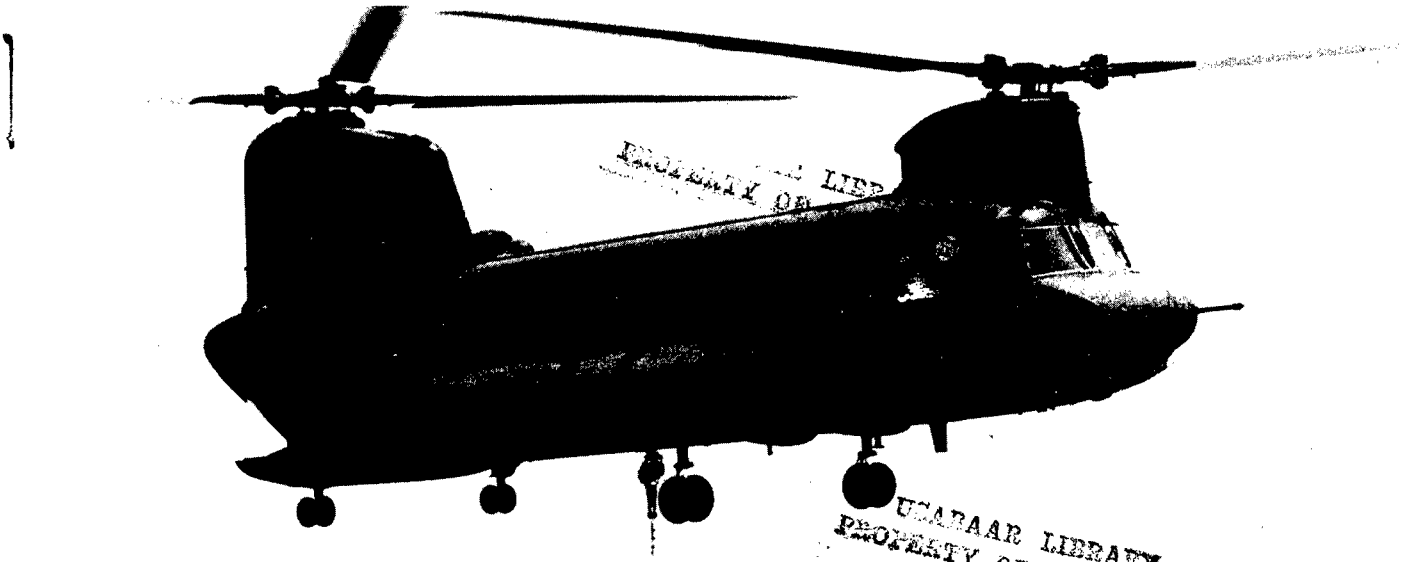
RUTARY WING SORTIE STUDY

BY PHASE OF OPERATION FOR FY 69



THE UNITED STATES ARMY BOARD FOR AVIATION ACCIDENT RESEARCH
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INTRODUCTION

This study represents a different approach in analyzing Army aircraft accidents to determine specific causes and the degree of occurrence in order that accident prevention measures may be applied more directly to the area of training and operations that produce the most accidents. It is developed around the sortie divided into phases and subphases to illustrate varying degrees of accident occurrence in helicopter operations and the points of highest exposure. The accident rate based on the sortie is not designed to replace the accident rate based on flying hours but rather is intended as an aid to the commander and aviator in effective aviation resource management and subsequent accident prevention. The approach used in this study is not entirely new since the sortie has been used as an index to combat exposure in describing the vulnerability of the helicopter in combat and has similar value in determining the hazard exposure that results in accidents.

The sortie study is only one of many possible approaches in developing methods of analyzing aircraft accidents. It opens the door to virtually unlimited in-depth research and studies to reduce the complex interrelated elements of an accident to manageable proportions. As a follow-on to this study, each phase will be separately studied in depth and reports of findings and conclusions published as the individual study phase is completed.

USABAAR solicits your comments on this study. AR 15-76 provides for direct communication with USABAAR by personnel in the field on matters pertaining to aviation safety. Request you send comments to:

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SORTIE STUDY

Problem: Computation of aircraft accident rates based on the number of accidents per 100,000 flying hours does not provide a realistic Army operations related accident exposure index. Consequently, the present rate system does not indicate the flight phase of maximum exposure to accident producing situations and is inadequate as a management tool for the conservation of aircraft resources.

Objective: To examine the sortie profile of rotary wing aircraft to determine the feasibility of:

a. Identifying the phase of operation in which the accident occurs.

b. Isolating the major causes of the accident in the various phases of operation.

c. Developing an accident rate system based on the maximum exposure situation, i.e. sortie.

d. Using the sortie exposure as a more effective tool of command management.

Scope: This study encompasses the US Army's rotary wing aircraft inventory and the accidents experienced during FY 69 with a comparison of fixed wing accident experience during FY 69.

General:

1. Successful mission completion has been the motto of each Army aviator, and in turn, is expected by each supported commander. In many instances missions are not completed because of some unplanned event which occurs between mission receipt and mission completion. The reasons for non-mission completion are many, but normally have to do with aircraft difficulties which lead to precautionary and forced landings, without damage, to emergency situations culminating in total aircraft destruction and possible loss of life. Regardless of mission completion or non-completion, a degree of exposure to accident producing situations is present. This degree of exposure must be considered when attempting to isolate and compare statistics used in the compilation of rates. When attempting to measure exposure, several factors must be taken into consideration: type mission, mission difficulty, aircraft complexity, terrain, aviator proficiency, cumulative flying hours, meteorological conditions and most important phase of flight.

