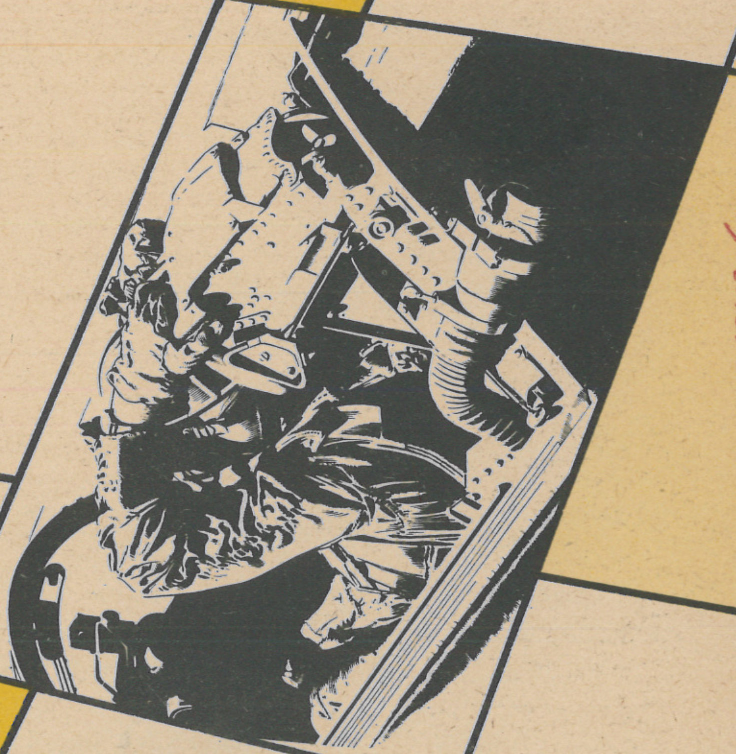
EJECTION SEAT Study



A Report of

Ejections and Bailouts

August 1949 through May 1956

U. S. Naval Aviation Safety Center

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Prepared by

U. S. Naval Aviation Safety Center

FOREWORD

EJECTION SEAT STUDY

Presented herein is a report on the ejection seat in emergency escape from U. S. Navy aircraft from the first ejection in August 1949 through May 1956.

The purpose of this study is to:

a. Present an analysis of the emergency uses of the ejection seat for the period covered.

b. Apprise operating commands of the ejection seat record.

c. Present brief discussions concerning the factors which influence the success of the ejection procedure.

This is the fourth report on emergency usage of the ejection seat prepared by the Naval Aviation Safety Center. It will be noted that the report considers all of the ejections which have occurred through May 1956 and thus includes the information contained in the previous reports. It is anticipated that additional reports will be prepared as the usage of the ejection seat increases.

Activities on the distribution list receive copies as indicated. A limited number of copies are available to other interested commands and may be obtained from the U. S. Naval Aviation Safety Center upon request.

CONCLUSIONS . .

Ejections

1. The increasing ejection rate per unit hours flown and an increasing number of these units flown indicate a steady mounting of the frequency of ejections.

2. The increase in the ejection rate without a corresponding increase in the fatality rate indicates the ejection process is becoming safer.

3. There is a pronounced relationship between successful ejections and altitude.

4. The relationship between altitude and successful ejection becomes apparent at 5000 feet and ejections become increasingly hazardous as the altitude decreases below this height.

5. The mean altitude at which ejections occur did not increase during the period covered by this study.

6. In terms of mach number, .70 is the beginning of the critically dangerous zone for ejections.

   a. In terms of indicated airspeed only, 400 knots is the beginning of the critically dangerous zone for ejections.

7. The mean speed at which ejections occur did not increase during the period covered by this study.

8. Ejecting from the F9F, F7U and TV model aircraft is significantly more dangerous than ejecting from the F2H and FJ models.

9. It is not more dangerous to eject from the sweptwing F9F than from the straight wing F9F.

10. The major ways in which injuries are sustained during ejections are (1) upon landing, (2) by the forces involved in ejecting the seat and

* *

pilot, and (3) by the shock of the opening parachute.

11. *Ejections are more dangerous than bailouts with present equipment.*

12. Navy and Air Force ejection injury ratios are nearly identical.

Bailouts

1. There is no relationship between altitude and injury in bailouts (as long as irreducible minimum is observed.)

2. Successful bailouts may be made at lower altitudes than can ejections with present equipment.

3. There is no relationship between speed and injuries resulting from bailouts within the speed range in which bailouts are made.

4. The mean speed at which bailouts are made is substantially slower than the mean speed at which ejections are made.

5. Bailing out from the F4U model aircraft is significantly more dangerous than bailing out of AD and SNJ models.

6. The major ways in which injuries are sustained during bailouts are (1) upon landing, (2) in the cockpit, (3) upon the fuselage, and (4) by parachute shock.

7. A large and significant difference in the number of injuries exists between trained parachute jumpers and untrained ones.

8. Training in bailout procedures and parachute landing techniques can reduce injuries to personnel.


TED WILBUR

RECOMMENDATIONS

1. Ejection data reveal that the current ejection equipment is not capable of functioning in the manner necessary to save the ejecting personnel at low altitudes. The efficiency of the present equipment diminishes rapidly at altitudes below 5000 feet. At altitudes below 3000 feet, the data indicate that a pilot will lose his life in more cases than in cases in which the equipment will save him. It is strongly recommended that the highest priority be assigned the development of equipment that will work at low altitudes.

2. As speeds increase above 400 knots, there is an accompanying increase in the percentage of ejections that result in fatal injuries. This indicates that the present ejection equipment becomes increasingly inadequate in the performance of its function to protect the pilot as speed increases. It is recommended that equipment be developed that will permit pilots to eject from high-speed aircraft with an excellent chance for survival.

3. An examination of a number of ejection fatalities reveals that some pilots with sufficient altitude to do so fail to separate from their seats. It is anticipated that this type fatality will increase, for more pilots will be rendered incapable of voluntary action as high-speed ejections increase. These fatalities may be prevented by the employment of automatic equipment that is capable of going through the necessary procedures regardless of the condition of the pilot. It is recommended that the ejection equipment be made completely automatic.

4. The F9F, F7U and TV aircraft are more dangerous from which to eject than the other models from which ejections have been made. It is recommended that research be done to determine the underlying causes that make some planes more dangerous than others from which to eject.

5. The fact that some models of aircraft are more dangerous from which to eject also holds true for bailouts. It is recommended that research be done to determine the underlying causes that make some planes more dangerous than others from which to bailout.

6. The injury rates of trained parachute jumpers are far less than those of operational bailouts. The high rate of injury resulting from emergency exits by flying personnel from disabled aircraft is, in a large measure, the result of improper parachuting technique, escape techniques and improper landing procedures. It is recommended that flying personnel be given more training in parachuting technique, escape techniques and landing procedures.

