MEASUREMENTS OF DELAYS IN ESCAPE FROM TANDEM-CREWED AIRCRAFT

REPORT No. 70/HUFAC/1

NOV. 1957

AVRO AIRCRAFT LIMITED

MEASUREMENTS OF DELAYS IN ESCAPE FROM TANDEM-CREWED AIRCRAFT

REPORT No. 70/HUFAC/1

NOVEMBER 1957

Prepared by ______________________
Staff Engineer, Human Factors

Approved by ______________________
Chief of Equipment Design

Authorized by ______________________
Chief Engineer

AVRO AIRCRAFT LIMITED
MALTON – ONTARIO

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SUMMARY

The paper considers the nature and duration of escape warning in tandem-crewed aircraft with respect to those escape incidents where little time is available for the escape, particularly those occuring near to the ground.

Experienced pilots and navigators performed escape sequences in a full-scale mock-up of a tandem-crewed supersonic aircraft equipped with Martin-Baker ejection seats. The subjects were dressed in personal equipment designed for high performance flight.

Measurements were taken of escape control operation, crew patter and movement, throughout the sequences, by an oscillograph, magnetic tape and cine photograph record.

Four sequences were used in the study. Two were without patter using a visual/audio warning system and differed only in the operation of the ejection seat firing control. The remaining sequences were conducted using voice communication; one using the standard service patter, the other the aircrews' spontaneous patter. Each crew performed 12 sequences, a total of 72 sequences being recorded during the study.

A sequence was considered to cover the time from the occasion of the flight condition demanding escape to the time at which the pilot (the last man to 'eject') cleared the fuselage of the aircraft.

The oscillograph record gave the most useful measure of elapsed time. The main findings were:-

SUMMARY cont'd...

(a) An escape sequence with patter took an average of 6.8 seconds to complete, the maximum time taken being 11 seconds.

(b) Warning without patter using a visual/audio system, took significantly less time (but is thought to be normally used only as a supporting warning).

It is concluded that the 'escape times' measured within the limits of this study are excessive, and that under actual conditions, this time will be lengthened since a situation 'appraisal' by the pilot will undoubtedly precede an order to abandon the aircraft.

In view of these conclusions it is recommended that -

(a) Due consideration be given to the proposal to so link the seats that the pilot, by operating one control, ejects both the navigator and in turn, himself. Such a linked system would necessitate complete automatic restraint prior to ejection for the navigator, and in addition an override that would permit independent navigator escape. A linked seat system could reduce total escape time for both occupants to approximately 2.5 seconds.

(b) An attempt be made to establish by experiment a brief and effective verbal warning.

(c) The significance of short periods of time in escape be studied more closely during the compilation of accident reports, particularly for aircraft carrying more than one occupant.

INTRODUCTION

One of the most important factors affecting escape from aircraft is the time taken by the aircrew to abandon the aircraft once the flight condition demanding the escape has been reached.

A high proportion of accidents occur during landing and take-off, and in most instances the time taken to escape becomes increasingly critical the nearer the aircraft is to the ground.

There have been accounts by World War II pilots of escapes from single seat aircraft in which delays due to the physical difficulties of disengaging the body from the cockpit were emphasized.[1] Delays of this nature have been minimized through the evolution of the ejection seat.[2,3] The pilot escaping from many current high performance aircraft has only to operate one control to initiate an automatic escape sequence: (a) the canopy is jettisoned, (b) the pilot is ejected, his legs having been restrained, (c) the seat falls stabilized, and the occupant separates from the seat at appropriate speed and altitude, (d) the personal parachute is then deployed. This automatic sequencing has unquestionably saved the lives of many aircrew since 'escape time' for a single ejection has been minimized.

There is, however, another escape delay problem peculiar to aircraft carrying more than one crew member which has received relatively little attention. It is the delay due to communication (warning of the need of escape) that must invariably occur between crew members once the pilot recognizes the flight condition demanding escape.

INTRODUCTION Cont'd...

This report deals with measurements of the time taken by the occupants of a tandem-crewed aircraft to 'escape', when the method of communicating the escape warning between the crew members was by verbal message, visual/audio warning (light plus horn), or a combination of both methods.

PROCEDURE

The tests were conducted in a full-scale mock-up of a supersonic tandem-crewed aircraft. The cockpits were fully instrumented and equipped with all the associated controls, switches etc., together with Martin-Baker Mk. 4 ejection seats.(Fig 1) For the purposes of these trials a seat pan alternative D firing ring was attached to the seats.

Measurement of 'escape time' commenced when a red warning light in a central position on the pilot's instrument panel was energized from an external source. This light represented the occurrence of the flight condition demanding escape. Pilots were instructed to initiate their escape sequence upon seeing the red warning light - therefore their subsequent actions were timed under ideal conditions as the pilot and navigator were anticipating the sequence*. A sequence was considered to be complete when the pilot (the last to 'eject') had 'cleared' the fuselage of the aircraft.

Instrumentation - As stated above, the escape warning from pilot to navigator was conveyed by verbal or visual means: the AIC/10

---

* Under actual escape conditions additional delays could occur - see Discussion.