2. The exposure to accident producing situations while an aviator is performing numerous takeoffs and landings in one hour is far

greater than the exposure experienced by an aviator flying cross country with one takeoff and landing during the same period of time. This degree of exposure must be considered in formulating rates. This study reveals the degree of exposure present in any given flight by breaking the flight down into sorties.

3. Sortie Definitions:

a. Rotary wing - a takeoff and landing, by one aircraft, in which flight out of ground effect is conducted.

b. Fixed wing - a takeoff and landing by one aircraft.

c. Attempted sortie - a takeoff with the intent to complete a sortie which does not terminate in a safe landing.

4. A comparison of fixed and rotary wing accident rates based upon 100,000 hours and 100,000 sorties along with detailed phases of operation (fixed and rotary wing) are contained at Annex A.

5. The sortie profile breaks a sortie into eight phases of operation, with some phases being sub-divided into sub-phases. The phases of a sortie are shown at Annex B.

6. An explanation of type accidents during each phase of a sortie is contained at Annex C.

7. "Pre/Post sortie" containing the static and repositioning phases of operation is a ground environment. "During sortie" containing the flight out of ground effect phases of operation is an air environment. This is depicted in a two-sortie mission profile at Annex D.

8. The statistical information shown at Annex B has been further isolated and plotted on a sortie graph shown at Annex E to graphically portray the accident experience in each phase of a sortie.

9. During FY 69, there was a total of 1045 Rotary Wing accidents which occurred during some phase of a sortie. These accidents have been broken down into "Pre/Post" sortie data and "During" sortie data. A rate, based on 100,000 sorties, has been determined for both Pre/Post and During sortie data, Annex F.

10. To further isolate each phase of a sortie and show the number of accidents occurring in each, to include cause factors involved, a profile by phase has been depicted at Annex G. By further sub-dividing the phases into sub-phases with their corresponding accident experience, the sub-phases with higher accident potential are readily apparent.

11. The rotary wing accident rate based on flying hours since fiscal year 1965 has been FY 65 -22.0, 66 -21.4, 67 -23.4, 68 -20.4, and 69 -20.8.

FINDINGS

1. In the past five fiscal years there has been no significant reduction in rotary wing accident rates.

2. When sorties are broken down into phases and sub-phases of operation, accident cause factors can be directly related to specific phases and accident prevention measures directed toward the source problems and high exposure phases.

3. A more realistic index of accident experience is obtained when accident rates are based on 100,000 sorties rather than 100,000 flying hours.

4. During the pre-post sortie phases of operation "other personnel" cause factor is involved in 18.4% of the total accidents and facilities contribute to 20.8% of the total accidents.

5. During THE TAKEOFF phase 35% of the accidents were attributed to attempted takeoffs over a barrier or out of a confined area from a hover.

6. During the autorotation phase 362 out of the total 408 accidents occurred during the landing roll/touchdown portion of the autorotation.

7. Flight in the low level environment, contour and low level flight, produced one third of the accidents in the in-flight phase of operation.

8. Command supervision cause factor was present in 26.3% of all accidents and 34.4% of the accidents in a ground environment (static and repositioning phases of operation).

9. Crew error is a cause factor in 95% of the accidents in simulated emergency autorotation.

CONCLUSIONS

1. New approaches, techniques and methods of aircraft accident prevention must be employed in order to effect any further substantial reduction in rotary wing accident rates.

2. Isolating major cause factor in specific phases of operation and identifying the high exposure phases will provide a more effective accident prevention management tool for the commanders.

3. An accident rate based upon 100,000 sorties provide a realistic Army operations related accident exposure index based on the maximum exposure situation, i.e. sortie.

4. The ground environment phases provide the most fertile areas for reduction of accidents which can be substantially reduced by command emphasis in the areas of:

a. Improved facilities

b. Education of "other personnel"

c. Command supervision to assure strict compliance with established regulations and procedures.

5. Pilots are attempting takeoffs over barriers and out of confined areas without sufficient power reserve and without regard for established procedures, i.e. go-no-go procedure, UH-1.

6. The high accident exposure sub-phase of the autorotation phase is the landing roll/touchdown. The major cause factors are a combination of poor pilot technique (high airspeed, high sink rate, low rotor RPM) and environmental factors (high density altitude, rough terrain).

7. The low level environment is the single biggest offender in the inflight phase and produces a disproportionate amount of accidents in relation to the percentage of flight time accomplished at low level as compared to the total inflight time.

8. Command supervision cause factor is present in far too many accidents particularly in the ground environment. A reversal of this trend could materially reduce the ground environment accidents which are by and large preventable.

9. Although crew error is present in 95% of the simulated emergency autorotation accidents there are a significant number of other cause factors present, as shown at Annex G.

RECOMMENDATIONS:

1. That accident rates based upon 100,000 sortie be computed to provide an Army operations related accident exposure index.

2. That this study be disseminated to the field as an initial effort in assisting commanders in recognizing the phases of operation with the greatest accident potential and related cause factors so that corrective measures can be directed toward reducing specific types of accidents.