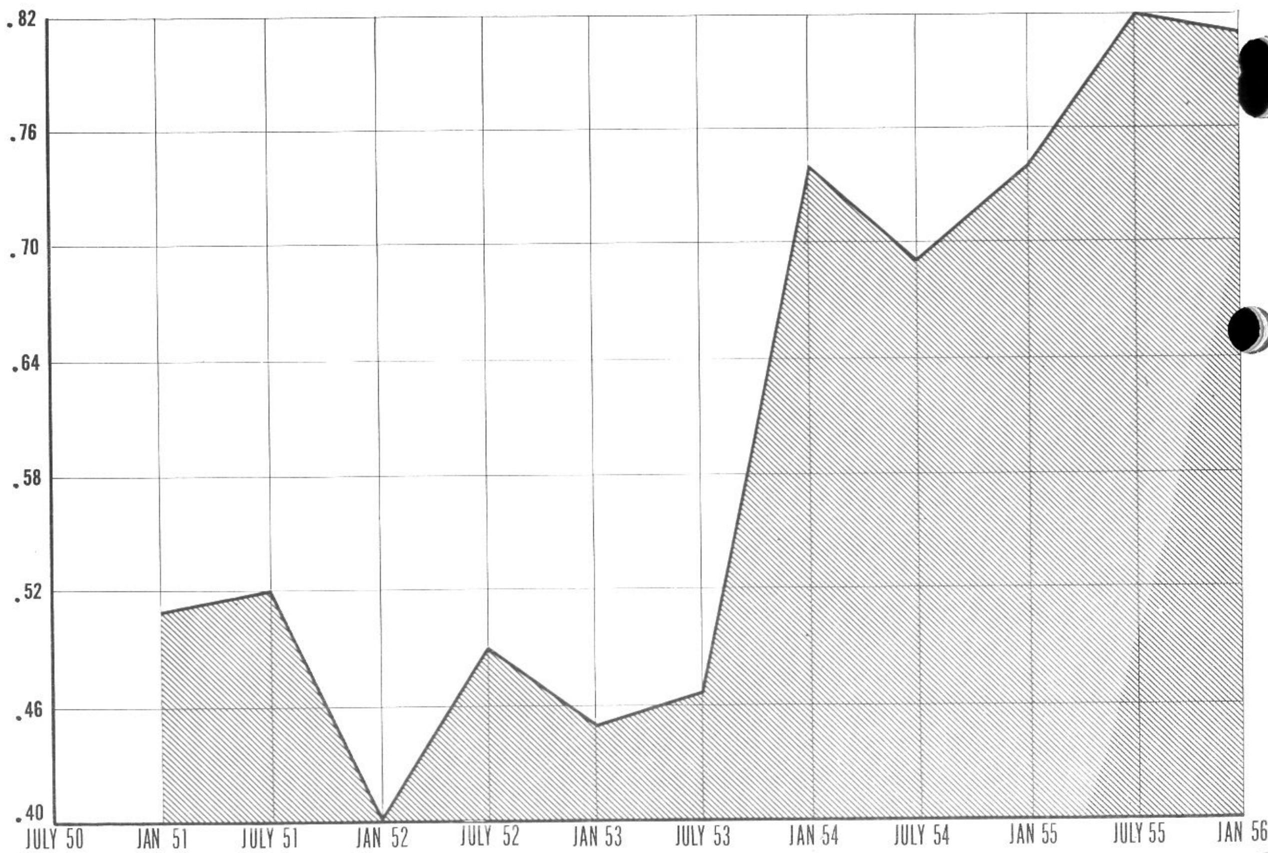
ANALYSIS

Ejection Rate

The rate at which ejections from jet aircraft have been occurring has evidenced a persistent upward trend since the July-December 1951 period low rate of .40 per 10,000 hours flown was recorded. Figure 1 clearly shows this trend. The last period used in this report is the July-December 1955 period which had an ejection rate of .81 which is slightly under the all time high of .82 scored for January-June 1955. A statistical analysis indicates that the chance of fluctuations of this size occurring by chance alone is but 1 in 10. This means that the reason for the large increase in the jet ejection rate will be discovered, probably, to be some systematic factor or factors involving engineering features or human variables or a combination of both material and human factors in the man-machine system rather than a chance factor as the underlying causal agent of the wide fluctuations in rate. This combination of an increasing ejection rate per unit hours flown

FIG 1

EJECTION RATE PER 10,000 HOURS

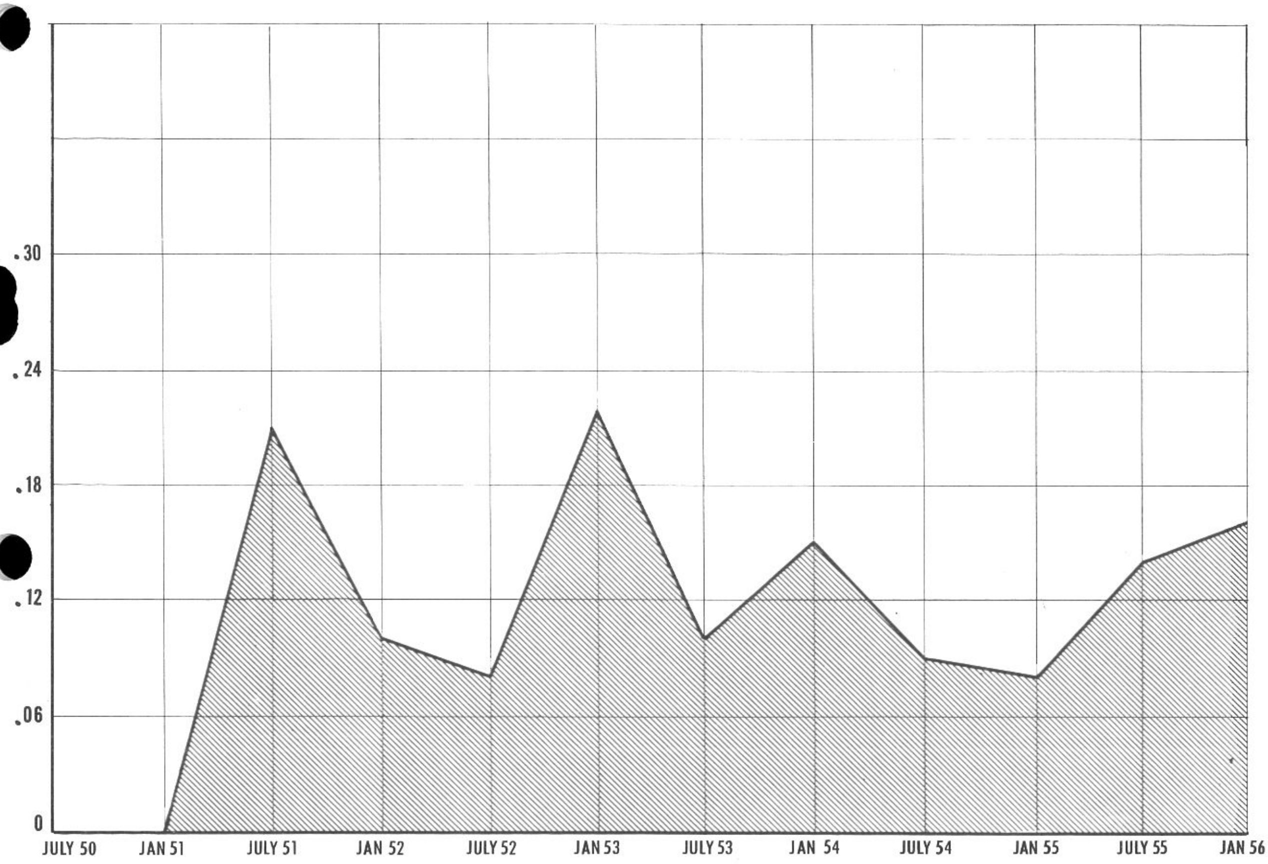


and an increasing number of these units flown indicate a steady mounting of the frequency of ejections to be expected in the future.

