other factors mentioned, to the contact.

2.6.4. Training

Emphasis during Snowbird work-ups and training is on achieving and maintaining formation references for the myriad of formations flown during an air demonstration or air show. All aircrew are briefed on the various rejoin and overshoot procedures and many are seen as they occur during the training program. However, they were not specifically practised during normal Snowbird training. This is especially true of the straight-ahead rejoin as it only pertains to

two of the team members, pilot #4 and pilot #5 (first and second line astern positions).

2.7. Medical

Medical response was initiated by the Snowbird co-ordinators through A3 Ops Winnipeg. An 8 Wing Ops Officer, who was present at the air show, co-ordinated the taking of toxicology samples for analysis. 431 (AD) Squadron SOP's do not specifically cover Flight Surgeon involvement in their Flight Safety Response Plan. The current system for obtaining Flight Surgeon support while the squadron is deployed is inconsistent. Flight Surgeon response procedures are generally passed on verbally through successive co-ordinators. 431 (AD) Squadron has no dedicated medical support nor a method to obtain specific Flight Surgeon advice while on deployment such as is the case for most CF deployed flying units.

There were no specific aeromedical causes identified in this investigation.

3. CONCLUSION

3.1. Findings

- 3.1.1. The mishap flight was properly authorized and operationally necessary;
- 3.1.2. All aircrew involved in the mishap were fit for flying duty;
- 3.1.3. All aircraft involved in the mishap were serviceable prior to the accident;
- 3.1.4. Aircraft #4 collided with aircraft #1 while pilot #4 attempted to salvage an overshoot with a non-standard manoeuvre;
- 3.1.5. Pilot #4 did not make a standard radio transmission during his overshoot manoeuvre in an attempt to reduce radio chatter;
- 3.1.6. Just prior to contact, pilot #3 and pilot #9 attempted to advise pilot #1 on the radio to pull up. These calls were not heard by pilot #1 as they were made simultaneously and interfered with each other;
- 3.1.7. All aircrew involved were aware of the proper formation overshoot procedures;
- 3.1.8. During Snowbird training/work-ups, straight-ahead rejoins and overshoots were briefed but were not practised as discrete manoeuvres;
- 3.1.9. 431 Squadron SOP's did not clearly define overshoot procedures;
- 3.1.10. Following take-off and departures there was an expectation that the formation would get together very quickly;
- 3.1.11. Pilot #4 felt pressure from pilot #8 and pilot #9 (the solos) who were waiting for him to get into position so they could complete their rejoins;
- 3.1.12. Rejoin spacing was to the Snowbird "route" position, which increased the probability of collision within the formation.
- 3.1.13. The 431 Squadron Flight Safety Response Plan does not include Flight Surgeon duties in the event of a Flight Safety incident and/or mishap; and
- 3.1.14. 431 (AD) Squadron has no dedicated medical support nor a method to obtain specific Flight Surgeon advice while on deployment such as is the case for most CF deployed flying units.

3.2. Causes

- 3.2.1. The contact between aircraft #4 and aircraft #1 occurred after aircraft #4 overshot aircraft #1 on a rejoin and pilot #4 attempted to regain formation position by conducting a non-standard manoeuvre.
- 3.2.2. Contributing to the accident was pilot #4's lack of practise with straight-ahead rejoins and overshoots.
- 3.2.3. Contributing to the accident was pilot #4's expectation that he rejoin quickly, supporting his decision to attempt a non-standard manoeuvre.
- 3.2.4. Contributing to the accident was the rejoin spacing to "route" which required a rejoin with closer spacing than necessary.

4. SAFETY MEASURES

4.1. Safety Measures Taken

The following safety measures were undertaken by 431 Squadron at their own initiative:

- 4.1.1. 431 Squadron SOP's have been modified such that the various procedures for overshoots are described;
- 4.1.2. 431 Squadron SOP's have been modified such that radio procedures are specified for rejoins and overshoots;
- 4.1.3. 431 Squadron SOP's have been modified such that there are detailed instructions specifying the rejoin sequence of aircraft;
- 4.1.4. 431 Squadron training programs have been modified to include a straight-ahead overshoot/rejoin for aircraft rejoining from a line astern position;
- 4.1.5. 431 Squadron SOP's have been modified such that rejoin spacing will be increased from the Snowbird "route" position to "wider than route". This increase will provide one aircraft length nose-tail separation or an increase of 10-20 feet between aircraft. This will reduce the probability of collision until the formation is stabilised whereupon pilot #1 would order the formation to compress into normal spacing;
- 4.1.6. 431 Squadron SOP's have been modified such that formations with elements of three aircraft joining on three aircraft will not occur over

populated areas. Also, 431 Squadron SOP's have been modified such that rejoins in "Vic" formation in high-density international environments will be to a "trail" position of 500 to 1000 feet until the lead pilot calls the formation into tight formation. These profiles will reduce both the probability of collision and the collateral damage if collision were to occur over populated areas and will have little impact on the set-up for the air demonstration;

- 4.1.7. Greater detail on speeds, flight patterns and radio procedures are being provided in formation briefings with respect to take-offs, re-joins and overshoots in high-density airspace; and
- 4.1.8. A practice formation flight to include a rejoin and overshoot for pilot #4 was flown prior to the next scheduled air show.