4. That in-depth studies be conducted in the following areas:

a. Landing roll/touchdown sub-phase of the autorotation phase to determine just how much influence cause factors such as training, standardization, command supervision, facilities, and design have in inducing the high incident of crew error in accidents occurring in the sub-phase.

b. Simulated emergency autorotation to determine what can be accomplished in selection of Instructor Pilots, standardization and training to create an awareness of environmental factors to reduce the number of these preventable accidents.

c. Low level accidents to determine if this environment is really as hazardous as the data would indicate, or that low level flights are not being conducted in accordance with established procedures (i.e. preflight planning, map recon.) engaged in when not required by the mission or weather and flown over poorly selected terrain that offers low probability of completing a successful autorotation in the event of a failure or malfunction.

ANNEX A

Comparison of rotary and fixed wing sortie data.

1. Rotary wing FY 69 data.

   a. Flying hours - 5,038,325

   b. Rate per 100,000 hours - 20.8

   c. Number of Sorties - 17,198,643

   d. Rate per 100,000 Sorties - 6.1

   e. Average of 17½ minutes between landing and takeoff

2. Fixed wing FY 69 data

   a. Flying hours - 1,062,264

   b. Rate per 100,000 hours - 10.3

   c. Number of Sorties - 1,451,664

   d. Rate per 100,000 Sorties - 7.5

   e. Average of 44 minutes between landing and takeoff

3. Rotary Wing phases of operation

   a. Static

   b. Repositioning

   c. Hover out of ground effect

   d. Takeoff

   e. In-flight (cruise)

   f. Autorotation

   g. Landing

   h. Go-around

4. Fixed wing phases of operation

   a. Static

   b. Ground taxi

   c. Takeoff

   d. In-flight (cruise)

   e. Landing

   f. Go-around

ANNEX B

ROTARY WING ACCIDENT
EXPERIENCE FOR FY 69 BY PHASE OF SORTIE

PHASE NUMBER	PHASE AND SUB-PHASE		NUMBER OF ACCIDENTS IN PHASE	CUMULATIVE TOTAL	PERCENT OF TOTAL
1	Static		40	40	3.8
2	Repositioning		172	212	16.5
	A. Ground Taxi	6			
	B. Hover Taxi	26			
	C. Hover Autorotation	25			
	D. Landing from a hover	59			
	E. Takeoff to a hover	56			
3	Hover out of ground effect		21	233	2.0
4	Takeoff		92	325	8.8
5	Inflight (Cruise)		114	439	10.9
6	Autorotation		408	847	39.0
	A. Emergency	287			
	B. Simulated	120			
	C. Unknown	1			
7	Landing		188	1035	18.0
8	Go around		5	1040	0.5
	Phase Undetermined		5	1045	0.5
					100.0

ANNEX C

EXPLANATIONS

STATIC

Any accident that happens after engine(s) have been started with an intent to fly and the aircraft is static such as:

1. Accidents while loading or unloading cargo/troops with the engine(s) running.

2. Accidents during hot refueling.

3. Accidents that occur because of a collision between an aircraft and a vehicle while the aircraft is static with engine(s) running and rotor(s) turning.

REPOSITIONING

Any accident that happens while repositioning an aircraft prior to takeoff or after landing such as:

1. Accidents that occur from striking an object with aircraft fuselage or rotor(s).

2. Accidents that occur because of an actual or simulated emergency while hovering in ground effect that would necessitate an immediate landing.

3. Accidents that occur because of a collision between aircraft.

HOVER OUT OF GROUND EFFECT

Any accident that occurs while the aircraft is hovering out of ground effect such as:

1. Accidents that occur while aircraft is hovering out of ground effect on a repelling, slingload or rescue mission.

TAKEOFF

Any accident that occurs after cyclic and/or collective have been applied to commence takeoff until cruise flight is established such as:

1. Accidents caused by striking a barrier or obstacle during takeoff or climbout.

2. Mid-airs during takeoff or climbout.

INFLIGHT (CRUISE)

Any accident that occurs after the takeoff phase is completed and before the landing phase is commenced such as:

1. Accidents that are caused from striking an object in contour or low level flight.

2. Mid-airs in flight.

AUTOROTATION

Any accident that occurs during an autorotation that is initiated because of an emergency, simulated, or actual, that requires an immediate autorotative landing while the aircraft is in a takeoff, inflight, landing, or go-around phase of operation such as:

1. Engine failure.

2. Any other material failure or malfunction severe enough to preclude the aircraft from being flown to an airfield or other suitable area for landing.

LANDING

Any accident that occurs between the time the aircraft begins a descent from cruise flight until it is at a hover in ground effect, or the landing gear is in contact with the landing surface and any landing roll or slide has been stopped such as:

1. Accidents that are caused by the aircraft striking a barrier or obstacle during an approach or descent.

2. Mid-airs during landing.

GO-AROUND

Any accident that occurs once the pilot has abandoned the approach until another landing is initiated or the aircraft is in cruise flight such as:

1. Accidents caused by the aircraft striking an obstacle during go-around.

2. Mid-airs during go-around.

ANNEX D

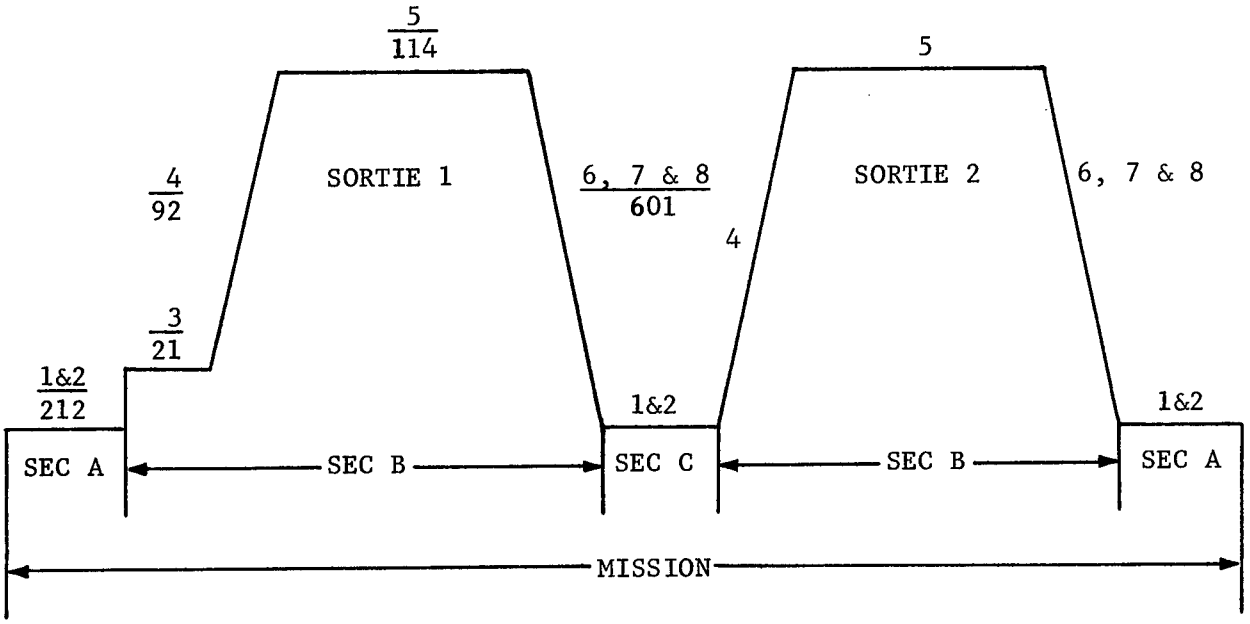
TWO SORTIE MISSION PROFILE

PHASES OF OPERATION
1. STATIC
2. REPOSITIONING
3. HOVER OUT OF GROUND EFFECT
4. TAKEOFF
5. IN-FLIGHT (cruise)
6. AUTOROTATION
7. LANDING
8. GO-AROUND

SECTION A - PRE/POST SORTIE
SECTION B - FLIGHT OUT OF GROUND EFFECT PORTION OF SORTIE
SECTION C - TURN AROUND BETWEEN SORTIES INCLUDE POST-SORTIE AND PRE-SORTIE ACTIVITY