Figure 2 indicates that the upward movement of the ejection rate has not been accompanied by a corresponding increase in the ejection fatality rate. With the exception of the two high points of .21 and .22 and the low point of 0, the fatality rate has never been higher than .16 nor lower than .08. Actually the rate has shown a steady tendency to vary about a mean of .12. The rates for the six-month periods beginning with July-December 1950 have been .00, .21, .10, .08, .22, .10, .15, .09, .08, .14 and .16 respectively. None of these fluctuations has been greater than would be expected by chance. The increase in the overall ejection rate without a corresponding increase in the fatality rate indicates that the safety with which a man ejects from a disabled aircraft is being continuously improved.

FIG 2

EJECTION FATALITY RATE PER 10,000 HOURS



Altitude

The range of altitude for ejections has varied from ejections directly on the ground, i.e., zero altitude, to 40,000 feet. The average height at which an ejection is made is 10,056 feet. The computation of the mean involved a few unusually high ejections and these atypical heights tend to distort the mean as a descriptive statistic. A better indicator is the median. The median is a point that indicates that half of all ejections took place below and half above this point. The median ejection altitude is 7941 feet.

An inspection of Table 1 shows that there is a persistent increase in the percentage of fatal ejections from the nine percent at the 3000- 5000-foot range to the 33 percent at the 2000- 3000-foot range and 54 percent between 1000-2000 feet to the high of 94 percent that occurs at heights less than 1000 feet. The records indicate that all ejections below 1000 feet have resulted in fatalities with the exception of one freak accident in which the pilot ejected on the ground and managed to survive the resulting crash to the ground with an unopened parachute. Two further facts emerge from the data emphasizing the relationship of altitude to success in ejection. First, of the recorded fatal injuries for which altitude at ejection is known, 82 percent resulted from ejections that were attempted at altitudes below 5000 feet, and, second, 43 percent of all ejections attempted below 5000 feet resulted in fatal injuries. The odds are 2.2 to 1 for survival below 5000 feet and 20.5 to 1 for survival above 5000 feet. It is at 3000 feet that the odds shift definitely against survival, for below this height the chances are 1.6 to 1 that the ejecting pilot will be killed. It is apparent from Table 1 that 1000 feet is just about the irreducible minimum below which an ejection is almost certain to result in a fatality with the equipment in use during the period covered by this study.

These figures indicate that a pronounced quantitative relationship between altitude and

TABLE 1

TYPE OF INJURY RESULTING FROM EJECTION ACCORDING TO ALTITUDE

Resulting Injury to Personnel

		Fatal		Critical		Serious		Minor		None	
Altitude	Total	No.	%	No.	%	No.	%	No.	%	No.	%
0 - 999	16	15	94			1	6				
1000 - 1999	13	7	54					5	38	1	8
2000 - 2999	12	4	33			3	25	4	33	1	8
3000 - 4999	23	2	9			7	30	8	35	6	26
5000 - 9999	51	2	4			8	16	29	57	12	24
10,000- 19,999	53	3	6	1	2	5	9	31	58	13	25
20,000- 29,999	10							8	80	2	20
30,000- above	9	1	11			3	33	5	56		
TOTALS	187	34	18	1	1	27	14	90	48	35	19

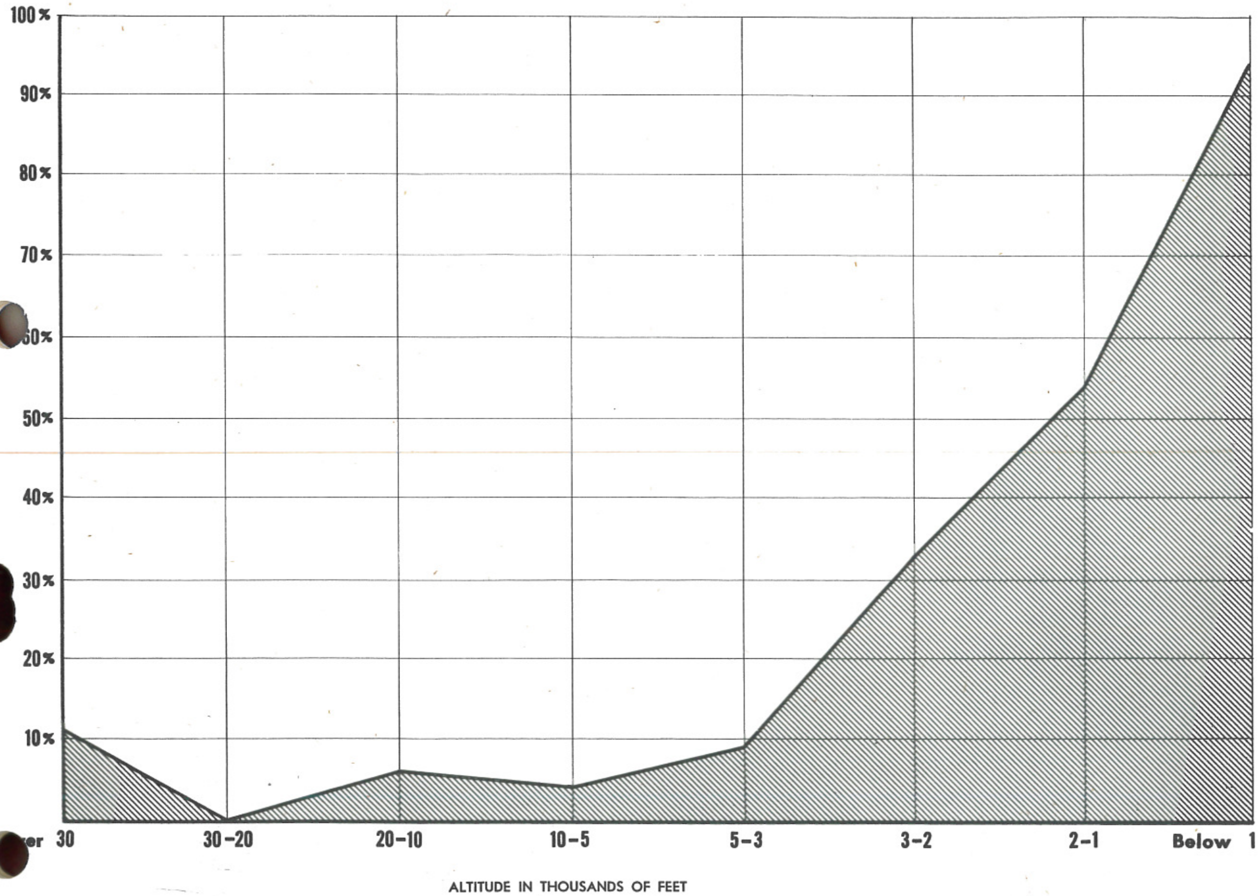
Note: The difference in total cases that occurs between the various tables in this report is due to the differences in the number of cases in which the information necessary could not be obtained.

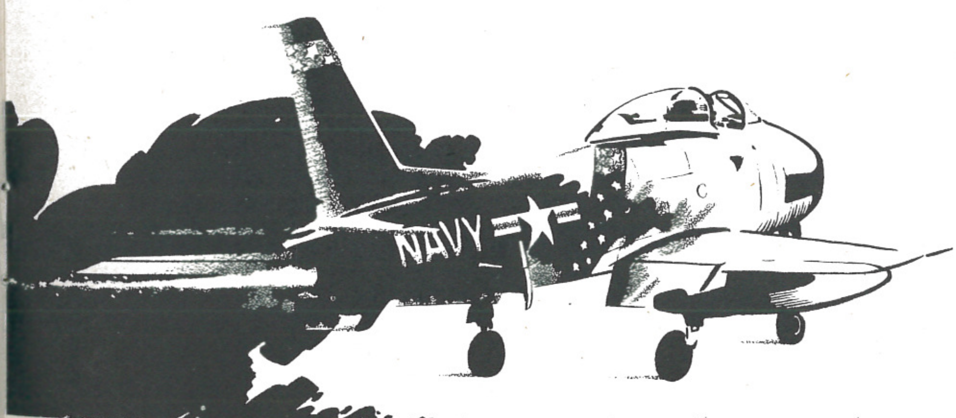
injury exists. This relationship begins at 5000 feet and is revealed by a decided acceleration in fatal ejections below this height. A pilot's chances of a successful ejection decrease directly as the altitude decreases below 5000 feet. (Figure 3).

