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Please address reply to:  
"The Commanding Officer"

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~~STAFF IN CONFIDENCE~~

Royal Naval Air Station  
Yeovilton  
Somerset  
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The Flag Officer Naval Air Command

24 June 1977

Sir,

BOARD OF INQUIRY REPORT - ACCIDENT TO THE SHARKS DISPLAY TEAM OF 705 NAVAL AIR SQUADRON ON 13 JUNE 1977

1. We have the honour to submit the following report upon our investigation into the circumstances attending the accident to the Sharks Display Team of 705 Naval Air Squadron on 13 June 1977.

NARRATIVE OF EVENTS

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2. The Sharks Display Team were briefed at 1150 and the six aircraft took off from Royal Naval Air Station Culdrose at 1220. After carrying out some basic turns to settle the formation down, a full display routine was performed over the airfield.

3. The formation then transitted to an area off Praa Sands and commenced a second display at approximately 1240. The display commenced as normal with a dive and left turn to position 300 yards off-shore, parallel to the beach, at 100 feet.

4. The first manoeuvre, a figure of eight, was initiated by entering a climbing right turn up to 250 feet, stabilising at 85 to 90 knots. The turn was later reversed for the second part of the figure of eight.

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5. After approximately three quarters of the left turn had been completed, and just prior to reaching the normal roll-out point to run in towards the beach, Shark 5 saw a white haze (which he later likened to shattered perspex) coming from the direction of the nose of Shark 4 or Shark 3. Simultaneously, Shark Leader, Shark 2 and Shark 3 heard a series of sharp bangs, and at the same instant Shark 4 began to vibrate severely both vertically and laterally. Shark 5 started to pull away from the formation, transmitting "Sharks, Break". On hearing this call Shark Leader asked what had happened and Shark 3 reported canopy damage to his aircraft, but that control was unaffected.

6. Shark Leader abandoned the display and initiated a gentle climbing turn to the right up to 500 feet, calling for a formation tell-off. After two calls, acknowledged only by 2, 3 and 5, the Leader saw that two aircraft had crashed into the sea. He then called the remaining aircraft to Channel 3 and transmitted a MAYDAY call.

7. Shark Leader maintained his 500 feet orbit to act as a radio link. Shark 3, and subsequently Shark 2, returned to Culdrose where 3 carried out a precautionary landing. Shark 5 descended to act as a site marker at the impact area. On arrival of the Search and Rescue Wessex 1, Shark 5 cleared the area and returned to Culdrose, and Shark Leader carried out a precautionary landing in a field to check his aircraft for damage.

8. A full Search and Rescue operation was initiated at 1245 and the bodies of the three aircrew were recovered at 1310, 1423 and 1720.

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9. The positions of the two crashed aircraft were marked with buoys by ships and divers and the wreckage was salvaged on 15 June 1977.

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10. Ouldrose, at the Board's request, asked the local media to broadcast/publish an appeal for any further witnesses or people having cine film or photographs to come forward.

FACTUAL EVIDENCE

FLYING EXPERIENCE

	FLT LT HOWLEY (SHARK 4)	LT CDR BAILEY (PASSENGER SHARK 4)	LT BROWN (SHARK 6)
<u>lots Logbook 11. Flying Hours</u>			
a. Total flying hours	3230.00	4707.00	2940.00
b. Total Flying Hours - Gazelle	1164.25	450.15	113.15
c. Recent Flying Experience			
(i) January 1977	45.55	25.20	7.25
(ii) February 1977	29.50	31.05	23.35
(iii) March 1977	37.45	22.50	30.55
(iv) April 1977	19.20	5.25	16.00
(v) May 1977	31.30	23.35	23.00
(vi) June 1977	10.40	4.40	12.20
<u>lots Logbook 12. Sharks Formation Practise</u>			
a. Work-up practise	5.45	NIL	3.30
b. Actual routine practise	8.55	NIL	8.55
c. Over-the-sea practises	2	NIL	2
<u>13. Flying Ability</u>			
C 89/RAF rm 5200	a. Current flying assessment	Exceptional	Above Average
"-"	b. Known flying weaknesses	None	None
lots Logbook	c. Awarded Competency to Instruct (Gazelle)	11 Mar 75	21 Nov 75
"-"	d. Instrument Rating	GREEN	WHITE
<u>14. Survival Drills and Aircrew Medical</u>			
rvival gister	a. Abandon Aircraft Drill	5 May 77	5 May 77
	b. Dry Liferaft Drill	25 Apr 77	25 Apr 77
	c. Wet Liferaft Drill	27 Apr 77	27 May 77
	d. MS5 Liferaft Drill	May 77	May 77
	e. Wet Winching Drill	-	Nov 75
	f. SMAC 35	-	Nov 75
	g. Medical Category	Due Nov 76	Due Nov 76
		A1/G1/Z1	A1/- (Glasses)
<u>15. Additional Squadron Duties</u>			
705	(In addition to normal instructional duties)	Training Officer	Senior Pilot. Flight Safety Officer. OIC E Coy.
			ACRBO. Security Officer. 2. IC E Coy.