LEGEND

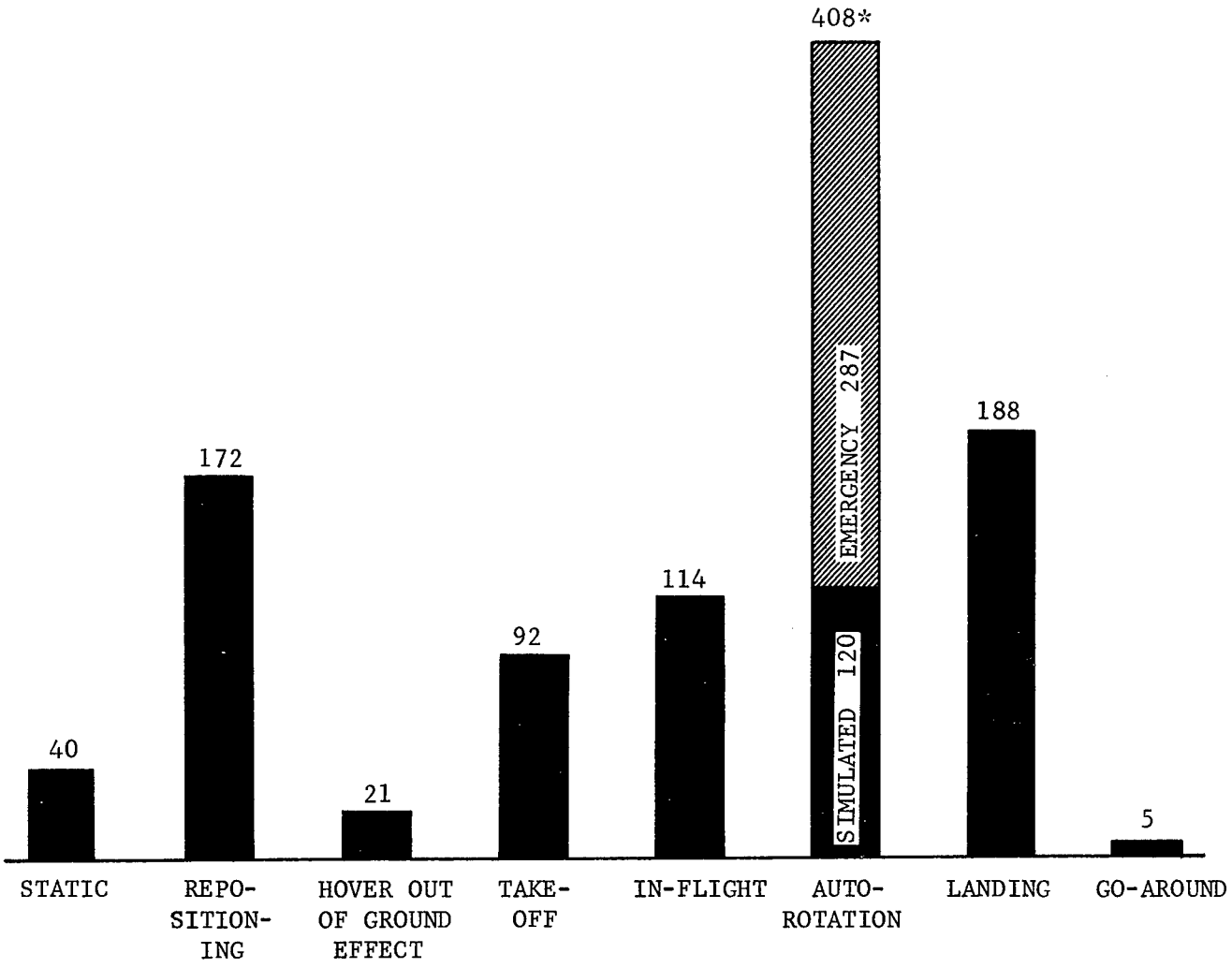
PHASE / Accidents 3/21 Example



NOTE: Graphic profile of a two sortie mission. Each sortie is independent of the other and stands alone.

ANNEX E

FY 69 ACCIDENTS BY PHASE OF OPERATION



Total Accidents 1045
Phase of Operation Undetermined
in 5 Accidents

*Includes 1 accident sub-phase unknown

ANNEX F

ROTARY WING PRE AND POST SORTIE
FY 69

No. of Landings: 17,198,643

Sortie Rate: 6.1
Pre/Post Sortie Rate: 1.3

CODE	PHASE OF OPERATION		NO. OF ACCIDENTS
1	Static		40
2	Repositioning		172
	A. Ground Taxi	(6)	
	B. Hover Taxi	(26)	
	C. Hover Autorotation	(25)	
	D. Landing From a Hover	(59)	
	E. Takeoff To a Hover	(56)	
	TOTAL		212

Pre-Sortie - After engine(s) has been started and rotor(s) are turning until cyclic and/or collective have been applied to commence takeoff.

Post Sortie - When landing phase has been terminated to a hover in ground effect or landing gear is in contact with the landing surface until engine(s) and rotor(s) are stopped.

ROTARY WING DURING SORTIE
FY 69

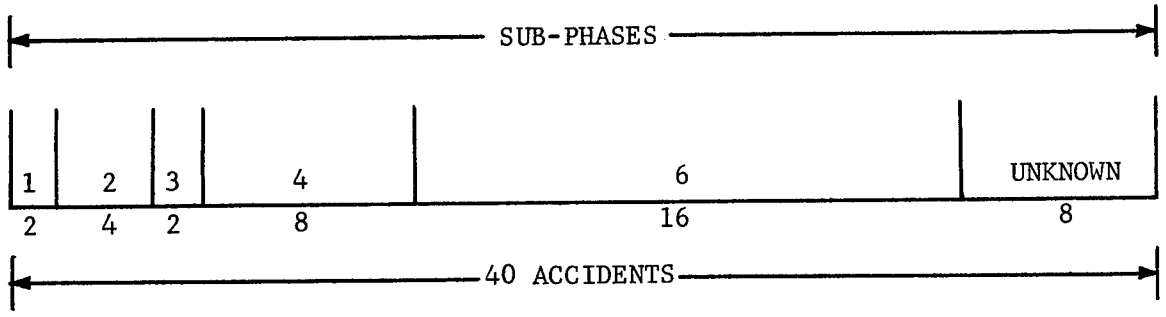
No. of Landings: 17, 198, 643

Sortie Rate: 6.1
During Sortie Rate: 4.8

CODE	PHASE OF OPERATION		NO. OF ACCIDENTS
3	Hover Out of Ground Effect		21
4	Takeoff		92
5	Inflight		114
6	Autorotation		408
	A. Emergency	(287)	
	B. Simulated	(120)	
	C. Unknown	(1)	
7	Landing		188
8	Go-around		5
9	Undetermined		5
	TOTAL		833

Sortie - From the time cyclic and/or collective have been applied to commence takeoff until landing phase is complete and aircraft is at a hover, in ground effect, or landing gear is in contact with landing surface.

ANNEX G
STATIC PHASE FY 69 (R/W)



