AD NUMBER
AD516871
CLASSIFICATION CHANGES
TO: unclassified
FROM: confidential
LIMITATION CHANGES
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BRL MR 2098

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MEMORANDUM REPORT NO. 2098

ANALYSIS OF COMBAT DAMAGE ON CH-53A AND HH-53B HELICOPTERS IN SOUTHEAST ASIA (1967 THROUGH JUNE 1969) (U)

by

Walter S. Thompson
Raymond E. Wheeler

June 1971

U.S. ARMY ABERDEEN RESEARCH AND DEVELOPMENT CENTER
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ABERDEEN PROVING GROUND, MARYLAND

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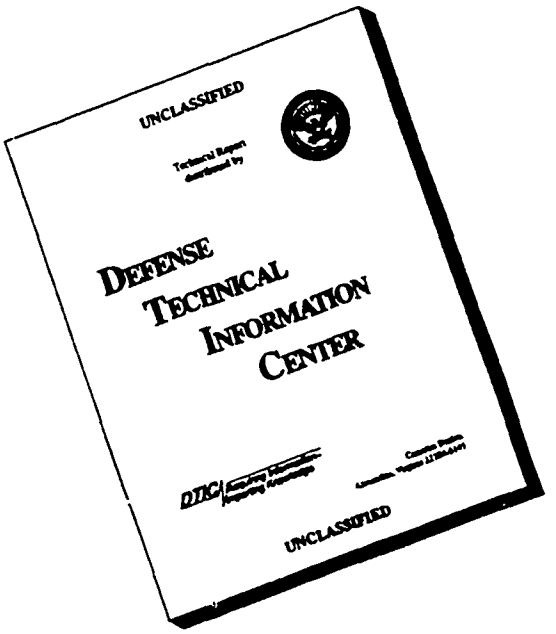

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ANALYSIS OF COMBAT DAMAGE ON CH-53A AND HH-53B HELICOPTERS IN SOUTHEAST ASIA (1967 THROUGH JUNE 1969) (U)

Walter S. Thompson
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RDT&D Project No. 1F162203A150

ABERDEEN PROVING GROUND, MARYLAND

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BALLISTIC RESEARCH LABORATORIES

MEMORANDUM REPORT NO. 2098

WSThompson/REWheeler/ams
Aberdeen Proving Ground, Md.
June 1971

ANALYSIS OF COMBAT DAMAGE ON CH-53A AND HH-53B HELICOPTERS IN SOUTHEAST ASIA (1967 THROUGH JUNE 1969) (U)

(UNCLASSIFIED) ABSTRACT

This report analyzes 345 cases of combat damage to U.S. Marine Corps CH-53A and U.S. Air Force HH-53B helicopters caused by ground fire in Southeast Asia, as reported to the Army Materiel Systems Analysis Agency and Ballistic Research Laboratories (AMSAA/BRL) through a number of data sources. Tabulated statistics and related analyses are provided for sorties flown, sorties hit, total hits, distribution of hits, circumstances of hits, and aircraft systems and components hit. Data are correlated with respect to crashes, forced landings, mission aborts, and damage-grounded aircraft. Hit frequency and hit multiples by weapon types are correlated with aircraft altitude, airspeed, and other factors; components and system damage are identified by reactions caused. Observations are compared with those from other analyses, for similarities with the CH-54, and for contrast with other helicopters. Comments on passive defense measures are included.

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(UNCLASSIFIED) TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

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The Sikorsky CH-53A "Sea Stallion" shown in Figure 1 is a twin-turbine heavy assault transport helicopter used by the U. S. Marine Corps for combat operations and other duties in Vietnam. Powered by two General Electric T64-6 or T64-12 engines, the helicopter has a six-blade 72.2-foot diameter main rotor and a four-blade 16-foot diameter tail rotor. The dual-wheel tricycle landing gear and tail skid are retractable, and a water-tight hull allows water landings and takeoffs. A full-size rear opening, with built-in ramp, allows cargo loading and unloading, facilitated by a hydraulically operated internal cargo loading system and floor rollers. An external cargo system permits in-flight sling pickup and release of up to 20,000 pounds without ground assistance. For parking configuration, the main rotor blades retract aft, over the fuselage, and the tail pylon folds up.