TECHNICAL EVIDENCE

closure 6g 16. The technical documents of GAZELLE HT2 XW 859 and XS 415 were presented

to the Board by the Inspections Department of Royal Naval Air Station Culdrose. Included was a signed statement that they had been compared with the necessary Master Lists and no discrepancies were apparent.

17. The Board took the opportunity to examine the three other aircraft damaged during the accident.

a. XX 391, flown by Shark 3, had been struck in the port after perspex cabin window by a missile which subsequently struck the after door frame member and exited in four places through the front perspex panels. The damage is consistent with the aircraft being struck by a high density, high energy projectile at a shallow angle to the longitudinal axis.

b. XW 856, flown by Shark 5, had slight debris impact damage on the starboard side of the tail rotor fairing, tail rotor drive shaft and the aft face of the main gearbox fairing.

c. XW 895, flown by Shark Leader, had suffered no damage. The negligible damage on the starboard side of this aircraft, noted by the pilot, was caused by the fuel filler cap striking the fuselage during normal refuelling operations.

#### MEDICAL EVIDENCE

18. The Medical Documents of Lieutenant Commander G A H BAILEY Royal Navy, Lieutenant P M BROWN Royal Navy and Flight Lieutenant R S HOWLEY Royal Air Force were scrutinised by the Board. All were found to be in date as regards aircrew medicals and to have no history of recent illness within the last three months.

[REDACTED]

19. Surgeon Captain [REDACTED] was questioned by the Board:

a. as to the condition of the bodies on arrival at Royal Naval Air Station Culdrose.

b. on the results of the stripping, and examination carried out by himself and Wing Commander [REDACTED] Royal Air Force, (Pathologist from IPTM RAF Halton)

c. on the results of the Post Mortem carried out by the Coroners Pathologist assisted by Wing Commander [REDACTED].

Detail was not requested by the Board and Surgeon Captain [REDACTED] stated that all three aircrew had suffered gross physical injuries on impact with the water, undoubtedly leading to immediate death and incompatible with any chance of survival. He also stated on questioning that no injuries such as might

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be caused by flying debris prior to impact had been found on any of the bodies. It was stated that the damage to the safety and survival equipment of the aircrew was due to impact greater than that which they could be expected to survive unharmed. Apart possibly from the separation of both seats in Gazelle XS 415 from their mountings, no criticism of safety and survival equipment could be countenanced.

#### SALVAGE AND ACCIDENT INVESTIGATION

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20. The Accident Investigation Unit Investigating Officer stated that from the disposition of the wreckage and its general appearance after recovery, it was possible to conclude with some confidence that both aircraft had been substantially intact on impact with the water. He added that 95 per cent of the wreckage had been successfully recovered, and was being transported to Lee-on-Solent for examination which would culminate in a detailed report.

#### OPINIONS OF THE BOARD

##### DISPLAY CLEARANCE

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21. The Board was satisfied that the Display had been properly approved by the Chief of Staff to the Flag Officer Naval Air Command, although no written approval was available for inspection by the Board. It was noted that the Display Request Form did not lay down the distance to be maintained between aircraft. The distance adopted was slightly less than  $1\frac{1}{2}$  rotor spans, the minimum laid down in Culdrose Air Orders, however, the Board accepts that this was the distance used when the Display was demonstrated and approved. Regulations governing display flying were understood by the Leader and all Display Team members.