FIG 3

PERCENTAGE OF FATALITIES

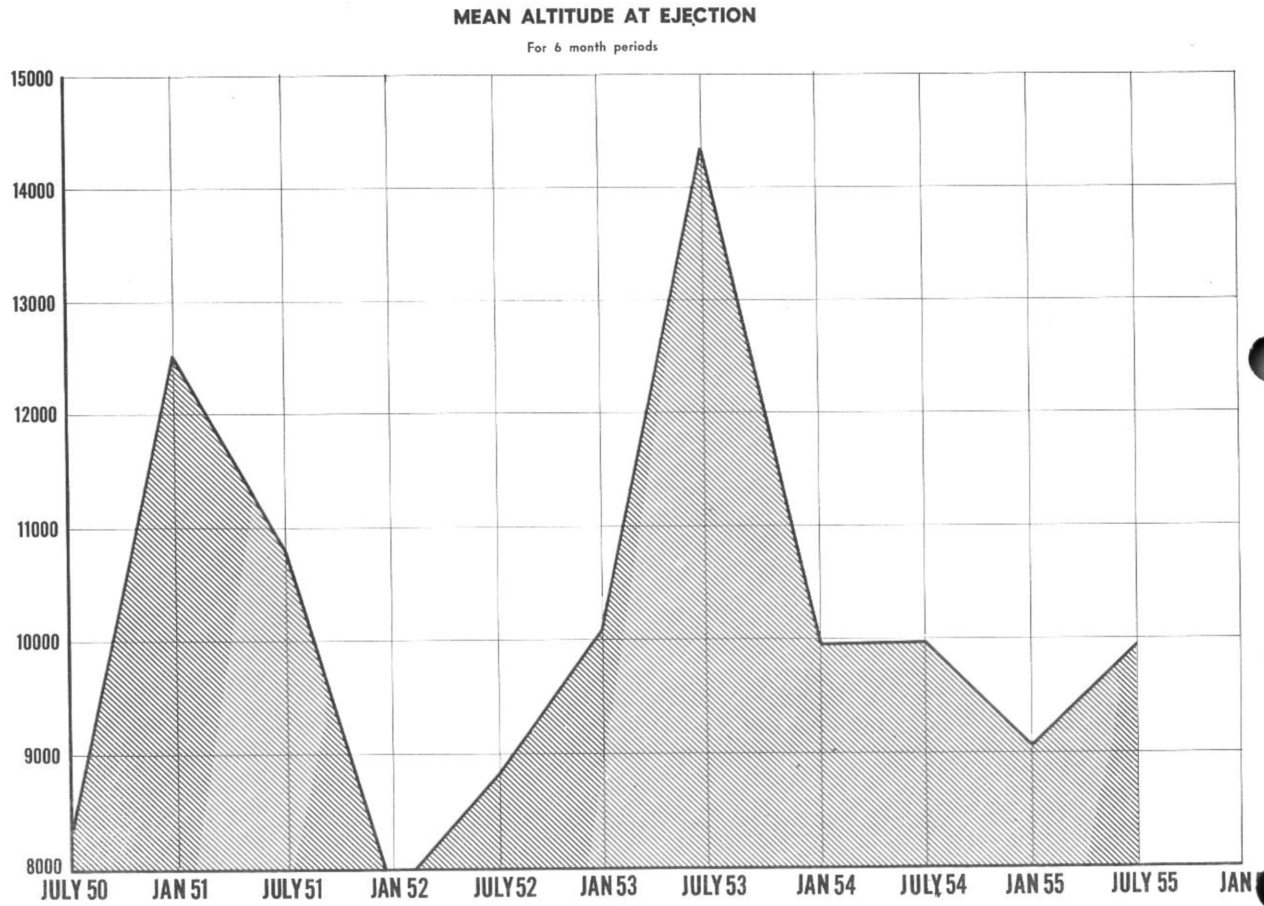
Resulting from Ejection according to Altitude





The mean altitude at ejection has been plotted for the six-month periods beginning July - December 1950 and ending July 1955. The wide fluctuations in the mean altitudes indicate no persistent trend. (Figure 4).

FIG 4



Bailouts

TABLE 2

TYPE OF INJURY RESULTING FROM BAILOUT ACCORDING TO ALTITUDE

Resulting Injury to Personnel

		Fatal		Critical		Serious		Minor		None	
Altitude	Total	No.	%	No.	%	No.	%	No.	%	No.	%
0 - 999	22	6	27	1	5	4	18	8	36	3	14
1000 - 1999	12							6	50	6	50
2000 - 2999	26	2	8			2	8	15	58	7	27
3000 - 4999	47	1	2	1	2	4	9	31	66	10	21
5000 - 9999	30	3	10			9	30	14	47	4	13
10,000- 19,999	6					1	17	5	83		
20,000- above											
TOTALS	143	12	8	2	1	20	14	79	55	30	21

For the period covered in this study, there have been recorded no bailouts at any altitude above 15,000 feet. (See Table 2). Ninety-five percent have taken place below 10,000 feet with the mean bailout height being 3097 feet. As mentioned above in connection with ejections, the median is, perhaps, a better statistical representative than the mean. The median bailout took place at 3425 feet; a difference of 4516 feet existing between the bailout and ejection medians. Only 27 percent of bailouts are fatal below 1000 feet compared to the 94 percent that result from ejections below 1000 feet.

There is no noticeable relationship between the altitude at which bailout occurs and injury as exists between height and injuries during ejections except when the minimum altitude is reached. Other things being equal, the minimum for performing a safe bailout is somewhere between 300 and 500 feet.

Speed

TABLE 3

TYPE OF INJURY RESULTING FROM EJECTION ACCORDING TO SPEED

Resulting Injury to Personnel

		Fatal		Critical		Serious		Minor		None	
Speed	Total	No.	%	No.	%	No.	%	No.	%	No.	%
100 - 149	10							8	80	2	20
150 - 199	41	3	7			7	17	18	44	13	32
200 - 249	36	3	8			10	28	15	41	8	22
250 - 299	27	1	4			1	4	21	78	4	15
300 - 349	19	3	16	1	5	1	5	12	63	2	11
350 - 399	11	1	9			2	18	6	55	2	18
400 - 449	5	1	20					4	80		
450 - 499	5	2	40			1	20	1	20	1	20
500 - 549	10	5	50			3	30	2	20		
550 - 599											
600 -	1	1	100								
TOTALS	165	20	12	1	1	25	15	87	53	32	19

Table 3 shows the type of injury occurring at various speed groupings. The mean speed at which ejections are made is 254 knots indicated airspeed.

Table 3 reveals that ejections made from planes traveling less than 400 knots resulted in 8 percent fatalities compared to the 43 percent fatal ejections above 400 knots. Only 21 (13 percent) ejections were made at speeds greater than 400 knots, but these 21 cases represent 45 percent of the entire group of ejection fatalities.

