CANADIAN FORCES
FLIGHT SAFETY INVESTIGATION REPORT (FSIR)

FINAL REPORT

FILE NUMBER: 1010-CT114142
DATE OF REPORT: 29 January 2002

AIRCRAFT TYPE: CT114142 Tutor
DATE/TIME: 0857 local 10 April, 2001
LOCATION: 19 Wing Comox, Runway 29
CATEGORY: "B" Category accident, No injury

SYNOPSIS

The aircraft was number five of a 9-plane formation landing after an on-field air show practice at 19 Wing Comox. During touchdown, the aircraft experienced a hard landing and the right-hand main gear and nose-gear collapsed. The aircraft was kept on the runway and came to a stop without interfering with the rest of the formation. The pilot shut down the aircraft without further incident. There were no injuries.

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1. FACTUAL INFORMATION

1.1. History of the Flight

The aircraft was number five of a 9-plane formation landing after an on-field air show practice at 19 Wing Comox. During touchdown on runway 29, the aircraft experienced a firm landing and the right-hand main gear and nose-gear collapsed. The aircraft was kept on the runway and came to a stop without interfering with the rest of the formation. The pilot shut down the aircraft without further incident. There were no injuries.

The positions in the formation are depicted in Figure 1:

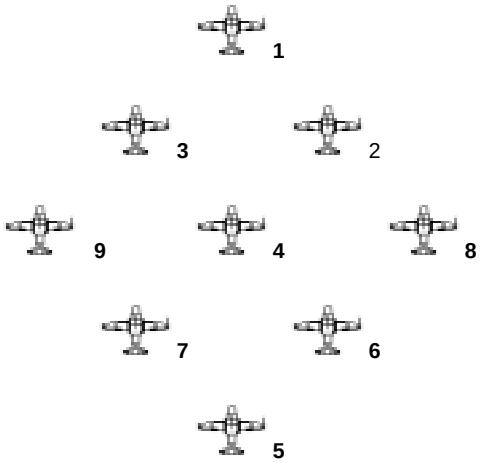

Figure 1

As the formation touched down, number five experienced a firm landing. The aircraft then bounced and became airborne. The aircraft then quickly descended towards the ground, struck the runway surface again and all three landing gears contacted the runway surface heavily. The right-hand main gear was forced upwards through the top surface of the right wing and collapsed. The nose-gear also partially collapsed. The aircraft became airborne again and then settled back down on the runway surface, slid along the runway on the right-hand smoke tank, left-hand main gear and partially collapsed nose-gear, and came to a stop. (Annex A, Photo 1) The pilot shut down the engine, turned off electrical equipment and egressed from the aircraft. The on-scene-command-emergency-response (OSCER) vehicle and fire fighting vehicles arrived on scene within approximately two minutes and sprayed foam on the underside of the aircraft. An ambulance arrived at the accident site after approximately eight minutes from the time of the accident and took the pilot to the 19 Wing hospital.

1.2. Injuries to Personnel

	Crew

Fatalities	0
Major injury	0
Minor injury	0

1.3. Damage to Aircraft

The aircraft sustained “B” category damage. The following is a summary of the damage to various aircraft components:

Nose Gear: The nose gear was fractured at the right hand mounting point, with damage to the landing gear door. The nose gear tire was blown and the wheel had disintegrated. (Annex A, Photo 2)

Right-hand Landing Gear: The rear landing gear mount was fractured and forced up through the skin of the upper wing surface. The gear actuator was broken at the eye end. (Annex A, Photo 3 and Photo 4)

Left-hand Landing Gear: The rear trunnion was fractured at the bulkhead. The landing gear door was forced upward and backward at the hinge point, and the aircraft skin on the upper wing surface above the landing gear mount was visibly buckled. (Annex A, Photo 5)

Engine: The J-85 engine showed visible signs of foreign object damage (FOD) to at least the second stage of compression. (Annex A, Photo 6)

Right-hand smoke tank: The right-hand smoke tank showed signs of damage from scraping along the runway and from a small fire created by leaking diesel fuel. (Annex A, Photo 7 and Photo 8)

1.4. Collateral Damage

There was no collateral damage and therefore no claim against the crown.

1.5. Personnel Information

Rank	Capt
Currency/Category validity	Valid
Medical Category validity	Valid
Total flying time	2184 hrs
Flying hours on type	2148 hrs
Flying hours last 30 days	33 hrs
Duty time last 24 hrs	2 hrs

1.6. Aircraft Information

The aircraft was serviceable before contact. The centre of gravity and aircraft weight were within prescribed limits. The incident aircraft (CT-114142) had

accumulated 8644.3 flying hours. The latest Periodic Inspection was completed on 04 April, 2001.

1.7. Meteorological Information

The weather at the time of the mishap at Comox airport (CYQQ) was clear with few clouds at 4500 feet, few clouds at 10,000 feet, and scattered clouds at 14,000 feet. The surface winds were reported as 330 degrees true at 08 knots.

1.8. Aid to Navigation

All navigation aids at the airfield in Comox were serviceable at the time of the mishap. There were no applicable NOTAMS issued for the period of the flight, other than a NOTAM closing the Comox airspace during the Snowbird practice flight. The WADDS (wind and altimeter digital display system) information system, normally available to the tower personnel to pass wind and altimeter information to landing and departing aircraft, was unserviceable at the time of the accident. Conventional methods for accurately passing on this information to the landing formation were used effectively and this is not considered to be a factor in this accident.