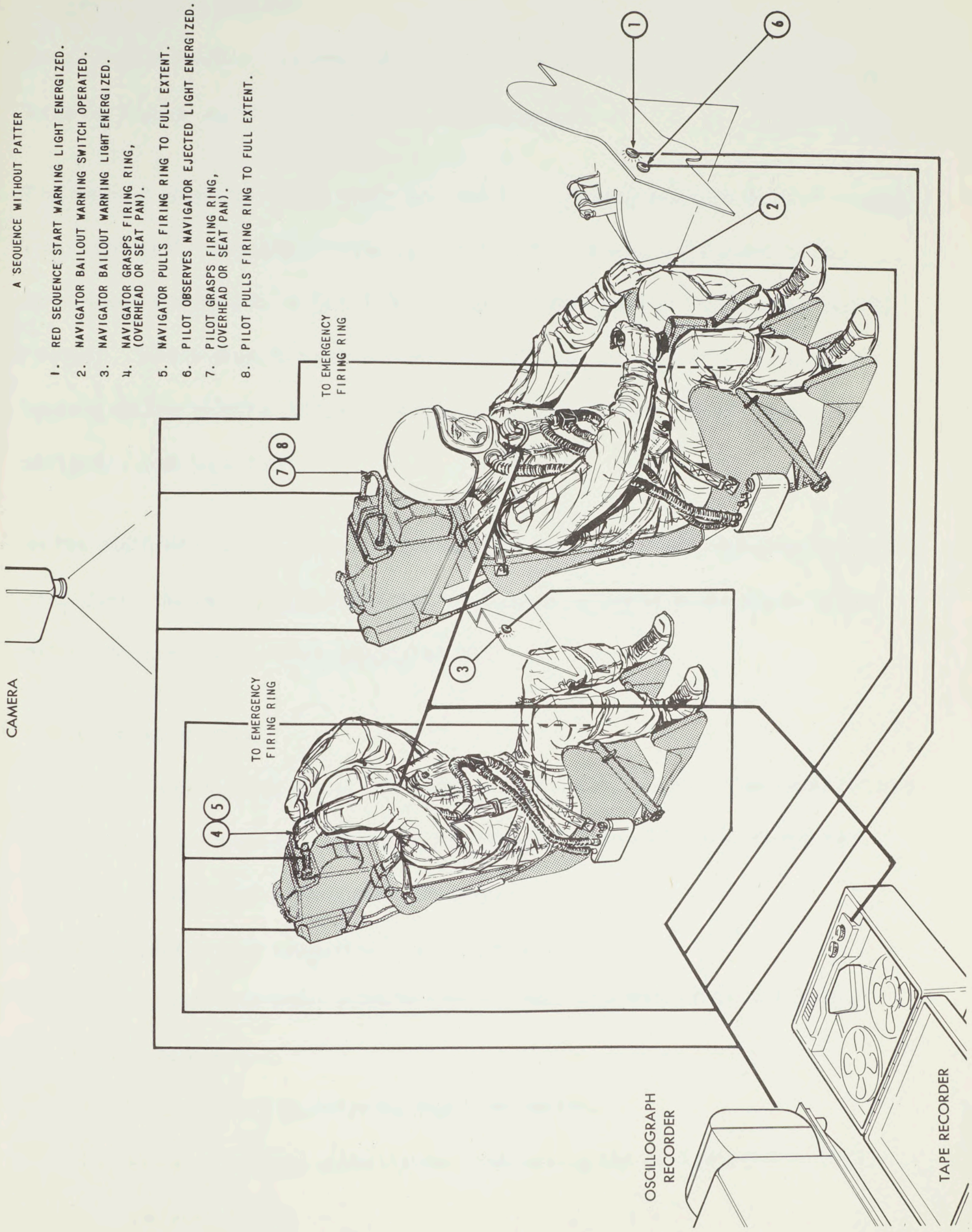


FIG. 1 – ESCAPE DELAY STUDY - TEST SITUATION AND APPARATUS

Instrumentation Cont'd. . .

intercommunication system, the red master warning light, and the escape warning lights were energized for this purpose.

The escape warning lights were located in a central position in each cockpit. The light in the navigator's cockpit was red, and was energized by the operation of a switch (termed the Navigator Bail-Out switch) in the pilot's cockpit. The action of ejection by the navigator energized a second light (green) on the pilot's instrument panel, which indicated to the pilot that the navigator had 'ejected'.

At the start of each sequence when the pilot's red master warning light was energized, three synchronized and continuous records of events in time, within the sequence, were commenced.

These records were:-

1. A cine-photographic record at 64 frames per second. The camera was positioned above the cockpits and clearly recorded head, trunk and arm movements throughout the sequence.
2. A magnetic tape record of verbal communication.
3. An oscillograph trace record showing the occasion of the following events in time:-
   (a) Sequence-start-warning light energized.
   (b) Pilot operation of the switch energizing the navigator's bail-out warning light.

Instrumentation Cont'd. . .

(c) Navigator grasping either the overhead or seat pan D firing ring.

(d) Navigator pulling firing ring to full extent.

(e) 'Navigator ejected' light in pilot's cockpit energized.

(f) Pilot grasping either the overhead or seat pan D firing ring.

(g) Pilot pulling firing ring to full extent.