With the present ejection system, it appears that the critical pivotal speed is around 400 knots. Below 400 knots, a pilot's chances of escaping fatal injuries are 13 to 1. Above 400 knots the chances of escaping a fatal injury decrease to 2.3 to 1.

PERCENTAGE OF FATALITIES

Resulting from Ejection according to Speed

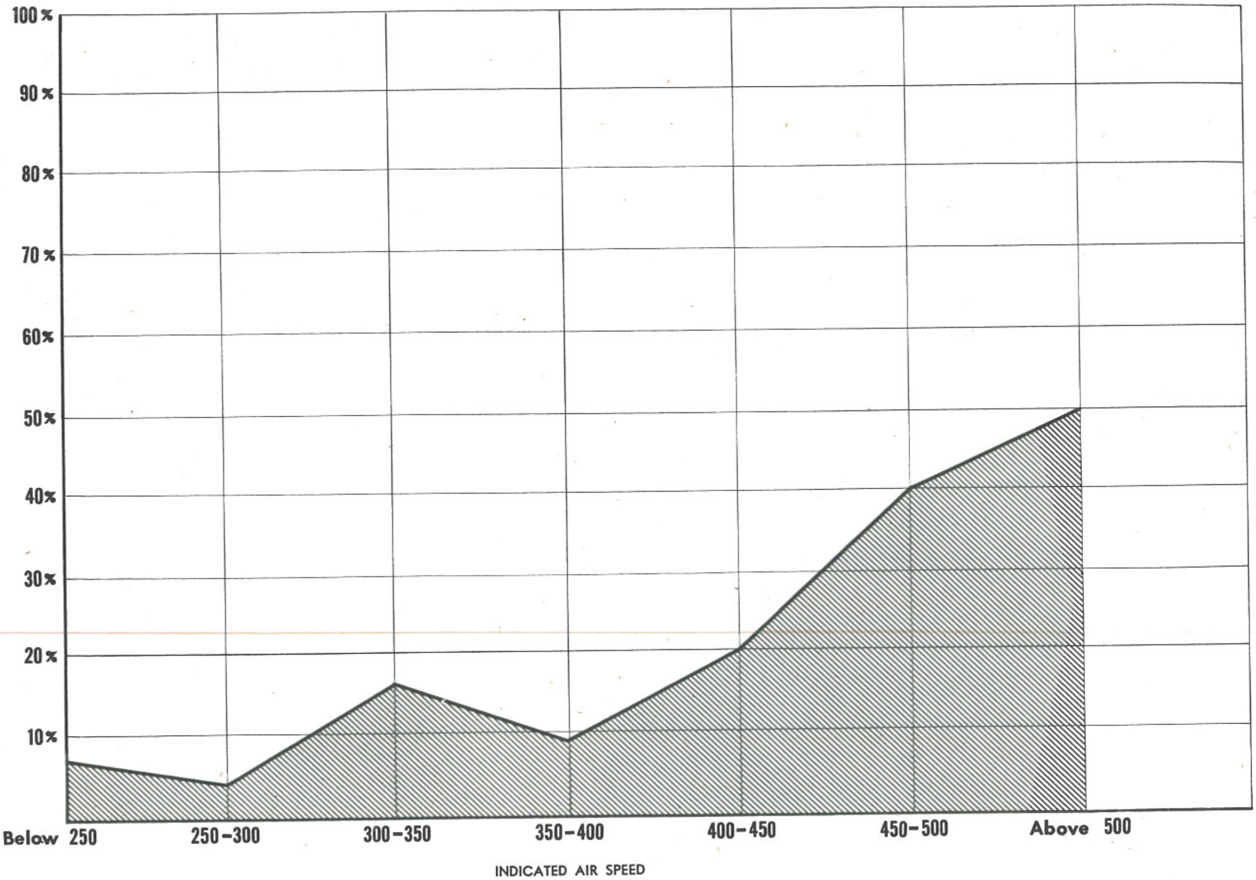


FIG 5

TABLE 4

TYPE OF INJURY RESULTING FROM EJECTION ACCORDING TO MACH NUMBER

Resulting Injury to Personnel

Mach No.	Total	Fatal No.	Fatal %	Critical No.	Critical %	Serious No.	Serious %	Minor No.	Minor %	None No.	None %
.15 - .19	2							2	100		
.20 - .24	13	2	15					6	46	5	38
.25 - .29	17	1	6			5	29	8	47	3	18
.30 - .34	19	3	16			4	21	9	47	3	16
.35 - .39	16	1	7			3	19	9	56	3	19
.40 - .44	20					2	10	12	60	6	30
.45 - .49	15	3	20			2	13	7	47	3	20
.50 - .54	13	1	8			1	8	9	69	2	15
.55 - .59	9	1	11			2	22	5	56	1	11
.60 - .64	8	1	13			2	25	4	50	1	13
.65 - .69	4							4	100		
.70 - .74	5	3	60					2	40		
.75 - .79	4	3	75			1	25				
.80 - .84	4					1	25	3	75		
.85 - .89	1							1	100		
.90 - .94	1					1	100				
.95 - .99	4	1	25			1	25	2	50		
TOTALS	155	20	13			25	16	83	54	27	17

Table 4 presents the injury to personnel according to mach number. The data indicate that mach number .70 is the beginning of critical zone for safe ejections with present equipment, for ejections above are more dangerous than those below this mach number. Thirty-seven percent of ejections above mach number .70 result in fatalities compared to 9 percent fatalities below .70. Over half (58%) of ejections made above mach .70 result in serious or fatal injuries, while about one-fifth (22%) end in fatal or serious injury below this mach number.

In Figure 6, the mean ejection speeds have been plotted for six-month periods for the past five years. No trend is apparent.