The CH-53A is crewed by a pilot, copilot, gunners, and crew chief. The main cabin accommodates 38 combat-equipped troops on inward-facing seats and a heli-team leader. An alternate configuration accommodates 24 stretchers and four attendants. CH-53A's in combat are fitted with side-door guns, engine air particle separators to protect the engines from sand and dust, and armor to protect the engines, pilot and copilot, and hydraulic reservoirs. A general arrangement is shown in Figure 2.

The U. S. Air Force employs the HH-53B helicopter for its Aerospace Rescue and Recovery Service. The HH-53B is similar to the CH-53A in most respects, but it is powered by T64-3 engines and is fitted with a retractable refueling probe, jettisonable twin auxiliary 450- or 650-gallon fuel tanks, and a rescue hoist with 250 feet of cable and 600 pounds capacity. Armament consists of three 7.62mm Miniguns, one on each side at mid fuselage and one by the ramp in the aft fuselage. In addition to the pilot and copilot, the HH-53B is crewed by two para-medics and a flight engineer who operates the guns when other duties allow.

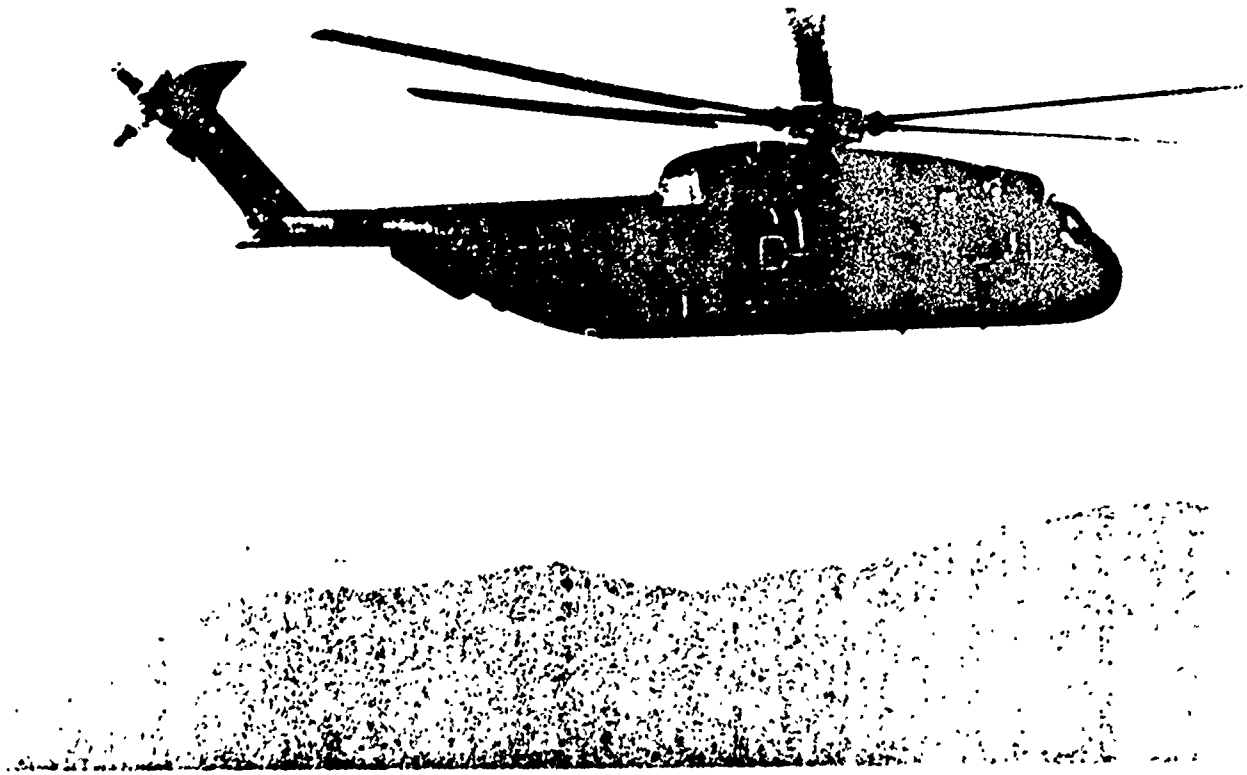

Figure 1. CH-53A Helicopter.