##### COMPETENCY OF PILOTS

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232  
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22. The Board was satisfied that all team members were fully competent to carry out their display duties as a result of the comprehensive selection process and the considerable work-up training carried out on 705 Squadron. All pilots were medically fit to fly and the Board found no evidence that any had indulged in any unusual activities during the 48 hours preceeding the accident. There was also no evidence to suggest that any of the team members was under mental stress or suffering from any condition likely to affect his performance.

##### DISPLAY ROUTINE

23. The display routine was considered by the Board to be within the competency of the pilots. The sequence was an extension of the successful programme flown in the 1975/1976 seasons with only minor modifications which could have had no bearing on the accident.

##### AIRCRAFT SERVICEABILITY

24. Examination of the MF 700C of GAZELLE HT2 XW 859 and XS 415 confirmed that both aircraft were serviceable in all respects before the flight in question. The appropriate Flight Servicing had been carried out and certified in accordance with current regulations. The Board therefore accepts that there were no known defects prior to flight which could have contributed to the accident.

##### BRIEFING AND AUTHORISATION

25. The Sortie Briefing, on the day of the accident, though short, was considered to be entirely satisfactory in view of the regular routine of

4 display practices. Standard procedures were not rebriefed and the Board  
 3 considers this acceptable even though minor amendments had been introduced  
 2 at various times as the Display had evolved. In the matter of formation  
 1 symmetry, however, evidence from team members indicated that different  
 5 interpretations had been placed on earlier verbal briefings on procedures  
 3, 189 to be adopted. Sharks 2 and 3 were agreed that 2 was to maintain briefed  
 2, 193 position on the Leader as accurately as possible and that 3 was to adjust  
 1 to any variation in 2's position from the ideal, in order to maintain  
 5 symmetry when flying in VIC formation. Shark 5 stated that although he had  
 not specifically discussed the matter with 6, his understanding was that in  
 straight and level flight, 6 would formate on 5, but during turns the inside  
 aircraft would be considered the Master position and the pilot flying on the  
 outside of the turn would adjust his position accordingly.

26. The Board does not consider that there was any confusion between Shark 2  
 and Shark 3, nor between Shark 5 and Shark 6, but believes that a standard  
 laid down procedure would have enabled all concerned to have had a better  
 understanding of the method of obtaining formation symmetry.

#### THE ACCIDENT

27. The Board accepts the evidence that the first display practice over  
 Royal Naval Air Station Culdrose went according to the briefing and that the  
 standard of formation keeping was a slight improvement on earlier practices.  
 From the evidence of Shark 5, the Board considers that the formation was  
 symmetrical and in balance up to the point of reversal of bank midway through  
 the figure of eight manoeuvre off Praa Sands. Although it was stated that  
 the formation maintained balance and symmetry throughout the left turn until the  
 accident occurred, the Board can find no expert evidence to positively determine  
 the position of Shark 6 after the reversal. However, the evidence of some  
 civilian eye witnesses suggests that he may have been experiencing difficulty  
 in maintaining his station.

28. In the opinion of the Board, the degree of lateral and vertical  
 oscillations of Shark 4 are suggestive of damage to the main rotor system,  
 caused by a technical defect, material failure or a collision between Sharks  
 4 and 6. The validity of the first two hypotheses, and possibly the third,  
 should be established by the Accident Investigation Unit.

#### CAUSE OF THE ACCIDENT

29. The Board is of the opinion that the accident could have been caused by  
 any of the following circumstances:-

- a. A mechanical defect or failure which caused Shark 4 to lose control  
 of his aircraft, and subsequently caused him to come into contact with  
 Shark 6.
- b. A mechanical defect or failure to Shark 6 causing him to lose control  
 of his aircraft and to come into contact with Shark 4.
- c. That Shark 4 moved from his formation position and came into contact  
 with Shark 6.
- d. That Shark 6, in attempting to maintain or regain his formation  
 position, came into contact with Shark 4.

30. The evidence in support of, or to discount, the suggested causes at 'a'  
 and 'b' above was not available to the Board and must await the outcome of the  
 Accident Investigation Unit's detailed report.

31. The evidence of Lieutenant GEORGE, Shark 5, is that Shark 4 maintained his formation position throughout the figure of eight manoeuvre up to the moment of the onset of heavy vertical and lateral vibration to Shark 4. The Board therefore discounted cause 'c' above.