The time taken for the canopies to open, and the time taken for the seats to travel up the rails to clear the fuselage, were calculated separately (see Results).

Subjects - Six qualified aircrews (6 pilots and 6 navigators) acted as subjects for the study. These included RCAF pilots and navigators, test pilots, and flight test observers. All were experienced on the AVRO CF-100 aircraft, and all had received instruction in the operation of the Martin-Baker ejection seat.

Personal Flying Equipment - Throughout the sequences each subject wore personal equipment designed for flight in high performance aircraft. This equipment included a pressure helmet, anti-g suit, pressure vest and pressure-gravity valve. The clothing was worn to simulate as nearly as possible actual conditions experienced whilst flying, and to enable an estimate to be made of any restrictions to movement that the personal equipment might impose.

Each subject was strapped firmly to the seat by the safety harness, and breathed 100% oxygen with the pressure vest inflated to safety pressure of 8-10 mm. Hg.

Instructions - A written briefing describing the purpose and nature of the trials was issued to the test subjects one day prior to their participation (see Appendix I).

Before entering the cockpits the subjects were verbally briefed, and were instructed to use their own spontaneous patter in Sequence D (below). Finally, when the crews were seated in the cockpits, and just prior to the commencement of each sequence, the actions to be taken by the subjects were again described.

At the start of each sequence the pilot sat with his right hand grasping the control column which was in the neutral position - his left hand was placed on the throttles which were open.

Crew Actions and Procedure During the Four Sequences Tested -

Sequence A - Without patter -

(i) The sequence-start-warning light in the pilot's cockpit was energized.

(ii) The pilot moved his left hand back and down to the navigator bail-out switch.

(iii) The pilot operated the navigator bail-out switch.

(iv) The navigator's bail-out light was energized.

(v) The navigator grasped and pulled the overhead D firing ring.

(vi) The pilot observed the 'navigator ejected' light energized.

(vii) The pilot grasped and pullcd the overhead D firing ring.

Crew Actions and Procedure During the Four Sequences Tested Cont'd. . .

Sequence B - Without patter -

This sequence differed only from Sequence A in that both pilot and navigator 'fired' the seat by means of a seat pan D firing ring instead of the overhead method.

Sequence C - Using standard service bail-out patter -

(i) The sequence-start-warning light in the pilot's cockpit was energized.

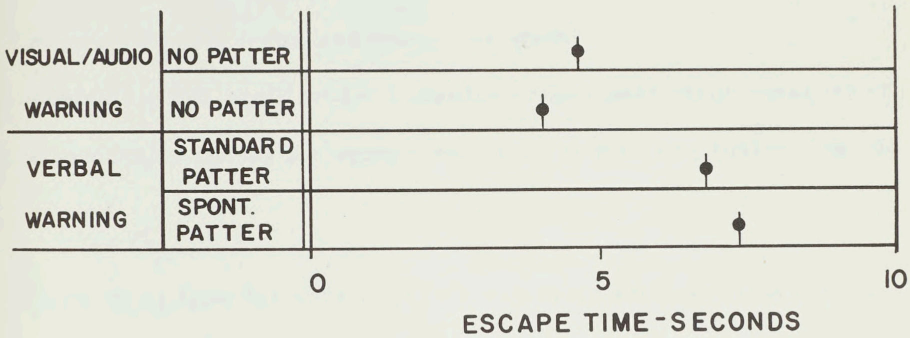
(ii) The pilot then said, "Prepare to abandon aircraft, prepare to abandon aircraft. Eject, eject". As he gave this verbal warning he prepared to operate the navigator bail-out switch as in Sequence A(ii) above. He operated the switch whilst saying, "Eject, eject". No verbal response was required from the navigator. The remaining actions required were as in Sequence A.

Sequence D - Using spontaneous patter -

For this sequence a verbal acknowledgment was required rom the navigator upon his receipt of the verbal warning. When the pilot heard the acknowledgment he then operated the navigator bail-out switch. Otherwise the actions required were as in Sequence A.

Throughout these trials the navigator was the first to 'eject'. Other possible sequences were not tested, for under actual escape conditions the pilot may wish to attempt to control the aircraft whilst the navigator ejects.

Trial Design - It was considered that no special escape practice was



ESCAPE TIMES MEASURED FOR CREWS WITH AND WITHOUT PATTER

FIG.2.

Trial Design Cont'd. . .

necessary prior to the commencement of the recorded trials, since the aircrews acting as subjects were currently engaged in flying in the CF-100 which is equipped with Martin-Baker ejection seats.

A systematic procedure was used which made provision for the four sequences to be presented in different order three times for each crew: thus each crew participated in 12 sequences, a total of 72 sequences being measured during the study.

Analysis - The oscillograph record gave the most useful measure of elapsed time during the sequences. This record was analyzed to .01 second.

Crew delay time for each sequence was calculated, and this data was examined by Analysis of Variance method (see Appendix II).

RESULTS

The total escape times for all crews and sequences are shown in Table 1. Fig. 2 summarises the evidence.

Clearly the most important finding is that, under optimum conditions, an escape sequence using verbal communication, can take an average of 6.8 seconds and as long as 11 seconds (Fig. 3, Sequence C).