1.9. Communications

All aircraft in the formation made radio transmissions as per unit Standard Operating Procedures (SOPs) on a discrete frequency. Standard communications with Tower were also made.

1.10. Aerodrome/Alighting Area Information

Runway 29 was in use at the time of the accident. This runway is 10,000 feet long and 200 feet wide. The runway was bare and dry at the time of the accident.

1.11. Flight Recorders

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

1.12. Wreckage and Impact Information

The aircraft's initial touchdown point was approximately 900 feet from the threshold of runway 29. The aircraft's final resting point was approximately 5850 feet from the threshold of runway 29. The wreckage was moved from its original resting point within a few hours of the accident to allow the use of the runway for recovering aircraft at 19 Wing. (Annex B)

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

Sparks, which were created from the aircraft sliding on the right-hand smoke tank, ignited diesel fuel leaking from the bottom of that tank. The fire was short-lived and extinguished itself. Fire retardant foam was sprayed on the underside of the aircraft by a firefighting vehicle as it arrived at the accident site. This was primarily done due to the presence of diesel fuel under and in the vicinity of the aircraft.

1.15. Survival Aspects

Not applicable.

1.15.1. Crash Survivability

The forces of impact sustained in this accident were survivable.

1.16. Test and Research Activities

Various landing gear components, as well the engine, were sent to QETE for fracture and damage analysis. This analysis concluded that the fractures were a direct cause of overload on the components caused by the hard impact on landing. Significant damage to the engine internal stator vanes caused by debris from the deteriorated nose gear assembly was determined to have rendered the engine virtually powerless.

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

The aircraft, CT-114142, was serviceable prior to the accident. There were no maintenance or aircraft response anomalies identified that contributed to the accident.

2.3. 9-plane formation landing

The primary purpose of the 9-plane formation landing is showmanship. However, it can also facilitate recovery to a congested, high density airport; ease air traffic flow control; and permit the most efficient landing plan for an aircraft with limited fuel capacity. This particular show manoeuvre requires specific limitations with respect to runway and environment. These are:

Runway: Minimum of 7000 feet long
Minimum of 200 feet wide
Condition: Bare and dry and free of FOD

Environment: Wind no greater than 10 Kts
Little crosswind
Light to nil turbulence
Low bird activity

The runway utilized and the environmental conditions at the time of the accident met all of these requirements.

A 7 plane landing is theoretically the same as the 9 plane landing except aircraft #8 and #9 are not present. The Team Lead is the only individual allowed to lead either the 7 or 9 plane landing. The positions are flown similarly to the normal Big Diamond formation but in a position which offers more vertical separation between aircraft, referred to as “deeper”. This is because the landing formation is flown with full flap, which creates additional wing or flap wash hence downwash, produced by the aircraft in front. A deeper position helps to reduce this effect.

Normal briefings and procedures were conducted prior to take-off. The team had just completed an on-field practice air show and were conducting the final 9-plane landing sequence to a full stop. The sequencing of aircraft for the 9-plane landing is depicted in Figure 1. In order to avoid wake turbulence from the preceding aircraft in the formation, the aircraft at the back of the formation touch down before the aircraft at the front of the formation. In other words, the aircraft land in the following order: Aircraft #5 lands first; then aircraft #6 and #7; followed by aircraft #4, #8 and #9; then aircraft #3 and #2; and finally aircraft #1. Aircraft #5 maintains visual references with aircraft #4 throughout the final approach. Once aircraft #5 touches the runway surface, he will reduce power and when he feels he has safely landed, the aircraft is under control and is not a threat to the rest of the formation, he will call "5's clear". This is the indication to the other members of the formation that it is safe for them to continue with their landing sequence. The rest of the formation will then continue to land ahead of aircraft #5 and move to the outside of the runway leaving an escape lane down the middle of the formation.

2.4. The Accident

2.4.1. Sequence of events

Refer to Annex B, reconstruction of the landing pattern. The investigation revealed that the final approach to landing was flown by Lead to near-ideal parameters. There were no distractions or environmental conditions which would have precipitated a problem with the landing that any of the other Team members observed. No other aircraft in the formation had difficulty during the landing sequence.

During short final, the pilot of aircraft #5 instinctively reduced power in anticipation of touching down on the runway. In doing so, he found himself move slightly high from the normal visual references on aircraft #4. This was most probably due to a coordinating pull back on the control stick to compensate for the power reduction. To correct from this slightly high or "thin" position error, he eased forward slightly on the control column to move towards the ideal position. In doing so, due to the close proximity with the runway surface and an overcompensation of forward pitch movement, aircraft #5 touched down on the runway surface at a relatively high and flyable airspeed (approximately 108 kts) in a flat attitude, all three landing gear impacting the surface simultaneously. This caused the aircraft to bounce back into the air to an altitude of approximately 10 feet. This brought the aircraft into the jet wash and downwash of the preceding aircraft in the formation, which were continuing their descent to the runway surface. By then, the pilot of aircraft #5 had made a control stick input to descend the aircraft towards the runway surface. This input was amplified by the jet wash and downwash he had just encountered and the aircraft descended rapidly to the runway surface. The aircraft also lost stability and transitioned into a right-wing and nose down attitude. The aircraft impacted in that attitude with approximately 8.5 'G" at approximately 90 kts. The aircraft had travelled approximately 300-500 feet down the runway from the first bounce point. The pilot heard and felt metallic crunching noises and elected to attempt

an overshoot at that point. The pilot eased back on the control stick and added full power to initiate the overshoot. The aircraft was travelling at approximately 80 knots at the time and climbed approximately 25 feet due to lift still generated by the wings. The engine gave no response and the pilot of aircraft #5 then elected to abort the overshoot attempt. He then settled the aircraft back down on the runway surface and kept the aircraft under directional control. He then transmitted the “5 clear” call on the radio and brought the aircraft to a stop. The pilot then egressed from the aircraft and waited for the emergency vehicles to arrive.