4.2. Further Safety Measures Recommended. It is recommended that:

- 4.2.1. 15 Wing review its Flight Surgeon support to 431 Squadron in the event of a Flight Safety mishap while deployed. 431 Squadron should then develop an applicable SOP.
- 4.2.2. 1 CAD investigate the establishment of a method for all CF deployed flying units to have access to Flight Surgeon support/advise if required.

4.3. DFS Remarks

This accident shows that even a very professional and well led team that takes great care with its procedures can make an error in judgment with potential for a much worse outcome than experienced here. It further demonstrates that no matter how much care has gone into developing procedures, situational variables can render some of those ineffective. Fortunately, this accident provided us with some relatively inexpensive lessons, and an opportunity for 431 Squadron and 15 Wing to demonstrate very effective risk management techniques; the safety measures quickly formulated and taken by the Snowbirds reduce the probability of a re-occurrence and the potential for collateral damage should contact occur. It would be even better to have the capacity for learning these types of lessons without incurring damage. A systematic way of looking for hazards, assessing them for risk, and implementing corrective action before an accident or significant incident ever happens must be our goal.



R. Harder
Colonel
Canadian Forces
Airworthiness Investigative Authority

Annex A

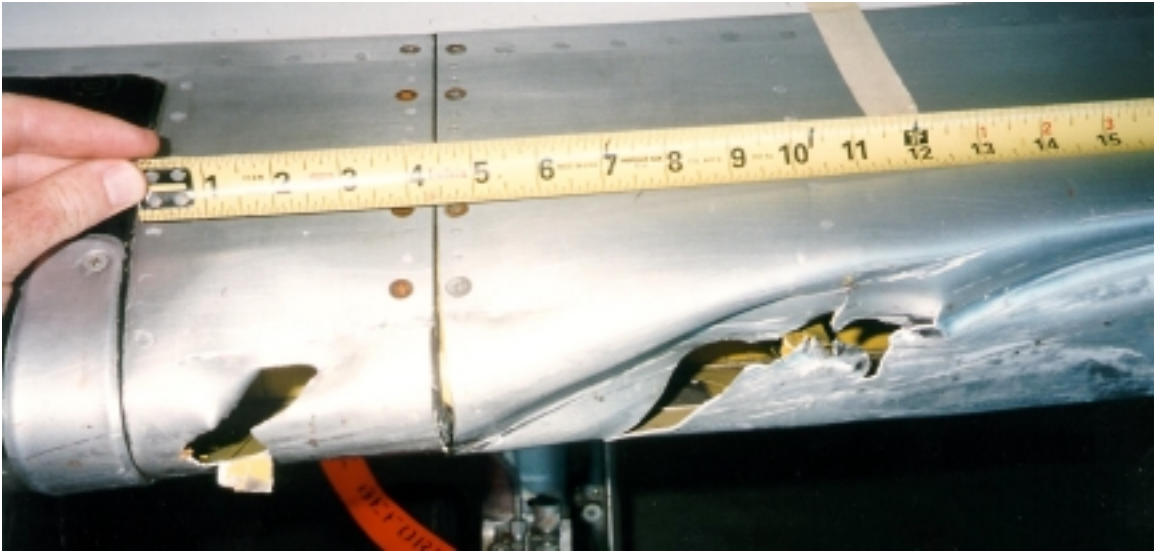


Photo 1: CT114006 Left Leading Edge

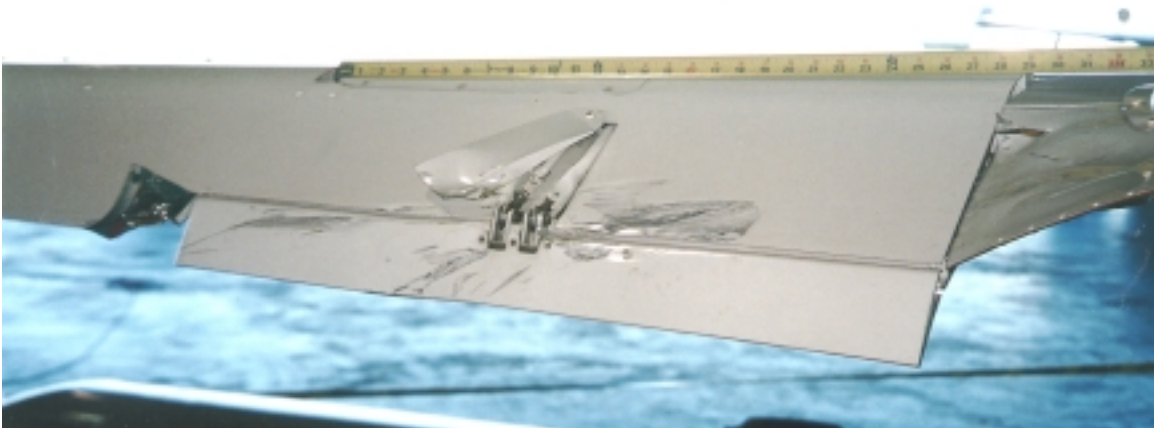


Photo 2: CT114172 Left 'T' Tail