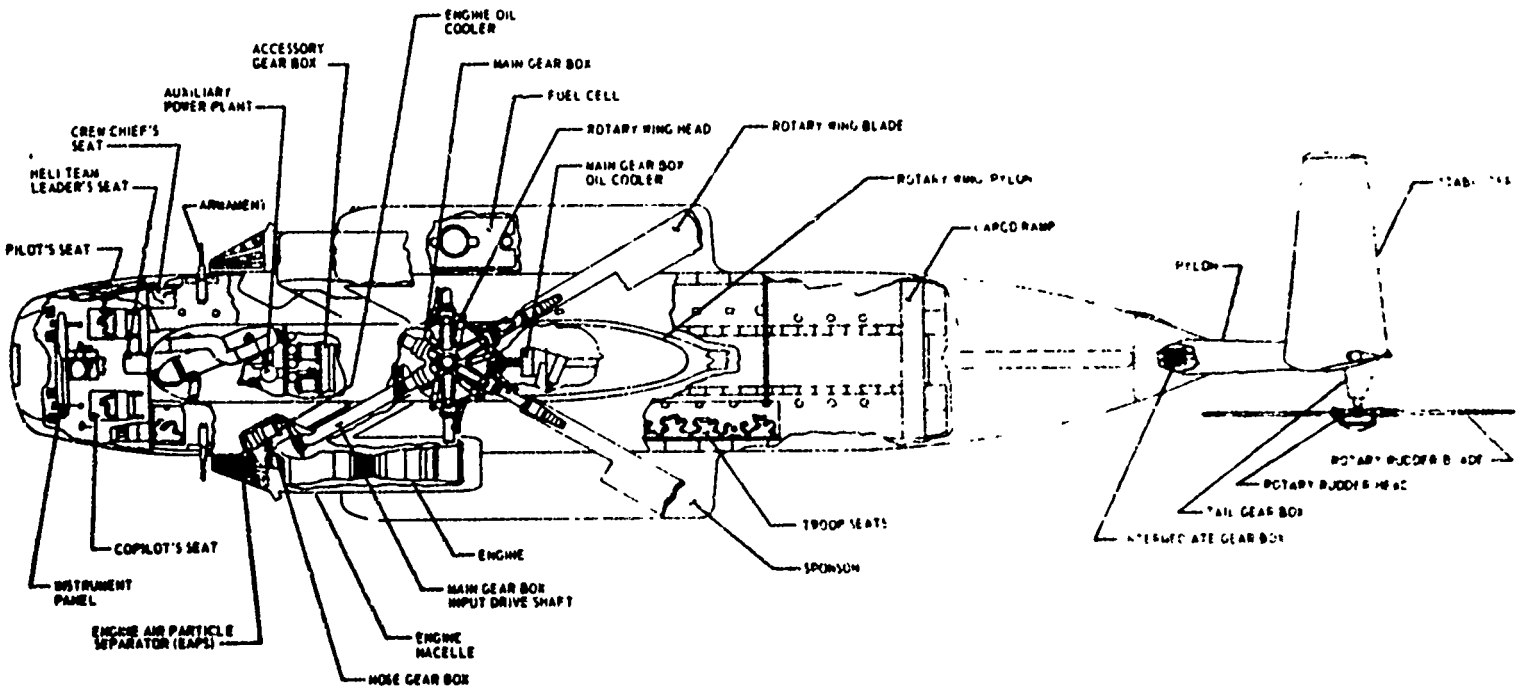

Figure 2. General Arrangement.