2.4.2. **Impact Marks**

There were no discernable impact marks from the initial touchdown of the aircraft at approximately 900 feet from the threshold of runway 29. This is to be expected as it is believed that the aircraft touched down on all three landing gear simultaneously and would have only left rubber marks at the same location where many other rubber marks were present from past aircraft touchdowns. The next visible impact marks on the runway surface were at approximately 2320 feet. This mark was determined to be a scrape caused by the nose gear after the rubber tire had slipped off of the rim. This mark continued to approximately 2920 feet, accompanied by a scrape mark caused by the right-hand smoke tank. The next impact marks were visible at approximately 4200 feet, which consisted of both the nose gear mark and right-hand smoke tank mark. These marks continued until the final aircraft resting position at approximately 5850 feet. Analysis of the impact marks, witness testimony and retrieved OLM data, enabled the reconstruction of the flight and ground path, which the aircraft followed, from short final to the final resting point approximately 5850 feet from the threshold of runway 29.

2.4.3. **Initial bounce**

The pilot indicated that he overcorrected from being slightly high on aircraft #4. Unaware of his close proximity with the ground, this over correction resulted in premature contact with the runway. The aircraft was travelling at approximately 108 knots at the time of this initial contact with the runway. A three-point landing at this high forward and vertical speed would result in a significant upwards energy transfer through the landing gear oleos. Also, in a phenomenon known to the Snowbirds, jet wash and downwash from the preceding aircraft would add to the airflow over the wings, subsequently increasing lift at this positive angle of attack of the wings. So, it is understandable that the aircraft would become airborne again quite easily. It is estimated that the aircraft reached a height of approximately 10 feet on this bounce. An overshoot at this point (the first overshoot opportunity) would most probably have been safe and effective despite the fact that the aircraft would have to have been pulled up through the jet wash from preceding aircraft in order to complete the overshoot. The pilot made a split-second decision to attempt to land vice overshoot for some or all of the following reasons. First, he did not feel that the bounce had put him in a dangerous position and believed that a salvaged landing would not be difficult to

complete. Second, he had never practiced or attempted an overshoot from this position before and, therefore, may have been hesitant to attempt it in this case. Third, although the pilot was aware of the dangers and effects of the jet wash and downwash from preceding aircraft at that stage of the landing sequence, they still surprised him and caused ill effects on his aircraft. It would be prudent to review the material discussed to ensure its adequacy and include it in both Squadron SOPs and the computerized training package. Fourth, the pilot may have been influenced by unconscious, self-induced pressure to complete the landing with the rest of the aircraft in the formation. Not correcting effectively from a "thin" position on short final was the first error, but it was one which could have been made by anyone – Snowbird 5 is a highly capable pilot. The decision not to overshoot at that point is pivotal and thus considered causal.

2.4.4. **Second impact**

As the aircraft reached a height of approximately 10 feet after the initial bounce, it entered the jet wash and downwash of other aircraft within the formation. Most likely, it would have been most affected by the wash created by aircraft #4 and aircraft #1. This airflow disturbance reduced aircraft stability in both pitch and roll. The pilot made a control input to direct the aircraft towards the runway surface in an attempt to land the aircraft. The jet wash and downwash (accentuated by the full flap configuration of the preceding aircraft) encountered at that time, coupled with the pilot's inputs, forced the aircraft right-wing down and nose down and caused a quick descent towards the runway surface. The aircraft impacted the runway surface as indicated by runway impact marks, aircraft damage and witness testimony. The aircraft impacted at approximately 8.5 G, which was severe enough to cause "B" category damage.

2.4.5. **Overshoot attempt**

After this heavy impact with the runway, the pilot decided that his flyable airspeed, his distance back from the rest of the formation, and the potential damage to the aircraft made an overshoot an appropriate course of action (the second overshoot opportunity). He, therefore, applied full power and eased back on the control stick in order to "fly" the aircraft into the overshoot. Unknown to him, the engine had been severely damaged by material broken off from the nose gear assembly during the second impact and then ingested (para 1.3). This FOD damaged, among other things, the internal stator vanes of the engine, rendering it non-functional, so there was no engine response when the pilot advanced the throttle. Despite that, the aircraft had climbed to approximately 25 feet due to pilot inputs and the still flyable airspeed. Realizing that the engine was not producing any power, the pilot aborted the overshoot attempt and landed the aircraft by easing it down and completing as smooth a landing as possible to allow for potential damage to the undercarriage.

The advisability of the overshoot decision is debatable. Had the engine not been damaged and responded fully, a successful overshoot would still have had to deal with the eight aircraft in front, with a circuit in an obviously damaged aircraft,

and with a subsequent landing with that same damage. Had the engine responded partially, or responded properly but then faltered, there could very well have been a significant risk of collision with the aircraft in front. Though arguably a moot point, there is argument for being thankful the engine did not respond.