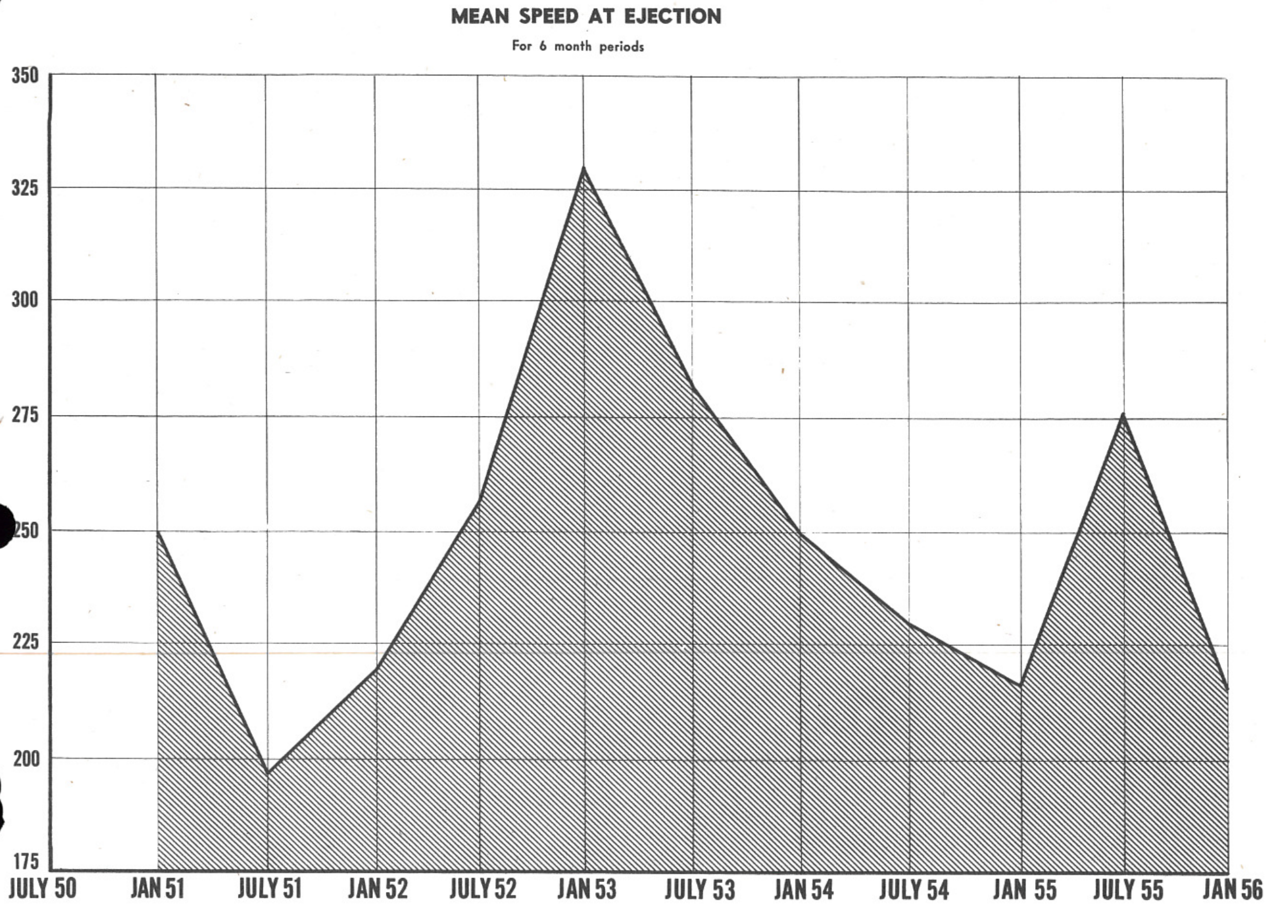


FIG 6

The bailout average speed is 157 knots, 97 knots slower than the mean ejection speed. The data presented in Table 5 indicates no relationship between speed and injuries within the range of speeds in which bailouts are made. A very high percentage of fatal bailouts (87 percent) occur at speeds less than 250 knots. There has been only one bailout reported at speeds greater than 400 knots; however, it is to be expected from the data concerning high-speed ejections that bailouts above 400 knots will follow the same trend that ejections have, i.e., an increasing fatality rate. A bailout at high speeds from the topside of a plane will probably be even more dangerous than ejections, for striking the fuselage is an added hazard in bailout procedures.

TABLE 5

TYPE OF INJURY RESULTING FROM BAILOUT ACCORDING TO SPEED

		Resulting Injury to Personnel									
		Fatal		Critical		Serious		Minor		None	
Speed	Total	No.	%	No.	%	No.	%	No.	%	No.	%
50 - 99	10			1	10	1	10	6	60	2	20
100 - 149	64	4	6	1	2	8	13	38	59	13	20
150 - 199	26	2	8			6	23	14	54	4	15
200 - 249	12	1	8			2	17	8	67	1	8
250 - 299	5					1	20	2	40	2	40
300 - 349	2					1	50			1	50
350 - 399											
400 - 449	1	1	100								
TOTALS	120	8	7	2	2	19	16	68	57	23	19

Model

TABLE 6

TYPE OF INJURY RESULTING FROM EJECTION ACCORDING TO MODEL

Resulting Injury to Personnel

Model	Total	Fatal No.	Fatal %	Critical No.	Critical %	Serious No.	Serious %	Minor No.	Minor %	None No.	None %
F2H	40	3	8			8	20	24	60	5	13
F3H	3					1	33	2	67		
F4D	1	1	100								
F7U	18	4	22	1	6	4	22	6	33	3	17
F8U	1							1	100		
F9F	107	29	27	1	1	14	13	50	47	13	12
FJ	17	1	6					8	47	8	47
A2D	1					1	100				
A4D	1	1	100								
TV	18	5	28			2	11	7	39	4	22
TOTALS	207	44	21	2	1	30	14	98	47	33	16

There are five models of planes from which at least 15 ejections have been made. These are the F9F, F2H, F7U, TV, and FJ with 107, 40, 18, 18 and 17 ejections respectively. The models, on the basis of fatalities, may be divided into a high fatality group and a low fatality group. The F9F with 27 percent fatalities, the F7U with 22 percent fatalities, and the TV with 28 percent fatalities compose the high group, while the F2H and FJ with 8 and 6 percent fatalities respectively form the low group. The difference of 19 percent between the highest of the low group (F2H) and the lowest of the high group (F7U) is not readily accounted for by chance. The difference of 19 percent could be obtained by chance in but 1 case out of 22. This data is contained in Table 6. It appears, from this data, that it is more dangerous to eject from some type aircraft than from others. (It is quite possible that the difference in hazards is due to factors other than the ejection system *per se.*)

The evolution of the F9F model aircraft from a straight-wing airplane to one with sweptwings affords an excellent opportunity to compare the injury groupings of a straight-wing aircraft with a sweptwing model under relatively controlled circumstances.

TABLE 7

TYPE OF INJURY RESULTING FROM EJECTION OF F9F-2, -4, -5 AND F9F-6, -7, -8, -9

Resulting Injury to Personnel

Model	Total	Fatal No.	Fatal %	Critical No.	Critical %	Serious No.	Serious %	Minor No.	Minor %	None No.	None %
F9F 2/4/5	53	14	26			7	13	29	55	3	6
F9F 6/7/8/9	54	15	28	1	2	7	13	21	39	10	19
TOTALS	107	29	27	1	1	14	13	50	47	13	12

Table 7 indicates that the record for the fatal and serious injury classifications of the two series of aircraft is nearly identical, and there is little difference between the "minor" and "none" categories. There is, therefore, no evidence from the only available data on the subject that there is any difference in the danger involved in ejecting from a straight-wing aircraft than from a sweptwing aircraft.

TABLE 8

TYPE OF INJURY RESULTING FROM BAILOUT ACCORDING TO MODEL

Resulting Injury to Personnel

Model	Total	Fatal No.	Fatal %	Critical No.	Critical %	Serious No.	Serious %	Minor No.	Minor %	None No.	None %
AD	39	4	10			6	15	24	62	5	13
AF	3					1	33	2	67		
AJ	1					1	100				
FG	3			1	33	1	33	1	33		
F2H	1					1	100				
F3D	4							3	75	1	25
F4U	13	3	23			5	38	4	31	1	7
F6F	9	1	11			1	11	6	67	1	11
F8F	7	2	29			2	29	3	43		
F9F	1							1	100		
AU	1							1	100		
JD	2	1	50					1	50		
SNJ	49	5	10	1	2	4	8	23	47	16	33
SNB	3									3	100
P5M	1					1	100				
R4Q	10	4	40					6	60		
TBM	7					1	14	4	57	2	29
T28	6					1	17	4	67	1	17
HUP2	2	1	50			1	50				
TOTALS	162	21	13	2	1	26	16	83	51	30	19

There are only three models of aircraft from which a sizable number of bailouts have been made. From SNJ's there have been 49, 39 from AD's, and 13 from F4U's. The fatality percentages taken from Table 8 are 10 percent AD's, 10 percent SNJ's, and 23 percent F4U's. The difference of 13 percent between the F4U and the other two plane models, AD and SNJ, is significant statistically and can not be accounted for by chance.