The U. S. Army's CH-54A heavy-lift helicopter is similar in size, if not shape, to the CH/HH-53. They incorporate the same main and tail rotor systems and tail rotor drive system. Mechanical flight control elements and primary hydraulic systems are essentially the same, and basic similarities can be found in the main transmission, oil coolers, and other features. Both types are used for recoveries and cargo hauling by sling. In the analyses to follow, observations from CH-54A combat data[1*] are incorporated where appropriate.

This study analyzes all the reported ground fire hits, their circumstances, and their results on CH-53A and HH-53B helicopters occurring from January 1967 through June 1969, as reported through a number of sources. Report sources and relative overlaps are listed in Table A-1 of Appendix A, which also presents sample reports from the major sources of data. The Navy Direct Enemy Action (DEA) reports obtained from Naval Safety Center, Norfolk, Virginia, provided the majority of the data for this analysis, but many cases were reported by other sources, and no single source was complete during the period. DEA summaries covered about 70 percent of all known cases. The Joint Services Incident and Damage Reports (JSIDR) covered about a quarter of the cases, and others covered lesser amounts. It appears reasonable to assume that some hits may not have been reported through any source, but certainly known data on all the important hits should have reached continental U. S. via one route or another.

Available operation data and reported case mission data are presented in Appendix B. Appendix C presents reported altitude, airspeed, and flight data reported for the hit-incidents. Appendix D presents threat data. Appendix E presents summarized systems-damage information; Appendix F presents aircraft reaction data.

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*References are listed on page 76.

(CONFIDENTIAL) 2. OPERATIONS DATA

The U. S. Marine Corps introduced the CH-53A to South Vietnam operations in January 1967 for use in combat assault and support missions; the first two reports of hits on CH-53A's were initiated on 17 January 1967. In the first year of CH-53A operations*, 26,500 sorties were logged with 10,600 flying hours for an average sortie time of 24 minutes. Of these sorties, 95 percent were combat-related. The Vietnam CH-53A inventory was 29 aircraft at the end of 1967, and this quantity was maintained at an average of about 30 possessed aircraft throughout the period of study. By the end of June 1969, these aircraft had accumulated about 116,000 sorties in 40,500 flying hours with little change in average sortie time; sorties averaged 19 minutes for 1968 and 21 minutes for the first half of 1969. Eighty-five percent of the total sorties were combat-related.

The initial increment of U. S. Air Force HH-53B's arrived at Udorn AB in Thailand in September 1967; the first reported hit occurred on 5 October 1967 during a training flight. The last of six HH-53's to be stationed there arrived in January of 1968. The helicopters joined HH-3E and HH-43 helicopters in search and rescue operations in support of fighter-bomber missions. A typical mission entailed take-off prior to each strike mission and arrival at an orbit position about 20 minutes before the strike aircraft began their penetration. The helicopters refueled from an HC-130 rescue command-and-control aircraft and remained on station sometimes for several hours. For retrieval of downed pilots from moderately defended areas, two A-1 escort aircraft preceded the HH-53B to suppress enemy fire and locate the downed personnel, while two additional A-1 aircraft followed at a distance behind the helicopter to attack any ground fire source in the event the latter received fire from the rear. In more lightly defended areas, the advance A-1's were not employed. In these regions there was usually a forward air controller aircraft to locate the downed crew.

* Source of operational data: Office of Chief of Naval Operations (OPREP-5).

The HH-53B inventory for these operations was maintained at an average of six aircraft through the period under study. During the 22 months of HH-53B operations through June 1969, the aircraft conducted 2954 sorties in 6169 flying hours. The early operations in 1967 averaged 1.5 hours per sortie, but an average of 2.0 to 2.4 hours per sortie was maintained through 1968 and 1969 operations. Of these sorties, about 60 percent were combat-related in 1968, and all were combat-related in the first half of 1969.

A table of CH-53A and HH-53B aircraft inventory and utilization during the period of study is presented in Table B-I. In Table B-II total sorties are broken down by mission types, and in Table B-III combat related sorties (excluding unavailable 1967 data) are presented on a basis of percent of total sorties.