2.5. Latent Factors

2.5.1. **SOPs and Training**

Though it is unreasonable to attempt to set a procedure for every potential problem scenario during Snowbird formation flight, lack of effective guidance for the scenario implicated in this accident can be considered a latent, contributing cause. In a dynamic and unique phase of formation flight, such as the 9-plane landing, some guidelines on which the pilots can base overshoot decisions would be useful. Though the associated emergency procedures cannot reasonably be practiced because of the high risk involved, they can be included in SOPs and/or any training material and can be re-emphasized and discussed (as they were in this case) amongst the Team demonstration pilots. Escape lanes once on the ground are clearly defined in the SOPs, but neither SOPs nor the computerized training package cover overshoot options or guidance during the landing phase. Questions such as, “At what point during the landing phase am I committed to landing and is an overshoot no longer a viable option?” or, “Is there such a point?” or, “What are some of the possible consequences of attempting an overshoot during certain phases of the 9-plane landing or multi-plane landing?” could be addressed.

2.5.2. **Viability of the Manoeuvre**

The nine-plane landing is designed as one of the “show” manoeuvres. Unlike the normal manoeuvres regularly conducted in front of the crowd, this one is only conducted when the runway and environmental conditions at the show airport meet the limitations outlined at para 2.3. Based on last year’s planned show sites, the nine-plane landing could have been performed at approximately 60% of the sites. At these sites, not all crowd lines enable the entire crowd to view the landing of air show aircraft. Also, it could be argued that, once the main portion of the “show” is completed, the audience directs its attention to something else and, potentially, does not watch the landing.

As indicated at para 2.3, in the 9 plane landing, the 7 plane landing and even a 5 plane landing, aircraft #5 is flown in the second line astern position where he will experience the jet wash and downwash from aircraft #1 and aircraft #4 ahead of him. Other than the missing aircraft, (aircraft #8 and #9 for the 7 plane landing and aircraft #6 and #7 additionally for the 5 plane landing) the references and aerodynamic effect from the other aircraft would not change significantly. The greatest differences between the 9 plane landing versus the 5 or 7 plane landing, would be the overall anxiety felt by pilot #5 having the additional aircraft in close proximity during the landing phase and the added complication in the event of an overshoot attempt. Therefore, although similar to the 5 and 7 plane landing, the

9 plane landing does have some unique complications. Opportunity to train for the 9-plane landing is limited due to the associated runway and environmental restrictions. In fact, the 9-plane landing cannot be practiced during the normal work-up period because of the absence of a suitable runway (in terms of length and width) at or near the Team's home base, Moose Jaw. Though waiting to practice the manoeuvre until the pilots are more comfortable in their positions (ie, during the Comox deployment) has advantages, time to practice is limited by waiting until then. Pressure to perform this high profile manoeuvre with limited opportunity to practice may therefore have been a factor.

While acknowledging that this manoeuvre is one which sets the Snowbirds apart from other show teams, DFS believes that, given its complexity, difficulty, limited training opportunity, and restrictive conditions, a formal risk assessment should be completed to determine the risks versus benefits of conducting the 7 and 9 plane landing manoeuvre.

2.5.3. **Individual Training**

Pilot #5 was an experienced pilot on the CT114, in his second full year as a demonstration pilot on the Team. He was a Qualified Flying Instructor and the 431 (AD) Squadron training officer responsible for the training process of all of the team members. It was, however, the first year he had flown in position #5 or indeed either of the line astern positions (he was #2 the year before). The pilot had flown with pilot #4 in aircraft #4 on one other occasion for a first line astern landing approximately four months prior to the accident in a demonstration of a 7 or 9 plane landing, the only dual flight of its kind. He flew five more second line astern landing sequences, all solo, within either a 5 or 7 plane formation. His first attempt at the 9 plane landing, also solo, happened the day prior without incident, and the accident flight was his second.

The pilot's low level of experience with the 9 plane landing in the second line astern position may have contributed to the chain of events that preceded the accident. If the manoeuvre is to be retained, the possibility of performing it more frequently in a dual "instructional" format prior to performing it solo should be considered.

2.5.4. **Historical accident rate**

The rate of accidents attributable to pilot error involving the Snowbird demonstration pilots shows a marked increase in the past 6 years (Figure 2). Although there is no single identifiable factor causing the increase in this case, there are a number of factors which may have contributed indirectly. This section looks at factors which may or may not have contributed to this particular accident, but which are worth considering for the sake of reducing the probability of future Snowbird accidents.