Injuries Sustained

TABLE 9

TYPE OF INJURY RESULTING FROM EJECTION ACCORDING TO PLACE SUSTAINED

Resulting Injury to Personnel

Where Sustained	Total	Fatal No.	Fatal %	Critical No.	Critical %	Serious No.	Serious %	Minor No.	Minor %
Landing	44	21	48			12	27	11	25
Landing — 'Chute	4					1	25	3	75
Landing — Cockpit	2					2	100		
Landing — Helmet	1							1	100
Landing — Force of Ejection	2							2	100
Drowning	5	5	100						
'Chute Shock	27					11	41	16	59
'Chute — Canopy	1							1	100
Force of Ejection	42					29	69	13	31
Cockpit	9					7	78	2	22
Canopy	3					1	33	2	67
TOTALS	140	26	19			63	45	51	36

The three major ways in which injuries are sustained during ejections are upon landing, by the forces involved in ejecting the seat and pilot, and by the shock produced by the opening parachute. Of these groups, the greatest number of injuries have been upon landing. There have been 44 of these, and they account for 31 percent of all accidents. If drownings, which are a type of landing accident, are combined with those recorded as "landing" accidents, this category accounts for 35 percent of all ejection injuries, and, of still greater importance, it accounts for 100 percent of all fatal accidents for which the cause is known.

The second highest group of injuries has been caused by the force of the ejection mechanism. The force necessary to eject the pilot caused 30 percent of ejection injuries. Fortunately there were no fatalities attributed to this source of injury. (A list of injuries resulting from the force of ejection is contained in Appendix I.)

The third most important cause of ejection injuries has been chute shock, which has accounted for 19 percent of injuries. Chute shock, also, did not result in any fatal injuries.

In many cases, a pilot's injuries have been the result of a combination of causes, e.g., the pilot may have sustained a portion of his injuries by striking the fuselage and accumulated additional injuries upon landing. The data in Table 9 shows that not only have 31 percent of ejection injuries been sustained upon landing, but that landing injuries have been involved in an additional 10 percent of the cases. That is, some injury has been sustained upon landing by 41 percent of all pilots ejecting from aircraft.

It is obvious that landing accidents, many of which are lack of altitude cases, involve the greatest degree of danger for ejecting pilots. It is evident also that the force involved in the actual ejection of the pilot and seat from the aircraft is potentially dangerous.

TABLE 10

TYPE OF INJURY RESULTING FROM BAILOUT ACCORDING TO WHERE SUSTAINED

Resulting Injury to Personnel

Where Sustained	Total	Fatal No.	Fatal %	Critical No.	Critical %	Serious No.	Serious %	Minor No.	Minor %
Landing	31	9	29	1	3	6	19	15	48
Landing — 'Chute	8							8	100
Landing — Cockpit	7	1	14	1	14	1	14	4	57
Landing — Fuselage	5	2	40			2	40	1	20
Drowning	2	2	100						
Cockpit	21	1	5			6	29	14	67
Cockpit — 'Chute	2					2	100		
Fuselage	15	1	7			3	20	11	73
Fuselage — 'Chute	4					2	50	2	50
'Chute Shock	18							18	100
'Chute — Canopy	1							1	100
Canopy	2	1	50					1	50
Helmet	1							1	100
TOTALS	117	17	15	2	1	22	19	76	65

Table 10 presents the data for bailouts for the locations at which injuries were sustained. Bailout injuries fall into four main groups:

upon landing, in cockpit, on fuselage and parachute shock.

The largest group of injuries has been sustained by bailout airmen upon landing, as they were in ejecting. There were 31 cases, or 26 percent of bailouts, in which the entire injury was sustained during landing, but some part of an injury was incurred during landing in 44 percent of all bailouts.

The next largest group of injuries was sustained in or on the cockpit. The cockpit was recorded as the sole cause of injury in 18 percent of the cases, but the cockpit was involved in some way in 26 percent of injuries.

The third major factor in causing injuries was the fuselage of the airplane. Twelve percent of all bailout injuries were sustained by the airman striking the fuselage, and, in addition, the fuselage was involved in another nine cases, making 26 percent in all.

Eighteen injuries were attributed to the opening shock of the parachute, all minor, but 'chute shock was reported being involved as an injury causal agent in 28 percent of all bailout accidents.

There is a wide variation in the patterns by which injuries have been sustained between ejections and bailouts. Whereas in ejections, all the fatal injuries were attributable to landing-drowning situations, the bailout fatalities were spread through the classifications of fuselage, landing-drowning, cockpit, canopy, and the combinations of cockpit-landing and fuselage-landing. Forty-six percent (not counting canopy) were received by the man bailing out on some part of the plane, while only 8 percent of ejection injuries were so sustained. In the elimination of fuselage accidents through the medium of the ejection seat mechanism, the force necessary to get the seat and pilot clear of the plane has replaced the fuselage as a major injury source, nevertheless no fatal injuries have been attributed to the ejection force itself. Another factor has been introduced inadvertently by the use of the ejection seat. This is the additional altitude that is necessary in order for the ejection to be successful.

Bailouts vs. Ejections

TABLE 11

TOTALS OF TYPES OF INJURIES RESULTING FROM EJECTIONS AND BAILOUTS

		Resulting Injury to Personnel									
		Fatal		Critical		Serious		Minor		None	
Type Accident	Total	No.	%	No.	%	No.	%	No.	%	No.	%
Ejections	207	44	21	2	1	30	14	98	47	33	16
Bailouts	162	21	13	2	1	26	16	83	51	30	19
TOTALS	369	65	18	4	1	56	15	181	49	63	18

Table 11 presents the respective injury classifications and their accompanying percentages of injuries for all bailouts and all ejections. The percentages of the various types of injuries show a persistent trend. The fatal injuries are greater for the ejections while the less serious injury percentages are from the bailouts. The largest percentage difference is the 8 percent difference in the fatal injury category. The data indicates that the ejection procedure has been more dangerous than the bailout method and a statistical check indicates that the differences obtained between the two procedures could be obtained but once in 10 times by chance.

The information as a whole indicates that one fatality will occur for every 4.7 ejections, while for bailouts the rate will be one fatality for every 7.7 bailouts. (The bailout rates for the Navy and the Air Force are nearly identical.)

It should be recognized that the ejection method of escaping from disabled aircraft is not inherently more dangerous than bailout procedures except in one respect, i.e., the inability to eject successfully at low altitudes. This inequality should yield to research in the future. Much of the danger of the ejection system is not part of the ejection mechanism and procedure *per se*, but is a function of the variables presented by the operation and design of high-performance aircraft.

TABLE 12

TYPE OF INJURY RESULTING FROM BAILOUTS BY TRAINED PARACHUTISTS

Resulting Injury to Personnel

Parachutist	Totals	Fatal No.	Fatal %	Major No.	Major %	Minor - None No.	Minor - None %
Parachute Rigger Trainees (Lakehurst, N. J.)	321	0	0	5	2	316	98
Naval Parachutist (Lakehurst, N. J.)	479	0	0	1	1	478	99
Army Parachutist (Fort Benning, Ga.)	19,151	0	0	5	1	19,146	99
Naval Parachutist (El Centro, Calif.)	1,150	0	0	2	1	1,148	99
TOTALS	21,101	0	0	13	1	21,088	99

Table 12 is a list of injuries from accidents occurring among the various trained parachute groups. The striking thing about the data is that there are no fatalities recorded among these groups out of 22,101 jumps and, further, there have been only 13 serious injuries reported. This data has been placed in Table 13 and compared with the data gathered from Navy operational bailouts. The data of both groups have been condensed into a 2 X 2 Table for statistical treatment by the chi square technique. The results indicate that the difference in injury frequencies between the trained and untrained jumpers could not be expected reasonably to occur by chance and, indicates that the difference must be due to the systematic action of certain variables.