32. In considering cause 'd', the Board took into account the following factors:-

a. Turbulence. The morning Station Meteorological forecast gave the wind as northerly 15 to 20 knots increasing to 20 to 25 knots with gusts to 35 knots with moderate to locally severe turbulence. In the event the wind had moderated and turbulence levels were reported as slight to moderate at the time of the incident. The members of the formation confirmed that the turbulence levels were of no great significance, and indeed were less than those experienced on the first over-the-sea rehearsals on the previous Friday. The Board was therefore of the opinion that turbulence was not a contributory factor.

b. Visibility. The forecast visibility for the day was 10 kilometers decreasing to 5 to 8 kilometers in light rain. The actual visibility at the time of the incident was 8 kilometers, and there was no rain reported by the formation. The Board was therefore of the opinion that outside visibility was good and that forward visibility through the aircraft canopy was not reduced by rain, and therefore discounted these factors as contributory causes of the incident.

c. Sun and Sea Effects. Due to the cloud cover at the time of the incident, the sun was obliterated and was not therefore causing any difficulties to the pilots in the formation. For the same reason, there was no glare effect from the sea and though the relatively calm sea state produced few orientation cues, this was not considered to be an added difficulty in maintaining station. The Board therefore discounted any effects of sun and sea as contributory factors.

d. Outside Distractions. No members of the formation reported the presence of boats, birds, other aircraft or any other object which could have caused distraction. The Board are therefore of the opinion that outside distractions did not constitute a contributory factor in the incident.

Inside Distraction

e. Aircraft Performance. The Display was designed to ensure that no aircraft would be operating at or near maximum power. Furthermore, Squadron aircraft which had shown tendencies to be under-powered were not used for Display flying. Shark Leader had 50 to 55 per cent Torque applied during the turn in which the incident occurred. Shark 6 should therefore, in normal circumstances, have had more than sufficient power in hand to maintain his station on the outside of the turn and should not have approached a jack-stall or vertical bounce condition. The Board therefore considers that aircraft performance, other than a technical malfunction, should not have contributed to the accident.

f. The Task of Maintaining Formation Position.

(1) The method employed by Sharks 2 and 3 to maintain station was standard, in that they employed normal visual references from Leader. The relative ease of station keeping in these particular positions allowed them also to devote sufficient attention to maintaining symmetry with each other by cross-referring and sighting through Leader's fenestron in all phases of the display routine.

(2) The extra degree of difficulty experienced by Sharks 5 and 6

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in their particular station keeping task was highlighted by 5. He described the additional requirement to monitor not only his position relative to his section leader (Shark 4), but also to monitor Shark 2 in order to maintain the correct fore and aft line, horizontal separation and step-up from 2. This variation in requirements between the 2 and 3 and 5 and 6 positions was further confirmed by Shark 5 who stated that during the 1976 season, when he flew in the number 2 position, he was more easily able to monitor the position of both Leader and 3 to maintain his station as he did not have the additional task of observing an aircraft ahead of him.

(3) The Board took particular note of Lieutenant [REDACTED] statement that, having taken over the Shark 5 position for the 1977 season, a measure of the increased workload that this particular multi-cue position now imposed on him was significantly apparent during an inside turn. He stated that, during this manoeuvre, he was not free to devote any deliberate effort to monitoring the relative position of 6.

(4) The general workload of all members of the Sharks formation team was, by the very nature of the routine, undoubtedly high, particularly as at times the routine demanded bank angles of up to 50 degrees in a quick succession of manoeuvres. The Board is of the opinion that this already high workload was even higher for those pilots in the number 5 and 6 positions, and that this could have been a significant contributory factor in the accident.

g. Formation Aspects. Certain other aspects of this particular display formation could have had a bearing on the accident:

(1) Step-up. In order to enhance the visual appearance of the Display, the step-up between aircraft in formation had been reduced to give a flatter horizontal aspect. This practise demanded a greater degree of concentration, particularly on the part of 4, 5 and 6, in order to avoid encountering the downwash from 1, 2 and 3.

(2) Movement of Outside Aircraft in a Turn. In common with general experience, it was stated that an aircraft flying on the outside of a tight turn was more likely to lose formation position by dropping back and away from the formation rather than by overtaking the leader, thus requiring the pilot to carry out the relatively difficult manoeuvre of accelerating up to, and moving sideways in towards, the formation. This would be made even more difficult if, as in the case of the Sharks routine, high bank angles were being used.