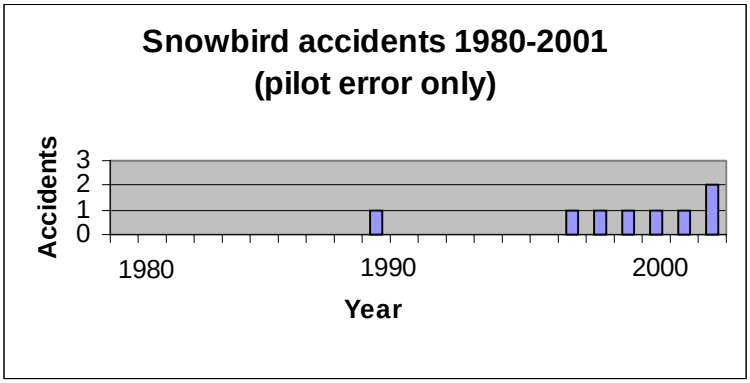

Figure 2

2.5.4.1. **Pilot tour length and rotation**

Since the beginning of this training season (2000/2001), 431 (AD) Squadron developed a new system of rotating pilots through different positions each year and increasing their time on the Team from 2 to 3 years. The concept of rotating pilots from the inner positions towards the outer positions was established primarily to attempt to reduce the higher frequency of incidents/accidents involving the outer pilots. With this concept, Team pilots would start as inners and move their way towards the outer part of the formation bringing more experience to these outer positions. While that concept allows the pilots to build more formation experience with the Team in general, there may also be some unintended negative effects. The rotation concept affects the training time of the second and third year pilots if they move positions within the formation. 431 (AD) Squadron, in the past, followed a "mentor" training system whereby the incoming pilot to a position was trained, for the most part, by the pilot on the opposite side of the formation who was in his second and last year with the team. For example, the current pilot #3 would train the incoming pilot #2. With the new concept of rotation, pilot #3 could also be moving to another new position within the formation. This would mean that this pilot is attempting to learn a new position (although his learning curve may not be quite as high as that of a new Team member) while also responsible for the training of the new pilot #2. This, ultimately, reduces the amount of training for both pilots in their respective new positions. The training season cannot be lengthened to compensate for this factor due to hard "show" season commencement dates. Past Team members have been utilized to train the incoming members but this is also availability-based and not always a feasible option unless these individuals remain posted to 431 (AD) Squadron until the training phase is complete (typically not until late April of the following year).

The problem is further complicated for position #5. His mentor would be pilot #4. For pilot #4 to fly with pilot #5 in the #5 position for training purposes, aircraft #4 would obviously not be present. Many of the manoeuvres performed require pilot #5 to fly behind and take his references from aircraft #4. Although the references are virtually the same from aircraft #5 to aircraft #4 as they are from aircraft #4 to aircraft #1, there are still some aerodynamic differences caused by the effect of

the additional aircraft in the formation. This results in pilot #5 conducting some manoeuvres for the first time solo (without previous dual exposure). This can put additional stress on pilot #5 as he is flying in a position never before practiced or seen and by himself without opportunity for direction or advice.

Based on these factors, it is possible that a rotation plan devised to solve one problem has caused other, unanticipated problems. Both approaches thus have some disadvantages. An assessment to confirm that the benefits of the changes outweigh the drawbacks would be prudent.

The show season can last almost six months of the year. For that period, the pilots are essentially away from home and their families, performing an extremely dynamic job, thus experiencing stressors that most other air force pilots do not. This has been the case since the inception of the Team, but increasing the tour length to three years may exacerbate this effect. As a result, the Team may find that third-year pilots (and perhaps even before this period) will begin to show signs of these stressors and/or possible complacency in their performance. Also, as a consequence of this as well as CF wide pilot shortages as discussed in para 2.5.4.2, fewer individuals may apply to the Team for tryouts which, in itself, may compound the problem with Team selections and Team composition. It should be noted that the Team has since introduced a mid-season break which helps to reduce the stress and alleviate the effects of the longer season, but this factor should continue to be monitored.

2.5.4.2. **Team experience levels**

As the Canadian Forces suffers from pilot shortages, the number and experience levels of applicants to the annual Team tryouts may also have suffered. The historic number of applicants for Team tryouts is depicted in Figure 3.

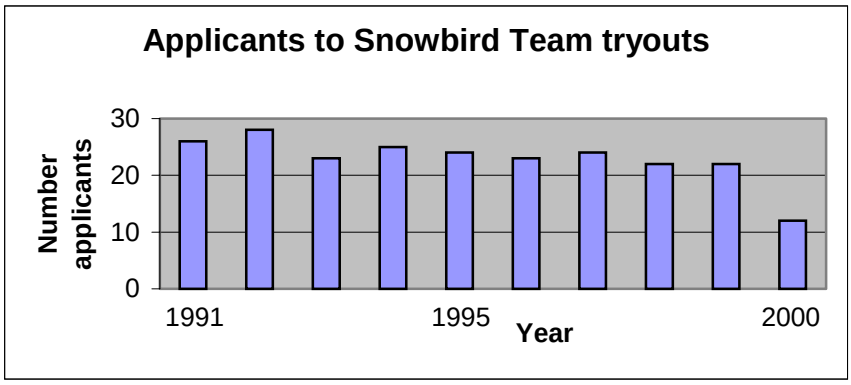

Figure 3

A major source for Snowbird applicants in the past has been 2 CFFTS. Since that unit stopped using Tutors, fewer instructors are likely to think of themselves as prospective Snowbirds. This effect is exacerbated by the fact that, in an attempt to alleviate past difficulties encountered with those applicant pilots who

have little jet experience, the most recent request for Team tryout applicants required a minimum of 1300 hours flying time, preferably all on jet aircraft. Conversely, pilots at the rank of Major are now accepted as “show” pilots which may increase the pool of applicants and should enable the Squadron to take advantage of individuals capable of assuming more staff responsibility as discussed at para 2.5.4.3. It is anticipated, however, that the number of applicants for annual Team tryouts will not increase significantly in the near future. This issue is examined further in para 2.5.4.4. Also, there is concern that some Commanding Officers have reduced the pool of Snowbird applicants to keep experience on their units. DMilC pilot career managers have recently directed Commanding Officers not to block pilot applications to the Team tryouts from their squadrons, but prospective applicants may still be pressured not to submit applications. Other CF squadrons cannot afford to lose valuable experienced pilots or they will suffer further as there are no pilots to back-fill the losses.