Table B-IV lists the yearly number of aircraft reported hit, the total number of hits received during the reporting period, and average number of hits per sortie hit. In conducting about 116,000 sorties, 336 CH-53A sorties received 763 hits; in conducting 1873 sorties, 9 HH-53B sorties received 71 hits. Specific total operational data are shown in Table I.

Table I. (C) General Sortie and Hit Data (U)

	CH-53A	HH-53B	All
Total Flying Hours	40,572	6,169	46,741
Total Sorties	115,997	2,954	118,951
Combat-Related Sorties	99,073	2,042*	101,115*
Average Sortie Time (hrs)	0.35	2.09	0.39
Sorties Hit	336	9	345
Total Hits	763	71	834
Flying Hours per Sortie Hit	121	685	135
Sorties Flown per Sortie Hit	345	328	345
Combat-Related Sorties Flown per Sortie Hit	295	227	293

*Assumed 75 percent of 1967 HH-53 sorties were combat related.

A first impression of the nine total hit-incidents reported for 22 months of HH-53B operations in comparison to 336 CH-53A incidents is that many cases involving the former model may not have been reported. On the other hand, the CH-53A inventory was consistently five times greater (30 vs 6), and the HH-53B missions average six times longer for each opportunity to encounter ground fire (2 hours vs 20 minutes). These factors alone could lead to a reporting rate ratio of 30 to one, with all other factors equal. The actual reporting ratio was 37.3 to one (336 to 9). Further, the CH-53A's were accumulating incident reports for eight months prior to introduction of the HH-53B's. The actual ratio of sorties flown over the reporting period was 39 to one. On the basis of these factors, the HH-53B reported data appear adequately representative.

On a basis of flying hours, the hit-risk for the CH-53A was considerably higher than the risk for the HH-53B, however, on a basis of total or combat-related sorties, the hit-risk for the two configurations were somewhat similar. Specifically, on the average, one CH-53A sortie was hit for every 121 flying hours, or for every 345 sorties, or for every 295 combat-related sorties; one HH-53B was hit for every 685 flying hours, but for every 328 sorties, or for every 227 combat-related sorties.

Yearly totals of sorties hit and total hits are listed in Table B-IV. The average number of hits per sortie hit was 2.27 for the CH-53A and 7.89 for the HH-53B. The high number of hits received in an average HH-53B incident is due in part to one case involving 25 hits - twenty-three fragments from an AAA projectile and two caliber .30 bullets; however, if that case is discounted, the average remains high at 5.8. The overall average for both types against all encountered threats was 2.42 hits per aircraft hit.

A study of the average number of sorties hit per combat-related sortie flown is presented in Table B-V. Data are listed for each month in 1968 and the first half of 1969, with 1967 shown by yearly total only. As previously stated, on an overall basis, 293 combat-related sorties were flown for every aircraft hit. On a month-to-month basis, the ratio fluctuated radically. For example, during May 1968 and

July 1968 these aircraft conducted an average of over 2,000 combat-related sorties before an aircraft was hit; September and November 1968 were also good months for avoiding hits. Then in January, February, and April 1969, and again abruptly in March 1969 these helicopters conducted relatively few missions per sortie receiving hits, as the averages for these month fell to within a range of 93 to 184 missions between hit-incidents. Viewed on a yearly basis, however, this rate began at 181 combat-related sorties per aircraft hit in 1967, and improved to 322 sorties in 1968 and 493 in the first half of 1969.

The distribution of sorties hit and total hits by mission, or task, are presented in Tables B-VI and B-VII, respectively, for each weapon type encountered. Unfortunately, reports for 44 percent of the cases did not specify this information. About two-thirds (66 percent) of the 191 cases with mission specified cited resupply as the task being performed at the time hits were received. Just over three-fourths of the resupply tasks involved delivery of on-board cargo and accounted for 80 percent of the caliber .50 incidents; the remainder involved externally carried supplies. Sling recoveries (non-rescue) and air-landed assaults also accounted for significant hit-incidents - 12 and 11 percent respectively. The above tasks entail USMC CH-53A usage only; no USAF HH-53B's were involved in these totals. Other CH-53A tasks incurring ground fire hits were reported in lesser percents of the total. Reported missions while receiving hits for the USAF model were: one training flight and eight rescue missions.