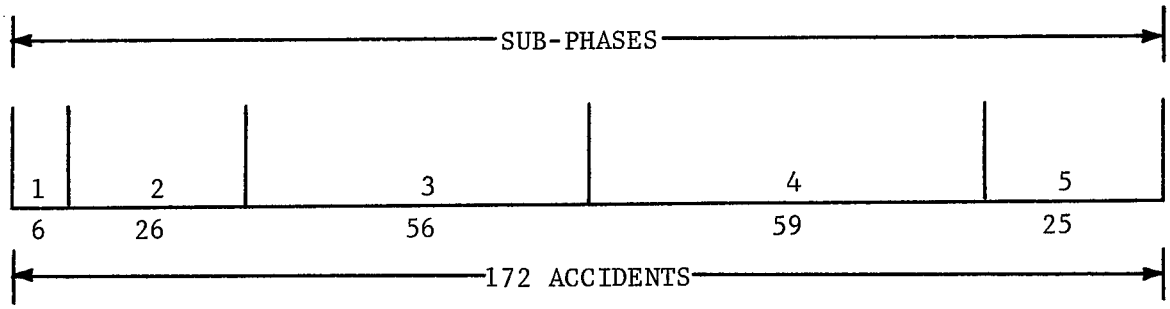
STATIC PHASE STATISTICS

SUB-PHASE NUMBER	SUB-PHASES OF OPERATION	NO. OF ACDTS	PERCENT OF TOTAL ACDTS
1	Starting engine(s)	2	5.0
2	Prior to leaving parking area engine(s) running	4	10.0
3	Prior to takeoff after leaving parking area	2	5.0
4	After completion of sortie, prior to final parking	8	20.0
5	After completion of sortie, after final parking	0	0
6	During interim between sorties when engine(s) has not been stopped	16	40.0
	Sub-Phase Unknown	8	20.0
	TOTALS	40	100.0

REPORTED CAUSE FACTORS	NO.	PERCENT OF TOTAL CAUSE FACTORS
Crew Error	20	26.7
Other Personnel	20	26.7
Training	1	1.3
Command Supervision	11	14.6
Material FL/MAL	2	2.7
Maintenance	1	1.3
Design	1	1.3
Facilities	12	16.0
Weather	5	6.7
Psychological/ Physiological	2	2.7
	75	100.0

NOTE: A total of 75 established, suspected and contributing cause factors were present in the 40 accidents experienced during the Static phase of sortie performance.

RE-POSITIONING PHASE FY 69 (R/W)



RE-POSITIONING PHASE STATISTICS

SUB-PHASE NUMBER	SUB-PHASES OF OPERATION	NO.OF ACDTS	PERCENT OF TOTAL ACCIDENTS
1	Ground Taxi	6	3.5
2	Hover Taxi	26	15.1
3	Takeoff to a Hover	56	32.6
4	Landing from a Hover	59	34.3
5	Hovering Auto-rotation	25	14.5
	TOTALS	172	100.0

REPORTED CAUSE FACTORS	NO.	PERCENT OF TOTAL CAUSE FACTORS
Crew Error	150	39.0
Other Personnel	19	4.9
Training	20	5.0
Command Supervision	62	16.2
Material FL/MAL	35	9.1
Maintenance	10	2.6
Design	4	1.0
Facilities	32	8.3
Weather	25	6.9
Psychological/ Physiological	27	7.0
	384	100.0

NOTE: A total of 384 established, suspected and contributing cause factors were present in the 172 accidents experienced during the re-positioning phase of sortie performance.

HOVER OUT OF GROUND EFFECT

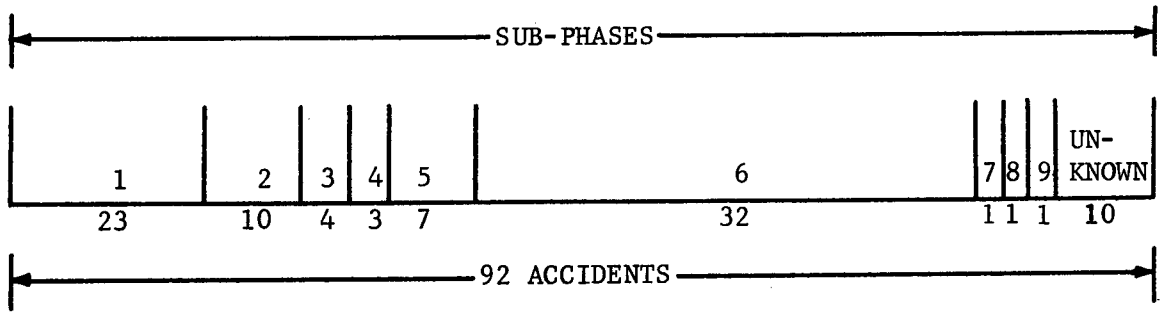
NO SUB-PHASE

HOVER OUT OF GROUND EFFECT STATISTICS

SUB-PHASE NUMBER	SUB-PHASE OF OPERATION	NO. OF ACCIDENTS	REPORTED CAUSE FACTORS	NO.	PERCENT TOTAL CAUSE FACTORS
NO SUB-PHASE OF OPERATION		21	Crew Error	20	44.4
			Other Personnel	1	2.2
			Training	2	4.5
			Command Supervision	6	13.3
			Material FL/MAL	2	4.5
			Maintenance	1	2.2
			Design	0	0
			Facilities	6	13.3
			Weather	4	8.9
			Psychological/ Physiological	3	6.7
	TOTALS	21		45	100.0

NOTE: A total of 45 established, suspected and contributing cause factors were present in the 21 accidents experienced during the Hover Out of Ground Effect phase of sortie performance.