2.5.4.3. **Commanding Officer Workload**

In 2000, as the CT114 was removed from its training role, 431 (AD) Squadron adopted the role of administering its own aircraft maintenance. Along with this change came approximately 70 personnel, increasing the size of 431 (AD) Squadron to approximately 85 personnel. The Squadron Commanding Officer (CO) is ultimately responsible for the administration and safe conduct of operations for this squadron. While this would normally be manageable by an officer at the rank of Major, in this case the CO is also the Team Lead. He is, therefore, not only responsible for the welfare, administration and safety of squadron personnel in general, but he is also responsible for training and working up the Team for the show season. This involves being on the road during the entire show season from end April to end October.

While no connection between this situation and the accident has been made, there is potential for the Team Lead’s workload to affect his ability to concentrate on the demanding role of leading one of the largest formation demonstration teams in the world in a safe and effective manner. Absent the time to participate in all Team discussions involving flight manoeuvres or flight safety issues, other members of the Team will be less likely to benefit from his experience, and the likelihood of misunderstanding or miscommunication between Lead and Team members increases. The increased administrative workload of this larger squadron may limit this complete participation. A similar observation was made by Central Flying School (CFS), during their mandated flying training evaluation in April 2001 and in a service paper submitted by the CO 431 (AD) Squadron in January 2001.

Wing Commander 15 Wing has attempted to mitigate this problem by introducing a Deputy Commanding Officer (DCO) position at the rank of Major (AERE or Logistics background); this position is planned to be officially filled in 2002 and is currently being temporarily manned by a Logistics Officer at the rank of Captain.

Also, one of the “show” pilots, at the rank of Major, has been assigned as the “Show Team Executive Officer” to manage specific issues which were previously carried out by the Commanding Officer.

2.5.4.4 **CT114 as a Unique to Snowbird Aircraft**

The elimination of the CT114 Tutor as a training platform for 2 Canadian Forces Flying Training School (August, 2000) will, eventually, affect the experience levels of those that do apply. It will increase the time required for pilots to become comfortable with the “side by side seated” Tutor that they may never have flown before. All successful Team tryout applicants will be conversion trained on the Tutor by the 431 (AD) Sqn Standards and Training cell. However, some pilots, including instructor pilots from 2CFFTS who historically make up approximately 80% of past successful Snowbird candidates, will not have had any flying experience on the Tutor prior to this conversion. This could contribute to lower comfort levels on the aircraft by the time new Team members begin demanding formation and show sequences.

3. CONCLUSION

3.1. Findings

3.1.1. The mishap flight was properly authorized and operationally necessary;

3.1.2. The pilot involved in the mishap was fit for flying duty;

3.1.3. The aircraft involved in the mishap was serviceable prior to the accident;

3.1.4. Pilot #5 allowed his aircraft to get “thin” on aircraft #4 and then he overcorrected in close proximity with the ground;

3.1.5. Pilot #5 initially touched aircraft #5 on the runway in such a manner as to cause the aircraft to bounce approximately 10 feet back in the air;

3.1.6. Pilot #5 did not attempt an overshoot during this bounce (the first overshoot opportunity);

3.1.7. Aircraft #5 entered jet wash and downwash from preceding aircraft and lost stability as pilot #5 attempted to land the aircraft.

3.1.8. Aircraft #5 impacted the runway in a right-wing, nose down attitude at approximately 90 kts and 8.5 G causing category B damage;

3.1.9. Pilot #5 then attempted an overshoot, however, the engine had been rendered powerless due to ingested FOD from the aircraft’s disintegrating nose wheel;

3.1.10. There were no injuries sustained by pilot #5;

3.1.11. A diesel fuel-fed fire originating from the right punctured smoke tank was quickly extinguished by fire fighters;

3.1.12. Pilot #5 had performed the 9 plane landing solo once the day prior to this accident without incident. He had flown the landing sequence as second line astern on six other occasions solo without incident. He had flown a demonstration flight for the manoeuvre dual on only one occasion four months prior to the accident;

3.1.13. Pilot # 5 had never practiced or attempted an overshoot from this position before. Indeed, overshoots from this position cannot reasonably be practiced because of the high risk involved;

3.1.14. Pilot #5 did not feel that the initial bounce had put him in a dangerous position;

3.1.15. Although aware of the dangers and effect of the jet wash and downwash from preceding aircraft at this stage of the landing sequence, this wash still adversely affected the pilots aircraft;

3.1.16. Pilot #5 may have been affected by self-induced pressure to complete the landing with the other aircraft in the formation;

3.1.17. An overshoot after the hard landing (the second overshoot opportunity) could have been catastrophic;

3.1.18. 431 (AD) Squadron SOPs or the 431 (AD) Squadron computerized training package did not offer any procedure, guideline or information to assist pilots in their decision to overshoot a landing attempt in the 9 plane landing sequence. Any informal discussions which took place did not assist the pilot to make a timely overshoot decision;

3.1.19. The 9 plane landing is not as commonly performed or as regularly viewed by audiences as other show sequences throughout the season;

3.1.20. The ability to train for the 9 plane landing is limited due to the restrictive runway and environmental restrictions in Moose Jaw;

3.1.21. The rate of accidents in 431 (AD) Squadron, attributed to pilot error, has increased over the past six years;

3.1.22. The newly created concept of internal pilot rotation may have a negative impact on the “mentor” style of training;

3.1.23. Lower CF pilot experience levels in general may affect the overall Team experience and proficiency levels in the future;

3.1.24. The increased tour length of 431 (AD) Squadron demonstration pilots, CF wide pilot shortage and elimination of the CT114 as a CF training aircraft may have an impact on future Team selections and dynamics;

3.1.25. Significantly higher squadron strength and thus Commanding Officer workload may have negatively affected the overall Team dynamics;

3.1.26. The utilization of the CT114 Tutor solely as a Snowbird aircraft could contribute to generally lower comfort levels for newer Team pilots.