TABLE 13

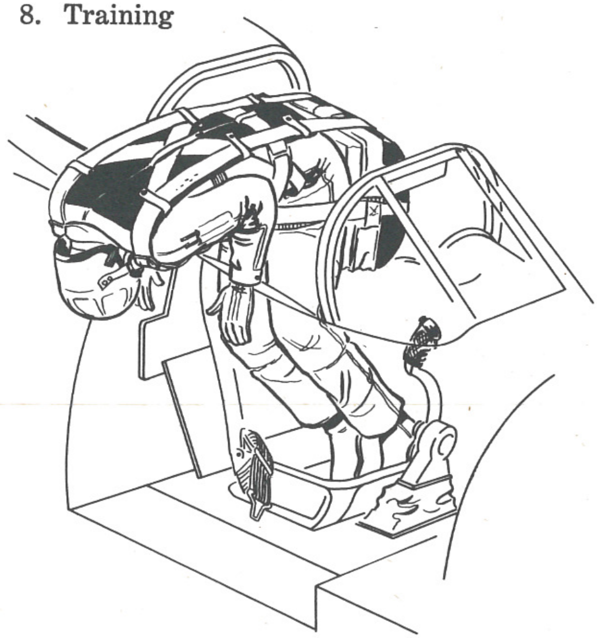
INJURY COMPARISON OF THE NAVAL NO-TRAINING GROUP WITH TRAINED PARACHUTIST GROUP

Injury to Personnel

Group	Fatal - Major	Minor - None	Totals
Trained Parachutists	13	21,088	21,101
No-Training Parachutists	49	113	162
TOTALS	62	21,201	21,263

The major known variables that determine injury frequencies upon bailout are:

1. Model of aircraft
2. Altitude
3. Wind speed
4. Equipment
5. Speed
6. Attitude
7. Terrain
8. Training

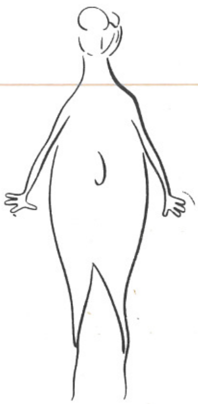


By using two groups in which all of these variables are equated but one, training, it would be possible to make a shrewd estimate of the effect of lack of training on injuries of this training variable.

This equating was achieved by comparing a trained group (parachute rigger trainees who have had training but no previous jumps) and an untrained group (men who have made a bailout but have had no training). This latter selection included particular type accidents from the operational bailouts.

The preceding variables are controlled in the Parachute Rigger Trainee group by various means. By the use of large transport type planes with side doors for jumpers, the danger of getting free of the plane that is present in certain models is avoided . The variable of altitude is not a factor in the jumping done by these trainees, for all jumps are made above the dangerous minimum. Weather conditions are carefully controlled, and jumping is done only when winds are less than 12 knots and the weather is clear. The terrain is usually a flat, unwooded plane, but jumpers often land in trees and rough terrain. No special equipment is used by the trainees other than that used in regular operations. Of the other variables, speed and attitude, speed of the plane at which bailouts are made by trained jumpers is moderate and attitude is always straight and level.

In the operational bailout group, the danger of escape from particular models was controlled by eliminating from the group all injuries except those incurred on landing, by



the parachute equipment, or by a combination of these two. The variable of altitude was controlled also by this method, i.e., the elimination of all low-altitude bailouts. The variables of speed and attitude were controlled by choosing only those cases that jumped free and clear of the plane. Parachute Rigger trainees jump only when the wind is 12 knots or less. The average ground speed wind for the operational bailouts was 8.5 knots. The terrain upon which both groups parachuted, while not as rigorously controlled as the other variables, presents no striking differences.

A comparison of the injuries resulting from bailout accidents among the Parachute Rigger Trainees, the trained group, vs. the selected operational bailouts, the untrained group, is presented in Table 14. A statistical comparison indicates that the differences in the number of injuries between the two groups is far beyond that which could be accounted for by chance. (chi square=26.9272).

TABLE 14

INJURY COMPARISON OF THE NAVAL NO-TRAINING GROUP (Landing and Parachute Injuries Only) WITH NAVAL PARACHUTE RIGGER TRAINEES

	Injury to Personnel		
Group	Fatal - Major	Minor - None	Totals
Parachute Rigger Trainees	6	315	321
Naval No-Training	13	71	84
TOTALS	19	386	405

The very large chi square value leaves no room for doubt that training in the proper bailout techniques is one systematic variable that is a major cause of the difference in injuries between the two groups, and that training in the proper techniques would reduce injuries significantly among the operational bailouts.

APPENDIX I

Injuries Attributed to Ejection Force

INJURY WHOLLY OR PARTIALLY INVOLVING THE BACK

Fractured coccyx (tail bone)
Contusions over coccyx (bruised tail bone)
Sprained back
Neck strain
Cervical-dorsal spine strain (upper back strain)
Moderate contusion (bruises) over tenth vertebrae (back), sprain both knees
Slight stiffness in lumbodorsal spine, shoulder girdles (blades) and neck
Spine sprain, abrasion left leg
Moderate bruises at base of spine
Contusions (bruises) and strains of back and sacro-coccygeal (tail) region
Mild sprain of muscles of cervical spinal group (back) and severe contusion (bruise) and sprain in region of coccyx (tail bone)
Moderate strain paraspinal musculature and ligaments in vicinity of T 8-9 (strained back)
Fracture vertebrae (back)
Fracture thoracic vertebrae (back)
Contusion neck and laceration of neck and arm
Compression fracture of eighth thoracic vertebrae (back)
Pain in coccygeal region (tail bone)
Strain lumbosacral (back)
Mild dorsal and lumbar back strain
Anterior displacement coccyx (tail bone)

OTHER INJURIES

Contusions of buttocks, sprains both ankles
Fracture of femur (thigh)
Contusions knees
Small hematoma (hemorrhage) of left calf and left foot, superficial abrasion
Contusion lower legs
Mild contusion thighs
Muscular strain both buttocks and left upper thigh
Dislocation right shoulder, simple
Chip fracture right elbow

APPENDIX II

TYPE OF INJURY RESULTING FROM EJECTION ACCORDING TO "Q"

Resulting Injury to Personnel

"Q"	Total	Fatal No.	Fatal %	Critical No.	Critical %	Serious No.	Serious %	Minor No.	Minor %	None No.	None %
25 - 84	27	2	7			4	15	12	44	9	33
85 - 144	32	4	12			7	22	16	50	5	16
145 - 204	24	2	8			3	13	13	54	6	25
205 - 264	16	2	12			2	12	11	69	1	6
265 - 324	13	1	8			1	8	8	61	3	23
325 - 384	9	1	11			2	22	5	56	1	11
385 - 444	7	1	14			1	14	5	71		
445 - 504	5	1	20					4	80		
505 - 664	9	1	11			1	11	5	56	2	22
665 - 724	5	3	60			1	20	1	20		
725 - 884	2	1	50			1	50				
885 - 944	1					1	100				
945 - 1004											
1005 - 1064	1							1	100		
1065 - 1124											
1125 - 1184	1							1	100		
1185 - 1244	1					1	100				
1245 - 1304	1	1	100								
1305 - 1364	1							1	100		
TOTALS	155	20	13			25	16	83	54	27	17

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