A comparison between the Sequence A, B and C, D showed a highly significant difference between the mean scores for the sequence. This expected difference was due to the delay imposed by the verbal patter used in Sequences C and D.

RESULTS Cont'd. . .

TABLE I

Total Escape Times - All Sequences (Seconds)

Crew	Sequence A			Sequence B			Sequence C			Sequence D		
	1	2	3	1	2	3	1	2	3	1	2	3
1	3.81	3.14	2.56	2.37	3.60	3.57	7.52	6.23	6.67	7.03	8.38	4.86
2	8.53	8.73	6.68	6.10	6.53	6.90	10.32	11.03	9.90	11.50	8.58	8.32
3	4.27	3.28	3.27	3.28	3.75	3.32	7.82	4.35	4.84	7.60	6.19	6.06
4	3.47	3.10	3.08	3.85	3.60	2.74	7.20	4.54	5.36	8.53	7.55	6.85
5	5.57	4.48	4.68	4.30	3.83	4.33	6.71	5.65	6.30	8.07	6.15	6.46
6	6.72	3.79	4.58	4.38	4.40	4.25	7.62	6.41	6.17	8.02	7.44	5.82
Mean	5.3	4.4	4.1	4.0	4.2	4.0	7.8	6.3	6.5	8.4	7.3	6.3

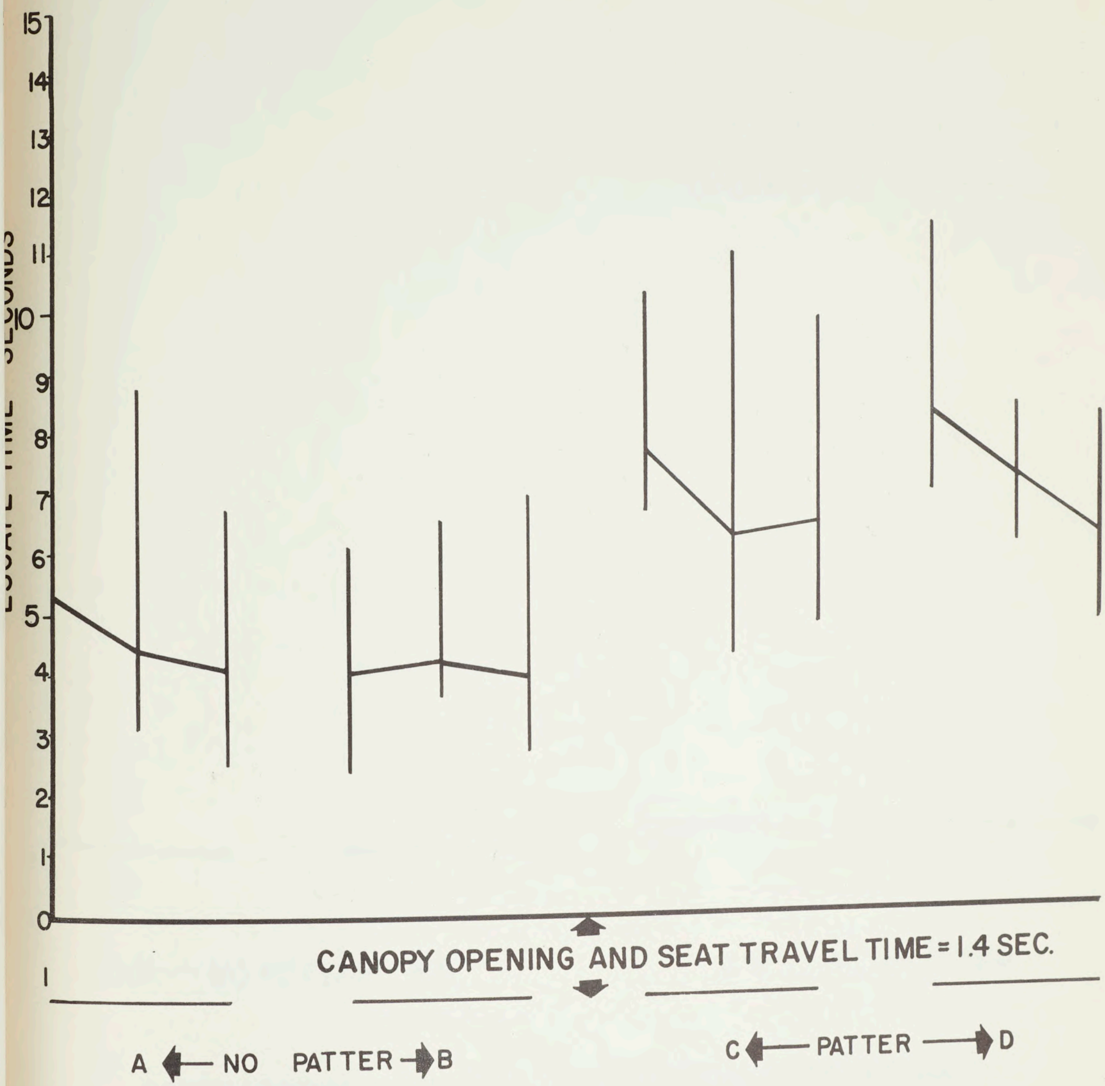
Canopy opening time, and time for the ejection seat to travel up the rails was calculated* (1.4 seconds) and must be added to the above means to determine a representative 'escape time'.

