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BRIEF SUMMARY
OF
PROGRESS OF FIRST ARROW
AIRCRAFT 25201

MAY 1958

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(Aircraft 25201)

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AVRO AIRCRAFT LIMITED

AVRO ARROW





BRIEF SUMMARY OF PROGRESS OF FIRST ARROW (AIRCRAFT 25201)

An operational requirement for a supersonic all-weather interceptor to follow the CF-100 was generated by the R.C.A.F. in November 1952 and Spec. Air 7-3, which covered the requirement for a design study, was issued to Avro in April 1953.

A ministerial directive giving Avro authority to proceed with the design study was issued in July, 1953.

Authority to proceed with the design and development of the CF-105 aircraft was received by Avro in May, 1954, at which time design of the airframe was commenced.

The first issue of engineering information was made to Production in the latter part of 1954, and the first aircraft was rolled out of the Production Shop on October 4th, 1957.

The first engine runs on Aircraft 25201 took place on December 4th, 1957, the aircraft started taxi trials December 24th, 1957, and the first flight was made on March 25th, 1958.

This brief report covers the flights made to date and the preparation for the next phase of flying.

GENERAL

Aircraft 25201 made nine flights in the first twenty-nine days of flying and generally achieved a high degree of reliability, two flights being made in one afternoon, and a third flight was in preparation for the same afternoon, but the weather deteriorated.



The aircraft flew supersonic on the third flight and reached Mach 1.52 at approximately 50,000 feet on the seventh flight.

The aircraft has been flown by three different pilots, Mr. Zurakowski, Avro Chief Development Pilot, making the first seven flights, and F/L Woodman, R.C.A.F. Pilot, and Mr. Potocki, Avro Development Pilot, carrying out the 8th and 9th flights respectively. On the 9th flight, Mr. Potocki was cleared to fly up to Mach 1.7 and 55,000 ft., but after carrying out assessment of the low speed handling and acceleration up to Mach 1.2, the weather closed in to almost zero ground visibility, and he did not attempt a speed run.

The aircraft has not yet been pushed to its maximum capability with the Pratt and Whitney J.75 engines, and probing at higher speeds will be carried out on the next series of flights.

Most of the flights have been carried out at a weight considerably in excess of the estimated production mission weight, the highest take-off weight being around 67,000 lb., and the highest landing weight being approximately 54,000 lb.

Total flying hours to date are 8 hours and 10 minutes, of which at least one half hour has been above Mach 1.

PILOT'S IMPRESSIONS OF FLYING CHARACTERISTICS

The following is an extract from a detailed report by Mr. Zurakowski, on the handling qualities of the aircraft based on his flights to date.

" 13. CONCLUSIONS

- 13.1 In general, handling characteristics and performance of aircraft agreed well with estimates.



- 13.2 Take-off, initial climb, and handling at low speeds (limited by 15° incidence) were satisfactory. Some longitudinal pitching at medium speed was eliminated after first flight by alterations to elevator control circuit and, in last flight, longitudinal behaviour of aircraft was much better. Speeds up to 450 knots A.S.I. and turns up to 2-1/2 'g' were tested at lower altitude. Lateral and longitudinal control was sensitive, and pilot's tendency to over-control was present.
- 13.3 In Flight No. 7, at 49,000 ft., aircraft reached M.N. = 1.52 on climb, still accelerating, showing excess of thrust available. Handling of the aircraft at supersonic speeds at higher altitudes was good.
- 13.4 Landing characteristics of aircraft were satisfactory except that, apparently due to restriction of pilot's view ahead, landing speeds were higher than estimated. Drag chute reliability was high, deceleration power very good.
- 13.5 Engine control was very good, reliability high. Some loss of thrust at transonic speeds at higher altitudes was investigated.
- 13.6 Yaw damping system was a considerable help in accurate flying of the aircraft.

SIGNED: J. Zurkowski "

NOTES

- 13.2 The damping system is not yet installed on either the pitch or roll axis and this, coupled with the adjustments which are being made to the control feel system, should eliminate this condition.
- 13.4 An investigation is at present being carried out to improve the pilot's view on landing.



13.5 The loss in thrust is now believed to have been rectified by Pratt and Whitney.

A great deal of data recorded from flight test instrumentation is still being analyzed, but the behaviour and general performance of the aircraft is very close to that predicted.

The aircraft is at present having its first major inspection since first flight, and certain equipment which had only limited flight approval is being replaced, snags cleared up, and the instrumentation brought to a higher standard in readiness for the next series of flights, which we hope to commence during the last week in May.

We are scheduling eight to nine flights in Stage Two of our flight program, and the aircraft will be cleared on the first flight of this series to the following:

Mach No. = 1.75
E. A. S. = 500 knots
Altitude = 60,000 ft.
NW = 250,000, that is: $n = 5$ at 50,000 lb.
 $n = 3.85$ at 65,000 lb.