(3) Formation ground positioning. In order to maintain the correct ground position relative to the spectators during a display it was the practice of the leader to make small variations in applied bank angle to take wind effect into account. This had been briefed to the team and all pilots were aware that these variations might occur. At the time of the incident the formation was turning from a beam towards a head wind and, although the leader stated that he had not yet initiated the roll-out, Sharks 2 and 3 had the impression that the bank had begun to ease slightly.

33. The Board is therefore of the opinion that, if the Accident Investigation Unit reports no mechanical or material defect in either aircraft, the most likely cause of the accident is that Lieutenant BROWN fell astern of his formation position some time during the left turn in the figure of eight, and,

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in attempting to regain that position whilst also concentrating on achieving formation symmetry with Shark 5, possibly at the instant when the formation was slightly adjusting the bank angle, came into contact with Shark 4.

#### CONCLUSIONS

34. The display routine was a logical development of the 1975 and 1976 displays and was within the competence of the pilots.
35. The display routine was well understood by the pilots. Responsibilities for maintaining symmetry were not laid down but no confusion appeared to exist between Shark 2 and Shark 3 and between Shark 5 and Shark 6.
36. The display had been approved verbally. Distances between aircraft were not laid down but had not changed since the display had been demonstrated and approved.
37. The preparation and work-up for the 1977 displays was satisfactory.
38. The briefing was satisfactory.
39. The weather conditions were suitable for the Display.
40. The pilots were qualified, in flying practice and medically fit. Their activities during the previous 48 hours were perfectly normal. They had had adequate rest and there was no evidence to suggest that they were suffering from any worries or emotional upsets.
41. The flying programme for Monday 13 June 1977 was sensibly planned to include an Instructional Sortie for each pilot before starting display rehearsals.
42. The aircraft were serviceable prior to take-off.
43. There was a significant increase in the workload of numbers 5 and 6, compared with numbers 2 and 3, in the Sharks formation.
44. In the event that the Accident Investigation Unit can show that neither aircraft suffered mechanical break up, the Board concludes that the most likely cause of the accident was that Shark 6 came into collision with Shark 4.
45. As death was instantaneous on impact with the water, the proper functioning of Survival Equipment does not come into question.
46. The Search and Rescue operation was satisfactory.

#### RECOMMENDATIONS

47. Formation display flying forms an integral part of Service aviation, with immeasurable benefits to recruiting, morale, publicity and a more tangible return in an increasing level of aviation expertise and skill of those taking part. It creates a goal for less experienced personnel and engenders job satisfaction and a pride in ones Service.
48. The particular difference between fixed-wing and rotary-wing formation flying is the obvious reduction of visual cues for the helicopter pilot, especially for assessing lateral separation between rotor tips. The helicopter, being a less stable platform, demands a higher level of concentration in order to maintain adequate safety margins, where a lapse of concentration is more likely to have serious consequences.

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49. To increase the number of aircraft in formation will increase the workload of the individual pilots, more significantly for those with a greater number of separation cues to process. To decrease vertical and lateral separations, for instance to produce a more visually acceptable display routine, will, combined with this increased workload, significantly reduce the available margins for error, perhaps to the point where a previously adequate level of performance may deteriorate to a level where errors will occur.

50. The Sharks formation display routine was successfully flown in the 1975/1976 seasons. The Board are satisfied that basically the same display routine was employed for the 1977 team and that the pilots were competent in all respects to take part. However, the Board considers that despite the successful 1975/1976 seasons and the 1977 work-up, a multi-aircraft formation display routine, such as practised by the Sharks, constitutes a situation in which insufficient margin is allowed for error by pilots whose prime function is not close formation display flying.

51. The Board recommends that formation display flying by helicopters continues but, bearing in mind the factors outlined at paragraphs 47 to 50 above, further recommends that:

- a. Where personnel are drawn from normal Squadron strength, 4 aircraft should be considered as the optimum number for a formation display team.
- b. When formation display teams of more than 4 aircraft are required, consideration should be given to nominating pilots to carry out this task as their primary role.

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Lieutenant Commander Royal Navy



Surgeon Commander Royal Navy



Captain Royal Navy