3.2. Causes

3.2.1. The damage sustained by aircraft #5 occurred due to a hard landing by pilot #5 after a bounced touch down exacerbated by preceding aircraft jet wash and down wash.

3.2.2. Contributing to the accident was the lack of effective guidance, within 431 (AD) Squadron SOPs and training tools, for 9 plane landing overshoots.

3.2.3. The pilot's low level of experience with the 9 plane landing in the second line astern position may have contributed to the chain of events that preceded the accident;

3.2.4. Unconscious, self-induced pressure to complete the landing with the other aircraft in the formation may have contributed to the accident.

4. SAFETY MEASURES

4.1. Safety Measures Taken

4.1.1. Intra-squadron discussions were initiated by the Team Lead to include courses of action during various phases of the 9 plane landing;

4.1.2. 15 Wing Commander and Commanding Officer of 431 (AD) Squadron elected to cease practicing or performing the 7 or 9 plane take-off and landing sequence until a formal risk assessment was completed;

4.1.3. 15 Wing Commander initiated a formal Risk Assessment of the risk associated with multi-plane landing techniques used by 431 (AD) Squadron. The decision has been made to eliminate the 7 and 9 plane take-off and landing from the Team's list of manoeuvres.

4.1.4. A permanent Deputy Commanding Officer position has been created on 431 Squadron to help reduce some of the required duties of the Commanding Officer. Also, 15 Wing has temporarily assigned a Public Affairs Officer to the Squadron for a similar purpose.

4.1.5. A "Show Team Executive Officer" has been created to further reduce some of the required duties of the Commanding Officer.

4.2. Further Safety measures Recommended

4.2.1. Any informal discussions and information, with respect to multi-plane landings and overshoots, should be reassessed for accuracy and included in both the SOPs and the computerized training package;

4.2.2. If the 9 plane landing is ever brought back as a Team manoeuvre, the number of dual flights required, prior to allowing a pilot to perform the 9 plane landing manoeuvre solo, should be reviewed;

4.2.3. The methodology of internal pilot rotation should be reassessed to confirm that its benefits outweigh its disadvantages;

4.2.4. An independent organization should review 431 (AD) Squadron to determine whether the issues discussed at para 2.5. and/or other issues have negatively affected the likelihood of Snowbird accidents and recommend reasonable mitigating actions;

4.2.5. Further action to reduce the Team Lead's Commanding Officer duties, such as making the temporarily assigned Public Affairs Officer position

permanent, should be considered. The effectiveness of the two measures noted in paras 4.1.4 and 4.1.5 should be monitored.

4.3. DFS Remarks

This Flight Safety Investigation Report examines factors which contributed to this accident, but also a number of issues which may not have been a factor at all or have been only peripherally implicated. That is as it should be, since the purpose of an accident investigation report is not primarily to identify cause, but to contribute to the prevention of future accidents. The trend in Snowbird accident rates concerns me (the Lake Erie accident has occurred as I write this). The Commanding Officer at the time was highly experienced, extremely competent and professional, and highly regarded, by the Team, throughout the air show community, and within the Air Force. The Team as a whole does its work more professionally, carefully, and methodically than ever before. If the accident rate can increase under these circumstances, there must be other factors at play; this report has attempted to identify some of them, but there may be others. It may also be that the Snowbirds are a litmus test of the state of the safety space of the air force as a whole: experience levels, societal influences, etc may be influencing our capacity for safe operations in ways of which we are only beginning to become aware. To a certain extent, this is speculation, but some speculation is appropriate when trying to detect factors which could cause future accidents.

A Team member has described this to me as a “shit happens” accident. If that is really the case, and no reasonable measures would have prevented it, then the nine-plane landing is a manoeuvre of unacceptably high risk; perhaps the decision to eliminate it recognizes that. I hope, however, that this action does not prejudice consideration of the other factors highlighted in this report.

R.E.K. Harder
Colonel
Director of Flight Safety

Annex A

Photo 1: Aircraft after coming to a rest on runway.

Photo 2: Nose gear and tire damage

Photo 3: Right-hand main landing gear

Photo 4: Right –hand main landing gear forced through upper surface of right wing.