The primary objectives of the Stage Two test series will be as follows:

- (a) Investigation of stability and control derivatives, using manual and damping step inputs.
- (b) To evaluate the revised flying control system.
- (c) To investigate the brake and gear dynamics.
- (d) To investigate possible engine performance deficiencies.
- (e) To evaluate the revised air conditioning system.

In summary, it can be said that the initial flight test program has been



particularly successful and, although the initial flights were mainly scheduled for pilots' assessment, sufficient flying was achieved to be able to credit at least five hours to our Phase One flight test program, providing an excellent start to the Arrow development program.

Appendix 1 gives a more detailed report of the nine flights carried out to date.

J. C. Floyd.

J. C. FLOYD,
Vice President Engineering,
Avro Aircraft Limited.

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AVRO ARROW



APPENDIX 1

ARROW FLIGHT DEVELOPMENT

Report No. 70/ENG PUB/7

1 May 1958

Project Management Services



ARROW FLIGHT DEVELOPMENT

1.0 INTRODUCTION

This report is a summary of the activities of the first ARROW aircraft (#25201) covering the period from its first flight on 25 March 1958, to 30 April 1958.

2.0 PHASE 1 FLIGHT TESTING

Phase 1 testing, which is to be conducted by AVRO, began with the first flight of the ARROW, and is intended to check the handling of the aircraft and the functioning of its systems. Up to and including the ninth flight, 8 hours and 10 minutes flying time has been achieved, of which about 5 hours can be credited to the estimated 150 useful flying hours required to complete Phase 1 testing.



2.1 AIRCRAFT FLIGHTS

2.1.1 1ST FLIGHT

Date	-	25 March 1958
Duration	-	35 minutes
Flight Data	-	Maximum speed - 250 knots
	-	Maximum altitude - 11,000 feet

TEST RESULTS

The main object of this flight was the preliminary assessment of handling qualities of the aircraft, which were found to be satisfactory for further development flights.

The flying control yaw axis damper system was set at standby during take-off and both NORMAL and EMERGENCY modes were tested during flight. The aircraft was landed with the damper system in NORMAL engagement. It was noted during this flight that the NORMAL Mode was more effective than the EMERGENCY Mode.

FLIGHT SNAGS

ACTION

- | | | |
|-----|---|--|
| (a) | No "Up and Locked" display of main and nose landing gear. | Micro-switches were adjusted |
| (b) | The equipment air conditioning temperature controller failed to function during flight. | A faulty temperature controller in the equipment bay was replaced. |
| (c) | Buffeting when landing gear doors are open in flight. | A design change is under consideration, whereby the doors would close after the leg is extended. |



2.1.2 2ND FLIGHT

Date	-	2 April 1958
Duration	-	50 minutes
Flight Data	-	Maximum speed - 250 knots (M = .45)
	-	Maximum altitude - 30,000 feet

TEST RESULTS

The object of this flight was to extend the pilot's preliminary assessment of the handling qualities of the aircraft, but due to the failure of the nose landing gear door to retract, the pilot restricted the aircraft to Mach .45 at 30,000 feet instead of the planned Mach .95 at this altitude. The pilot encountered some difficulty with lateral control, although it was somewhat improved with engagement of the control dampers in both NORMAL and EMERGENCY Mode.

The operation of afterburners did not effect lateral pitching or rolling of the aircraft.

Buffet was not severe with airbrakes extended.

Temperatures up to 240°F were measured in the engine shroud. These are considered satisfactory.

FLIGHT SNAGS

ACTION

(a)	Air conditioning warning light came on at 25,000 feet.	Cooling turbine now disconnected in an attempt to improve cockpit air conditioning.
(b)	Failure of landing gear "Up and Locked" display during flight.	Micro-switches re-adjusted.
(c)	Failure of UHF transmitter 10 minutes after take-off.	UHF checked out on ground o.k.



2.1.3 3RD FLIGHT

Date	-	3 April 1958
Duration	-	1 hour 5 minutes
Flight Data	-	Maximum speed - M = 1.1 at 40,000 ft.
	-	Maximum altitude - 40,000 ft.

TEST RESULTS

This flight was to assess the aircraft handling qualities at higher speeds and altitudes. It was noted that oscillations in pitch, at speeds of about 250 knots, could be eliminated by releasing the control column; while at speeds of 400 knots and above, the oscillations could be prevented by firmly holding the control column. Efforts to excite aileron flutter under various conditions were unsuccessful.

FLIGHT SNAGS

ACTION

- | | | |
|-----|--|--|
| (a) | The UHF transmitter failed to operate at altitudes above 20,000 feet. | Transmitter and interphone control panel replaced. |
| (b) | At 32,000 feet max engine power was only 93% of max rpm, with jet pipe temperature between 510 and 520°F. | Under investigation. |
| (c) | After a pull-up manoeuvre of approximately 1-1/2g, the cockpit indicator falsely indicated that the left hand landing gear was unlocked. | Micro-switch has been repositioned to give a more positive indication. |
| (d) | Fluctuations of the airflow of cockpit air conditioning were noted. | System is known to be faulty - waiting for redesigned hardware. |



2.1.4 4TH FLIGHT

Date	-	15 April 1958	
Duration	-	1 hour 15 minutes	
Flight Data	-	Maximum speed	- M = .9 at 40,000 ft.
	-	Maximum altitude	- 46,000 ft.