All the crews appear to have "learned" at about the same rate. However, rate of learning differed between Sequences; in Sequence D it was probably affected by the length of patter used by the subjects. The extent through which learning would possibly have continued was not established.

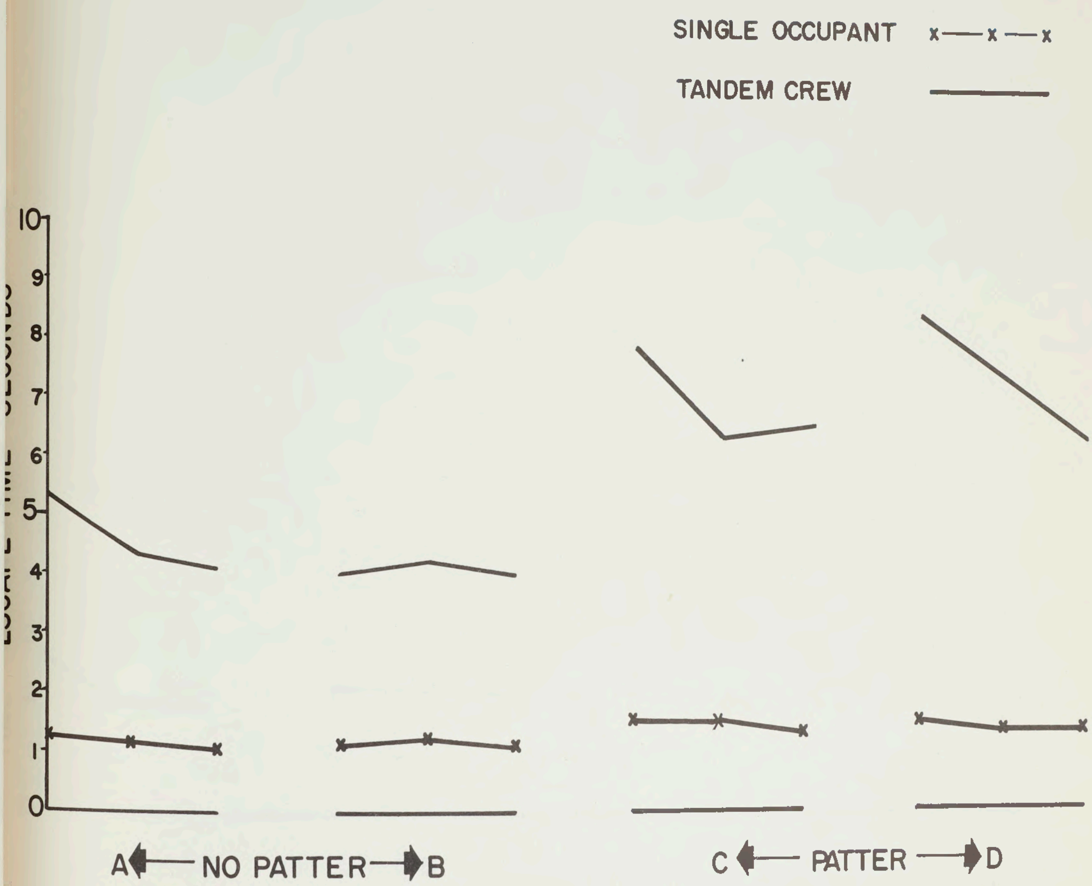
Time for a single occupant to complete an 'escape' was calculated from the component times within sequences. The mean times for the pilot to complete

---

* Average single canopy opening time 0.5 second. Seat rail travel time maximum 0.2 second.



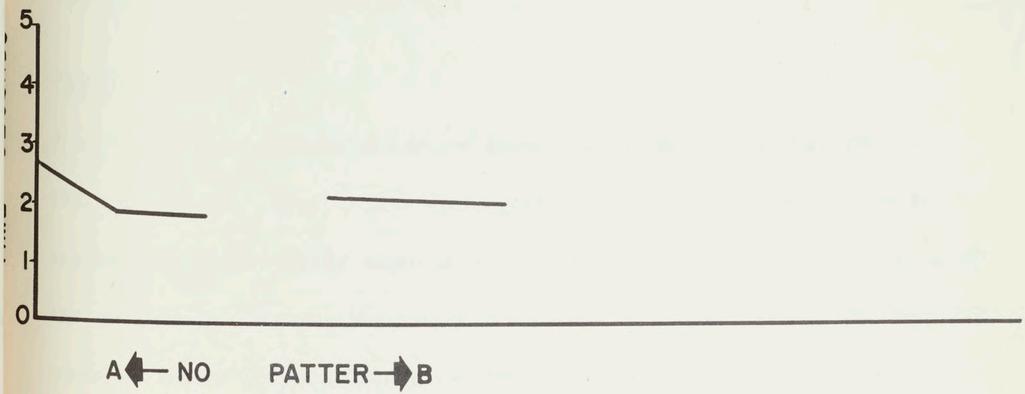
ESCAPE TIMES- MEANS AND RANGES
FOR ALL SEQUENCES FIG. 3



* CANOPY OPENING AND SEAT TRAVEL TIMES (FIG.3) MUST BE ADDED.