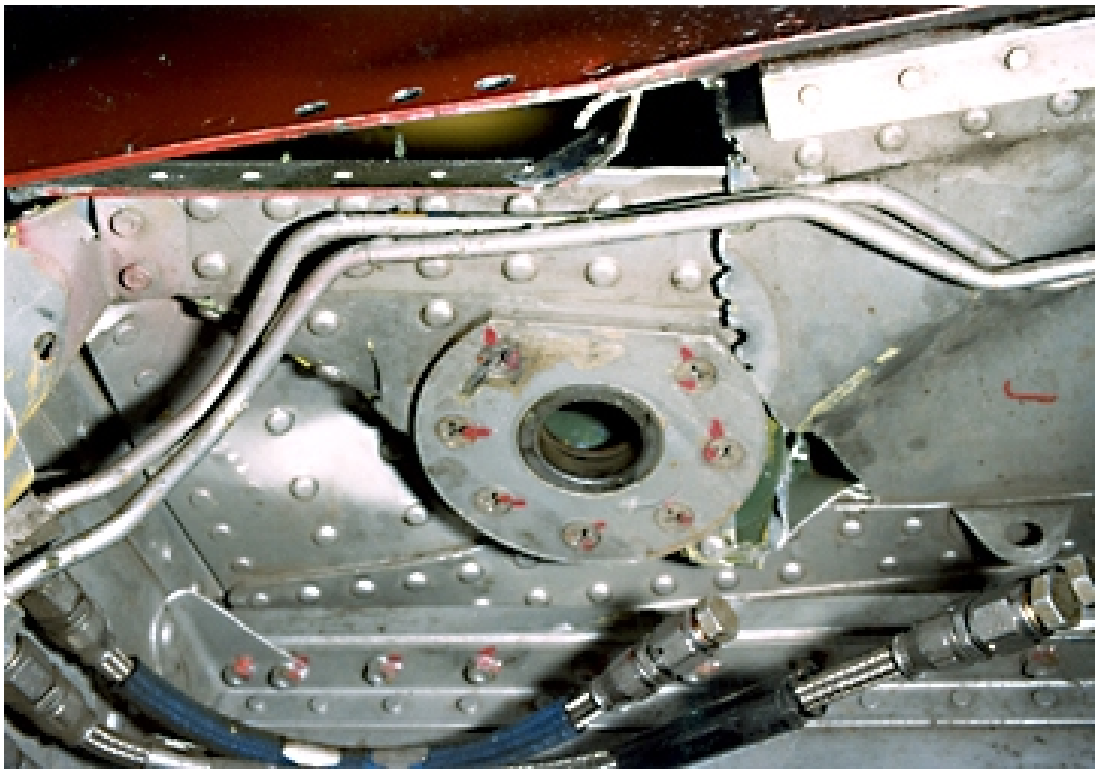

Photo 5: Left-hand landing gear mount

Photo 6: Engine damage

Photo 7: Right-hand smoke tank

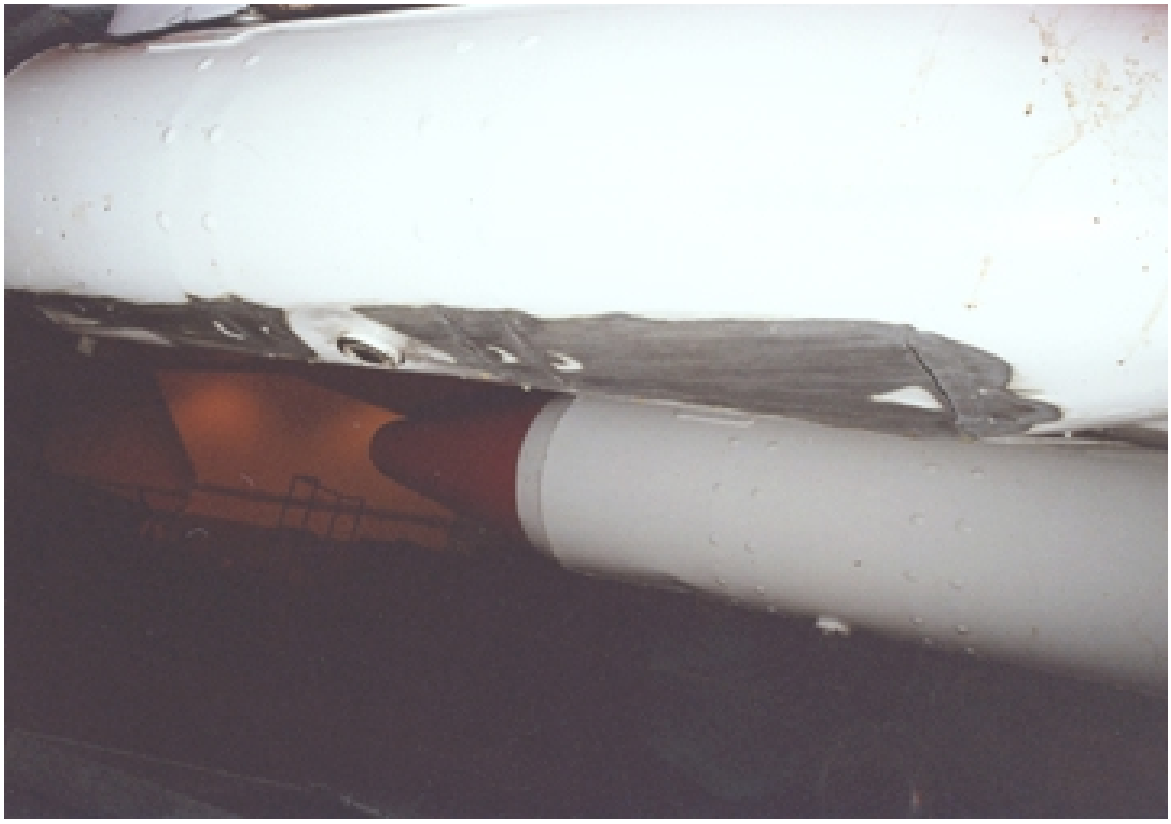

Photo 8: Right-hand smoke tank underside

Annex B: Reconstructed landing pattern and wreckage diagram