TEST RESULTS

This flight was intended to assess the aircraft handling qualities at speeds up to Mach 1.5 but the flight plan was changed about 10 minutes after take-off due to the failure of a transformer-rectifier unit. The failure of this unit meant automatic failure of d-c power to the instrumentation in the aircraft. This flight was then utilized for flight familiarization at the pilot's discretion.

FLIGHT SNAGS

ACTION

(a)	Failure of transformer-rectifier unit	Replaced Transformer Rectifier Unit.
-----	---------------------------------------	---



2.1.5 9TH FLIGHT

Date - 17 April 1958
 Duration - 1 hour 10 minutes
 Flight Data - Original flight plan aborted (see below)

TEST RESULTS

This flight was intended to assess the aircraft handling qualities at speeds up to Mach 1.5. The flight plan was changed about 20 minutes after take-off due to a landing gear retraction failure. The flight events leading up to the change in the original flight plan, were as follows:

Following a 2.5 g left hand turn, the left hand landing gear indicator indicated an unlocked up condition. The pilot then selected "Landing gear down" which was performed successfully. Following this, up retraction was selected but retraction was not achieved. At this point the original flight plan was changed and the pilot decided to carry out angle of attack measurements for various speeds and altitudes, within the limitations imposed by the extended landing gear.

FLIGHT SNAGS

(a) Unreliable up-lock indication and
 failure of landing gear retraction.

ACTION

Re-adjustment to micro-
 switches and actuator arms.



2.1.6 6TH FLIGHT

Date	-	18 April 1958	
Duration	-	55 minutes	
Flight Data	-	Maximum speed	- M = 1.2 at 42,000 ft.
	-	Maximum altitude	- 42,000 ft.

TEST RESULTS

This flight was to assess the flight handling qualities up to a limit of Mach 1.5. The aircraft was flown to Mach 1.2 at 42,000 feet without adverse handling characteristics. No attempt was made to reach the planned Mach 1.5 due to an indicated lack of fuel remaining at that stage of the flight. During the flight, a number of damper system checks were made.

FLIGHT SNAGS

No major snags were reported on this flight.



2.1.7 7TH FLIGHT

Date	-	18 April 1958
Duration	-	50 minutes
Flight Data	-	Maximum speed - M = 1.52 at 49,000 ft.
	-	Maximum altitude - 50,000 ft.

TEST RESULTS

This was the second flight in one day and established the maximum level flight speed so far obtained with this aircraft. This high speed run was carried out at 49,000 feet. The greatest altitude was also obtained during this flight; i.e. 50,000 feet. These are not necessarily the ultimate speeds or altitudes obtainable from this aircraft, but the best the pilot has attempted during these preliminary test flights.

Following this flight, F/L J. Woodman (C.E.P.E. Test Pilot) made a high speed taxi run in the ARROW and at one point lifted the nose wheel off the ground, but did not attempt to take-off.

FLIGHT SNAGS

ACTION

- | | | |
|-----|--|--|
| (a) | Some intake duct vibration became evident at about 450 knots | Investigations into the cause are being conducted. |
| (b) | The test fuel gauges, are still suspected to be unreliable. | Aircraft system is to be installed during the first grounding of the aircraft. |

2.1.8 8TH FLIGHT

Date - 22 April 1958

Duration - 45 minutes

Flight Data - Maximum speed - - M = 1.4

- Maximum altitude - 45,000 ft.

TEST RESULTS

This was a familiarization flight for F/L J. Woodman, the first RCAF pilot to fly the ARROW. Further tests of the flying control damper system were made.

FLIGHT SNAGSACTION

- | | | |
|-----|--|--|
| (a) | Engines still showing decreasing RPM with increasing altitude. | Still under investigation |
| (b) | On landing, right forward main wheel seized, with consequent damage to brake pads, discs and rims etc. | Caused by faulty brake |
| (c) | Excessive use of oxygen. | Tests show that the leak rate was ten times higher than normal.
Suggest pilot did not have anti-g hose connected. |



2.1.9 9TH FLIGHT

Date - 23 April 1958

Duration - 45 minutes

Flight Data - Maximum speed - M = 1.2 at 34,000 ft.

- Maximum altitude - 40,000 ft.

TEST RESULTS

This was a familiarisation flight for "Spud" Potocki, while at the same time giving further checks of the handling and stability of this aircraft. Maximum speed during this flight was Mach 1.2 at 34,000 feet. Although the pilot was cleared to fly at M = 1.7 and up to an altitude of 50,000 feet, the high speed run was cancelled due to rapidly deteriorating weather conditions. Mild manoeuvres up to 1.5 "g" turns were carried out. Part of the flight was made with the afterburners lit.

FLIGHT SNAGS

(a) Warning lights indicated left hand
a-c and d-c power failure.

ACTION

Left hand constant speed drive
unit replaced.