<u>DIFFERENCES BETWEEN SINGLE AND TANDEM CREW ESCAPE TIMES</u>*

FIG. 4.



PILOT TIME TO REACH AND OPERATE THE NAVIGATOR BAILOUT SWITCH.

FIG. 5.

RESULTS Cont'd. . .

'ejection' after the 'navigator ejected' light was energized, are shown in Fig. 4, and when compared with the results for the tandem crews, the delaying effect of communication can be seen.

The time taken by pilots to reach and operate the navigator bail-out switch is shown in Fig. 5. This time of approximately 2 seconds appeared to be excessive, and by inspection of the cine record it was found that all pilots chose to visually identify the position of the switch before operating it. The location of the switch in a bank, together with four others which were identical, presumably necessitated this visual identification and caused a slight additional delay.

DISCUSSION

The importance of time in escape from high performance aircraft needs little emphasis. Most pilots will agree that when an aircraft has to be abandoned, particularly when it is near to the ground, once they have made the decision to escape, they wish the escape to be executed in the minimum possible time. In many instances this is due to the fact that the escape has been left until a late moment in the hope that the emergency condition may be corrected, and the aircraft landed safely. In these circumstances the navigator possibly has time in which to (a) abandon the aircraft prior to the moment at which the pilot decides to escape, or (b) prepare himself for immediate ejection. There are, however, circumstances in which the aircraft must be abandoned within a very few seconds of the time at

DISCUSSION Cont'd...

which the flight condition demanding escape occurs. This paper is concerned particularly with incidents of the latter type.

A summary of ejection reports[4] shows that high performance aircraft are at times abandoned at altitudes of less than 1000 ft. The reasons for abandonment can vary considerably: loss of power, loss of control, structural failure, control system failure, fuel shortage and other causes may demand escape, often during the critical periods of landing and take-off. In these circumstances a high performance aircraft must be abandoned swiftly, (e.g. current jet aircraft take approximately 5 seconds to fall through 1000 ft. of height during a spin.)

This study has demonstrated that under ideal conditions a single occupant can perform the procedure of escape in approximately 2.5 seconds, and that for two occupants the escape time is extended considerably. The reader may query the realizm of these times in relation to actual escapes when the escape time may in fact be longer. Escape time, though critical in many accidents, has not been emphasized in accident statistic summaries.

The basic components in time which may contribute to delays in an escape sequence for a tandem aircrew may be described under three main headings:-

1. Appraisal time - Flight conditions may be reached, or emergencies occur, which demand immediate and unexpected escape by the aircrew.

DISCUSSION Cont'd. . .

The pilot as Captain of the aircraft is the only person qualified to assess the condition and to order escape. His assessment of the situation may be followed by an attempted correction, for he is trained to perform corrections as the major part of the piloting task. Presumably the pilot's recognition of the condition demanding escape may be accomplished to varying degrees by what may be termed 'stress'. Other psychological and physiological effects may be concomitants of this condition. No attempt will be made to discuss these effects here, except to say that they may be beneficial or detrimental. Certainly, if present, they may constitute an important component in both appraisal and warning periods.

Assuming no control correction attempt is made and that the effects of stress are not delaying, a period of 2 seconds may reasonably be considered to elapse before the pilot commences to warn his navigator to 'escape'.

2. Warning time - For certain flight conditions, e.g. loss of control or control system failure, the order to escape may in turn be quite unexpected by the navigator. There will probably be large individual differences in navigator response to the escape warning. The navigator may at one extreme be poised waiting to eject with alacrity, or at the other extreme may hesitate before resorting to escape by ejection.

Undoubtedly the nature of the escape warning will in part affect the response. Presumably most pilots and navigators who fly as a crew

DISCUSSION Cont'd...

agree that whenever possible a verbal warning by way of explanation will be used. This would seem to be substantiated by the warnings chosen by the crews in this study (Appendix III). The results obtained in the study show that the visual/audio warning can be effected in shorter time than the verbal warning; but it is probably not regarded with the same 'trust' as the verbal warning, and therefore would in actual escapes probably be used only as a supporting warning, unless the emergency condition destroyed the intercommunication facility.

The patter used in Sequence C of this study would seem to be unnecessarily long for the circumstances in which a swift escape sequence is essential. Clearly the spoken warning could be shortened, but the effect of the environment on the speaker[5] should be carefully taken into account. The aim should be to establish a brief, highly intelligible, standardized and compelling verbal warning.

3. Crew action time - The delays which may be attributed to crew action during escape have been largely reduced through the efforts of aeronautical engineers. As stated earlier the pilot and navigator each have only to operate one escape control to initiate a series of automatically sequenced escape events. However, the position of the ejection seat firing control may yet be improved for conditions in which accelerations are excessive. Similarly, the positioning of a visual/audio warning control should be optimised.

CONCLUSIONS AND RECOMMENDATIONS

The results obtained in this study suggest that escape sequences for a tandem crew can take an excessive period of time when considered in relation to low level incidents demanding escape. In fact, 'escape time' for a tandem-crew is some four times greater than that for a single occupant.