TAKEOFF PHASE FY 69 (R/W)



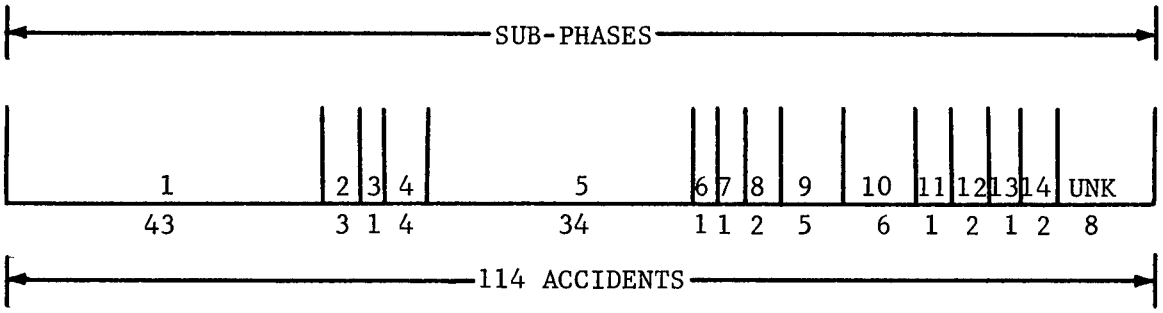
TAKEOFF PHASE STATISTICS

SUB-PHASE NUMBER	SUB-PHASES OF OPERATION	NO. OF ACDTS	PERCENT OF TOTAL ACCIDENTS
1	Climb	23	24.7
2	Climb (Over Barrier or from a confined area)	10	10.8
3	Climb (Over water)	4	4.3
4	Climb (In formation)	3	3.2
5	From a Hover	7	7.5
6	From a Hover (Over a Barrier or from a confined area)	32	34.4
7	From a Hover (Over water)	1	1.1
8	Actual Instruments	1	1.1
9	Run (Over a Barrier)	1	1.1
	Sub-Phase Unknown	10	10.8
	TOTALS	92	100.0

REPORTED CAUSE FACTORS	NO.	PERCENT OF TOTAL CAUSE FACTORS
Crew Error	75	36.2
Command Supervision	33	16.0
Other Personnel	5	2.4
Facilities	16	7.8
Weather	12	5.8
Training	9	4.3
Material FL/MAL	27	13.0
Design	1	0.5
Maintenance	9	4.3
Psychological/ Physiological	20	9.7
	207	100.0

NOTE: A total of 207 established, suspected and contributing cause factors were present in the 92 accidents experienced during the Takeoff phase of sortie performance.

INFLIGHT PHASE FY 69 (R/W)



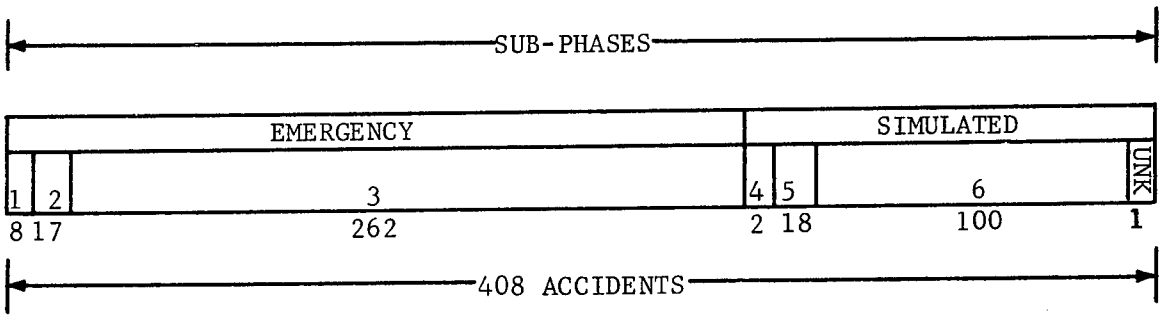
INFLIGHT PHASE STATISTICS

SUB-PHASE NUMBER	SUB-PHASES OF OPERATION	NO. OF ACDTS	PERCENT OF TOTAL ACCIDENTS
1	Normal	43	37.7
2	Break	3	2.7
3	Holding	1	0.9
4	Contour	4	3.4
5	Low Level	34	29.9
6	Unusual Attitude	1	0.9
7	Acrobatics	1	0.9
8	Search and Rescue	2	1.8
9	Strafing Run	5	4.4
10	Armed Recon	6	5.2
11	Evasive Action	1	0.9
12	Formation Normal	2	1.8
13	Formation Turning	1	0.9
14	Formation Break	2	1.8
	Sub-Phase Unknown	8	6.8
	TOTALS	114	100.0

REPORTED CAUSE FACTORS	NO.	PERCENT OF TOTAL CAUSE FACTORS
Crew Error	93	36.9
Other Personnel	7	2.8
Training	9	3.6
Command Supervision	24	9.5
Material Fl/MAL	31	12.3
Maintenance	9	3.6
Design	7	2.8
Facilities	4	1.6
Weather	28	11.1
Psychological/ Physiological	40	15.8
	252	100.0

NOTE: A total of 252 established, suspected and contributing cause factors were present in the 114 accidents experienced during the Inflight phase of sortie performance.