From the data presented in Tables B-VI and B-VII for number of sorties hit and total hits by mission type, average numbers of hits per sortie hit were calculated for each of the mission types. These values are presented in Table B-VIII, broken down by weapon type. The overall average for all missions was 2.42 hits per sortie hit. Rescue missions had the highest average number of hits and were flown by both models, but only seven sorties were reported hit. These missions averaged 7.5 hits per sortie hit, considering all threats; discounting

the 23 individual fragment hits in one case involving an AAA projectile, the figure remained the highest at 5.6 hits per sortie hit. Second highest was training, at 5 hits per sortie hit; however, only one case was involved. Third highest was sling-recovery tasks, at 3.2 hits per sortie hit, which encompassed 23 cases (about 12 percent of the total with mission specified and all caliber .30 incidents). On the other hand, the two resupply categories - involving two-thirds of the cases in which mission was specified - both averaged about 2.0 hits per sortie hit. These two categories combined to account for 83 percent of the caliber .50 incidents, however, with an average of 4.4 caliber .50 hits per incident.

Slightly less than half of the damage reports did not specify if the crew knew when their helicopter was hit; only about 35 percent stated whether or not the crew observed the enemy fire. These data are presented in Table B-IX. When specified, crews reported knowing they were hit in 82 percent of the incidents, and observing enemy fire in about 35 percent.

(CONFIDENTIAL) 3. FLIGHT CONDITIONS

Appendix C presents the reported combat data correlated with phase and conditions of flight.

Numbers of sorties hit, distributed by flight phase and threat, are presented in Table C-I. Flight phase was not specified in 10 percent of the cases. More than half (55 percent) of the cases in which flight phase was specified involved hits received while en route to or from the landing, drop, or pick-up zones; 35 percent were hit while operating in these zones. Seventy percent of those hit en route were operating at altitudes over 1,000 feet above the ground. Only 3.6 percent of the aircraft were hit while on the ground (with power on). An additional few involved hovering and orbiting maneuvers. Encounters with HE projectiles were more numerous for on-ground, hovering, and take-off phases. By flight phase, distribution of calibers .30 and .50 weapons

encounters resembled the overall threat pattern.

Table C-II presents the distribution of total hits by flight phase, and the pattern is similar to that for number of aircraft hit.

The data from Tables C-I and C-II were combined to obtain average numbers of hits per sortie hit for the various flight phases, as presented in Table C-III. Compared to an overall average of 2.42, the average number of hits received generally increased as operations neared ground level: 1.9 for en route high (over 1000 feet altitude); 2.6 for en route low (under 1000 feet altitude); 3.1 for landing and descending. Comparable averages obtained in a study of CH-54A data[1] were very similar. Hovering, the helicopters were expectedly susceptible to high numbers of hits, averaging 4.7 hits per sortie hit if HE projectile fragment hits are excluded, and 6.4 hits if they are included.

Tables C-IV and C-V present sorties hit and total hits, respectively, correlated with reported altitude information. Fifty-eight percent of the time these aircraft were hit at altitudes above 750 feet. The altitude band in which these aircraft most often received hits was from 1001 to 1500 feet, accounting for 20 percent of the cases. The altitude band below (751 to 1000 feet) accounted for 12 percent; the two bands above (1501 to 2000 feet and 2001 to 3000 feet) accounted for 11 percent and 12 percent respectively. Hits were sustained from caliber .30 small arms and caliber .50 weapons at altitudes above 3000 feet. One AAA projectile caused numerous fragment-hits on an HH-53B at 6000 feet altitude.

Viewed on a cumulative basis, the incidents for which altitude was reported were distributed as follows:

Table II. (C) Percent of Sorties Hit Versus Altitude (U)

Altitude Specified, Ft.	Percent of Sorties Hit
On Ground (Power On)	4
50 and Under	12
100 and Under	18
300 and Under	32
500 and Under	39
1000 and Under	53
2000 and Under	84
3000 and Under	96

Comparison of the above data with that available for other helicopters is shown in Table III. The CH-53A and CH-54A appear to differ distinctly from other helicopters in operations and exposure to ground fire, based on percent of sorties hit at altitudes over 1000 feet. Despite the small sample, the HH-53B proved identical to the HH-43 rescue helicopter in this respect.