In the light of this evidence it is recommended that due consideration be given to the proposal that the seats be so linked together, that the pilot upon deciding that the crew must escape immediately, operates the firing control of his seat and ejects the navigator; the navigator's seat in ejecting then fires the pilot's seat. Such an arrangement could reduce total escape time for both occupants to approximately 2. 5 seconds.

However, in order that the navigator be properly positioned for ejection, an automatic restraint for the navigator would be a mandatory component of a linked system. Furthermore, the navigator should be provided with an override which would enable him to eject alone (a) in cases where there is ample time for the escape, or (b) should the pilot be incapacitated, e.g. by anoxia. Certainly the design of a linked seat system should be such that the reliability of the escape system is maintained at the highest level.

It seems reasonable to conclude that the standard escape patter used in this study is unreasonably long where very little time is available for the escape.

It is recommended that a brief and effective warning be determined by

CONCLUSIONS AND RECOMMENDATIONS Cont'd. . .

experiment for use in current tandem-crewed jet aircraft.

The significance of short periods of time in escape, particularly for aircraft carrying more than one crew member, should be studied more closely during the compilation of accident reports. One approach might be to record all jet aircraft intercommunication on recoverable miniature tape recorders. Valuable information could thus be obtained that in time would provide more details about crew behaviour during actual escapes.

REFERENCES

1. Mackersey, Ian. (1956) Into the Silk. Hale.
2. Martin, James. (1956) Ejection from high speed aircraft. J. Roy. Aero. Soc., 60, No. 550, p. 659.
3. Frost, Richard H. (1956) Escape from High Speed Aircraft. Stanley Aviation Corp.
4. Martin, James. (1957) Ejection Reports. Martin-Baker Aircraft Co., Denham, England.
5. Henneman, R.H. (1954) A Comparison of the Visual and Auditory Senses as Channels for Data Presentation. WADC, TECH. REP. 54-363.

ACKNOWLEDGMENTS

The writer wishes to acknowledge the assistance given by the Royal Canadian Air Force Institute of Aviation Medicine through the services of Flight Sergeant R. M. Rynard.

Dr. J. Ogilvie of the Defence Research Medical Laboratories advised Mr. W. A. K Chambers of Avro in his work on the complete statistical analysis.

The pilots and navigators who acted as subjects, and the Test Department deserve special thanks.

APPENDIX I

INSTRUCTIONS FOR AIRCREW PARTICIPATING IN THE ESCAPE SEQUENCE TRIALS

The purpose of these tests is to obtain data that may assist in preparing a satisfactory escape sequence. The following points have been considered and instrumentation installed to record them:

(a) The physical movements of the aircrew during sequences.

(b) Elapsed time intervals for each step of an ejection sequence.

(c) Total elapsed time for complete sequence.

(d) Alternative escape sequences.

The attached sheets describe the escape sequence for the pilot and observer.

GENERAL

It is important that you understand these instructions. If you have any questions as to their meaning ask for clarification from the test personnel. Instructions for each sequence will be repeated to you when you are in the cockpit prior to each sequence.

Please do not discuss your actions in these trials with other participants until they have completed their test. Such discussion may affect our results.

PILOTS

The following will list the actions required by the pilot for four different escape sequences.

SEQUENCE A (No Patter)

1. The timed sequence will begin when the red warning light comes on in the front panel of the pilot's cockpit.

APPENDIX 1

INSTRUCTIONS FOR AIRCREW PARTICIPATING IN THE ESCAPE SEQUENCE TRIALS

The purpose of these tests is to obtain data that may assist in preparing a satisfactory escape sequence. The following points have been considered and instrumentation installed to record them:

(a) The physical movements of the aircrew during sequences.

(b) Elapsed time intervals for each step of an ejection sequence.

(c) Total elapsed time for complete sequence.

(d) Alternative escape sequences.

The attached sheets describe the escape sequence for the pilot and observer.

GENERAL

It is important that you understand these instructions. If you have any questions as to their meaning ask for clarification from the test personnel. Instructions for each sequence will be repeated to you when you are in the cockpit prior to each sequence.

Please do not discuss your actions in these trials with other participants until they have completed their test. Such discussion may affect our results.

PILOTS

The following will list the actions required by the pilot for four different escape sequences.

SEQUENCE A - (No Patter)

1. The timed sequence will begin when the red warning light comes on in the front panel of the pilot's cockpit.

APPENDIX 1 Cont'd. . .

2. The pilot immediately operates the "Nav. Bail out" switch. This switch is located on the left hand console immediately aft of the throttle box.

3. The next action of the pilot is initiated by the green "Nav. Bailed out" light coming on. This light is located beside the red warning light described in item 1 above.

4. The pilot, upon seeing the green light, shall take a firm grip on his overhead face blind and pull down as in a normal bail out. This action completes the pilot's portion of the escape sequence.

SEQUENCE B (No Patter)

1. As in (1) above the sequence begins with the red warning light coming ON.

2. The pilot selects Nav. Bail out as in (2) above.

3. The next action by the pilot is initiated by the green "NAV. BAILED OUT" light coming on as in (3) above.

4. The pilot, upon seeing this green light, shall take a firm grip on the ejection handle located between his legs on the front face of the seat pan. He must then pull up on this handle to complete his portion of the escape sequence.