AUTOROTATION PHASE FY 69 (R/W)



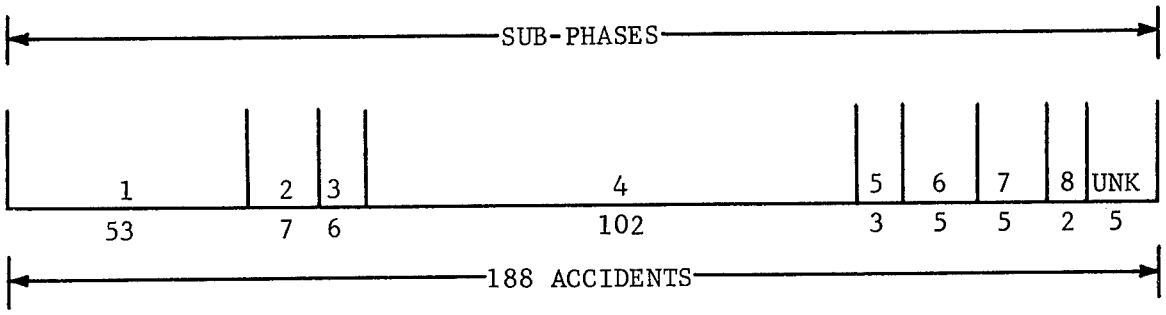
AUTOROTATION PHASE STATISTICS

SUB-PHASE NUMBER	SUB-PHASES OF OPERATION	NO. OF ACDTS	PERCENT OF TOTAL ACCIDENTS
1	Emergency Descent	8	2.0
2	Emergency Flare	17	4.1
3	Emergency Landing Roll/Touchdown	262	64.2
4	Simulated Emergency Descent	2	0.5
5	Simulated Emergency Flare	18	4.4
6	Simulated Emergency Landing roll/touchdown	100	24.5
	Sub-Phase Unknown	1	0.3
	TOTALS	408	100.0

REPORTED CAUSE FACTORS	NO.	PERCENT OF TOTAL CAUSE FACTORS
Emergency Autorotation Phase		
Crew Error	188	31.2
Other Personnel	6	1.0
Training	18	3.0
Command Supervision	58	9.6
Material FL/MAL	230	38.1
Maintenance	48	8.0
Design	5	0.8
Facilities	16	2.7
Weather	12	2.0
Psychological/ Physiological	22	3.6
TOTALS	603	100.0
Simulated Autorotation Phase		
Crew Error	115	57.2
Other Personnel	1	0.5
Training	9	4.5
Command Supervision	24	11.9
Material FL/MAL	14	7.0
Maintenance	4	2.0
Design	1	0.5
Facilities	9	4.5
Weather	10	4.9
Psychological/ Physiological	14	7.0
TOTALS	201	100.0

NOTE: A total of 804 established, suspected and contributing cause factors were present in the 408 accidents experienced during the Autorotation phase of sortie performance.

LANDING PHASE FY 69 (R/W)



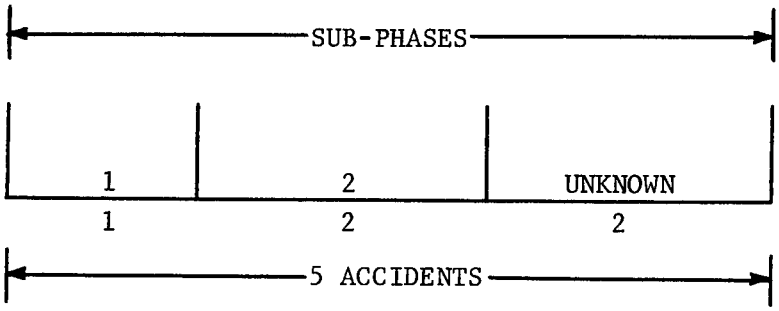
LANDING PHASE STATISTICS

SUB-PHASE NUMBER	SUB-PHASES OF OPERATION	NO. OF ACDTS	PERCENT OF TOTAL ACCIDENTS
1	Approach	53	28.2
2	Approach (Over Barrier)	7	3.7
3	Approach (Pinnacle)	6	3.2
4	Flare	102	54.2
5	Flare (Slope Landing)	3	1.6
6	Flare (Pinnacle)	5	2.7
7	Flare (Formation)	5	2.7
8	Roll/Slide	2	1.0
	Sub-Phase Unknown	5	2.7
	TOTALS	188	100.0

REPORTED CAUSE FACTORS	NO.	PERCENT OF TOTAL CAUSE FACTORS
Crew Error	149	38.1
Other Personnel	12	3.1
Training	17	4.4
Command Supervision	54	13.8
Material FL/MAL	66	16.9
Maintenance	22	5.6
Design	6	1.5
Facilities	18	4.6
Weather	27	6.9
Psychological/	20	5.1
	391	100.0

NOTE: A total of 391 established, suspected and contributing cause factors were present in the 188 accidents experienced during the Landing phase of sortie performance.

GO-AROUND PHASE FY 69 (R/W)



GO-AROUND PHASE STATISTICS

SUB-PHASE NUMBER	SUB-PHASES OF OPERATION	NO. OF ACDTS	PERCENT OF TOTAL ACCIDENTS
1	Overshot intended touchdown area Pinnacle	1	20.0
2	From simulated forced landing	2	40.0
	Sub-Phase Unknown	2	40.0
	TOTALS	5	100.0

REPORTED CAUSE FACTORS	NO.	PERCENT OF TOTAL CAUSE FACTORS
Crew Error	5	31.2
Other Personnel	0	0
Training	0	0
Command Supervision	3	18.8
Material FL/MAL	0	0
Maintenance	0	0
Design	0	0
Facilities	2	12.5
Weather	2	12.5
Psychological/ Physiological	4	25.0
	16	100.0

NOTE: A total of 16 established, suspected and contributing cause factors were present in the 5 accidents experienced during the Go-Around phase of sortie performance.

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