SEQUENCE C (With Patter)

1. As in A and B (1) above, the sequence begins with the red warning light coming ON.

2. The pilot verbally warns the Nav. "Prepare to abandon aircraft - prepare

APPENDIX 1 Cont'd. . .

to abandon aircraft" - (switches on NAV. BAIL OUT light) simultaneously saying, "Eject" - "Eject".

3. The next action of the pilot should be initiated by the green "NAV. BAILED OUT" light coming on as in A and B (3).

4. The pilot, upon seeing the green light, shall brace himself, take a firm grip on the overhead face blind, and pull down on the handle to complete his portion of this ejection sequence.

SEQUENCE D (With Patter)

1. As in A, B and C the sequence begins with the red warning light coming ON.

2. The pilot warns the Nav. verbally using his own words, but not switching on the Nav. Bail Out light until his command has been understood by acknowledgment from the Nav.

3. The next action by the pilot is initiated by the green "NAV. BAILED OUT" light coming on, as in A, B and C (3) above.

4. The pilot, upon seeing the green light, shall brace himself, take a firm grip on the overhead face blind, and pull down on the handle to complete his portion of the ejection sequence.

NAVIGATORS

The following lists the actions required by the navigator for four different escape sequences.

SEQUENCE A (No Patter)

1. The timed sequence for the navigator begins when his "Bail Out" light

APPENDIX I Cont'd. . .

comes on. This light is located in the centre of the navigator's front panel.

2. The navigator, upon seeing this light, shall brace himself, take a firm grip on his overhead face blind and pull down as in a normal bail out.

SEQUENCE B (No Patter)

1. As in Sequence A (1) above the sequence begins when his "Bail Out" light comes on.

2. The navigator, upon seeing this light, shall take a firm grip on the ejection handle located between his legs on the front face of the seat pan. He must then pull up on this handle to complete his portion of the escape sequence.

SEQUENCE C (With Patter)

1. Upon hearing the pilot saying "eject" "eject" and seeing the "Nav. Bail Out" light come on simultaneously, the navigator bails out as in Sequence A (2) above.

SEQUENCE D (With Patter)

1. Upon understanding the pilot's verbal bail out warning, the navigator must acknowledge verbally, he will then see his "Nav. Bail Out" light come on. He can then bail out as in Sequence A (2) above.

APPENDIX II

ANALYSIS OF VARIANCE

	D.F.	S.O.S.	Mean Sq.	V.R.	5%	1%
Crews	5	1,216,071	243,214.2	47.0^{xx}	2.53	3.70
Sequences	3	1,441,907	480,635.7	92.9^{xx}	2.92	4.51
Trials	2	173,073	86,536.5	16.7^{xx}	3.32	5.39
Crews X Sequences	15	156,072	10,404.8	2.01^{x}	2.01	2.70
Crews X Trials	10	49,142	4,914.2	1.05	2.16	2.98
Sequences X Trials	6	89,784	14,964.0	2.9^{x}	2.42	3.47
Crews X Sequences X Trials	30	155,148	5,171.6	-	-	-
Total	71	3,281,197	-	-	-	-

APPENDIX III

The 'Spontaneous patter' used in Sequence D by each crew was transcribed from the magnetic tape recorder, and is reproduced below.

Crew 1

Trial 1 Pilot: "O.K. Bob, prepare to abandon the aircraft."

Navigator: "O.K. Pete."

Trial 2 Pilot: "O.K. Bob, prepare to abandon the aircraft."

Navigator: "O.K. Pete."

Trial 3 Pilot: "O.K. Bob, stand by to eject."

Navigator: "O.K. Pete. Right."

Crew 2

Trial 1 Pilot: "Something's wrong here Alf. Bail out."

Navigator: "Roger, Tan. Bail out."

Trial 2. Same as above.

Trial 3 Same as above.

Crew 3

Trial 1 Pilot: "Navigator, aircraft in trouble. Bail out."

Navigator: "Understand - bail out."

Trial 2 Same as above.

Trial 3 Same as above.

Crew 4

Trial 1 Pilot: "We're on fire. We're on fire. We must eject."

APPENDIX III Cont'd. . .

Navigator: "O.K. Ready to eject."

Trial 2 Pilot: "We've got to get out. We're on fire. Eject. Acknowledge."

Navigator: "Ready to eject."

Trial 3 Pilot: "Fire. Fire. Eject. Eject."

Navigator: "Ready to eject."

Crew 5

Trial 1 Pilot: "Hey, Duane. The wing fell off, let's get out of here."

Navigator: "Roger. Prepared to bail out."

Trial 2 Pilot: "Hey, Duane, We're on fire. Bail out."

Navigator: "Right. Ready to go."

Trial 3 Pilot: "Hey Duane. Get out."

Navigator: "Right - Ready to go."

Crew 6

Trial 1 Pilot: "We're in trouble. We're in trouble. Bail out. Bail out."

Navigator: "Roger. Ready to go."

Trial 2 Pilot: "Bail out. Bail out."

Navigator: "Roger. Ready to go."

Trial 3 Pilot: "We're in trouble Geoff. Bail out. Bail out."

Navigator: "Ready to go."