Table III. (C) Comparative Altitude Data for Various Helicopters (U)

Aircraft Type	Main Role	Service	Percent Hit at Altitudes Over 1000 Feet
CH-53A	Cargo, Troop Transport	Marines	47
CH-54A[1]	Cargo	Army	64
CH-34[3,8]	Troop Transport	Marines	14
CH-47[2]	Cargo, Troop Transport	Army	8
CH-46[3]	Cargo, Troop Transport	Marines	9
UH-1D[4]	Cargo, Troop Transport	Army	9
UH-1B/C[4]	Fire Support, Recon	Army	7
OH-13 & 23[5]	Recon	Army	5
AH-1G[6]	Fire Support	Army	22
HH-53B	Rescue	USAF	14
HH-43[7]	Rescue	USAF	14

Data on average numbers of hits per sortie hit by altitude band were obtained from the data in Tables C-IV and C-V, and are presented in Table C-VI. The overall average of 2.42 hits per sortie hit is quite low for a helicopter the size of the CH/UH-53, comparing closely to like averages for smaller helicopters. Part of the reason for this seemingly low average is because these aircraft (predominantely CH-53A's) were more often at comparatively high altitudes when the majority of hits occurred. Normal operating altitude ranges for CH-53A helicopters are evidently much higher than those for smaller helicopters when engaging ground fire in their respective missions.

The manner in which this factor apparently contributes to the lowering of the average number of hits can be seen in Table C-VI. A minority of incidents occurring at lower altitudes involved many hits. Flying within 100 feet above the ground, the aircraft averaged 3 to 4 hits per incident; between 500 and 750 feet the average was over three hits per incident. Conversely, averages for altitudes above 1000 feet start at 1.97 and decline to 1.40 for altitudes over 3000 feet (excluding HE fragment hits).

Tables C-VII and C-VIII present sorties hit and total hits, respectively, correlated with reported airspeed information, with over three-fourths of the reports providing these data. The CH-53A's and UH-53B's were often travelling at relatively high speeds when hits occurred. Thirty percent were operating at 101 to 150 knots. Nine percent were hit while at zero airspeed. Trends for total hits were similar. The distribution by airspeed for average number of hits per sortie hit is presented in Table C-IX, and shows an expected decline with increases in airspeed. This value ranges from 4.3 hits per incident at zero airspeed to 2.0 hits at 101 to 150 knots.

It was established that these aircraft were more often hit at altitudes above 750 feet (or most often, in the altitude band of 1001 to 1500 feet), and, independent of these data, the most often reported airspeeds were 101 to 150 knots. Table C-X presents distribution of

sorties hit by caliber .30 weapons, in combinations of altitude and airspeed. Associated data for total hits are presented in Table C-XI. A check of this distribution shows that under each airspeed band (except zero knots) a clear majority can be found listed for the altitude band of 1001 to 1500 feet. The most often reported speed range of 101-150 knots shows a concentration of cases for altitudes of 750 to 1500 feet. Thus, for caliber .30 incidents it can be shown that the CH/HH-53 was usually flying at 101 to 150 knots and 1001 to 1500 feet altitude, in that combination, when hit.

Comparable data for caliber .50 incidents are shown in Tables C-XII and C-XIII, but the small sample size precludes any significant interpretations, other than noting a trend toward the higher altitude/speed combinations.

(CONFIDENTIAL) 4. THREAT

Reported or estimated threat is incorporated in much of the discussion throughout this report; however the detailed information on threat is concentrated in Appendix D. Bullet or projectile size was ascertained or estimated in virtually all reported cases; general type of weapon was also reported in a majority of cases. Distribution of the threat observed in the 345 sorties hit is presented in Table D-I; eighty-six percent caliber .30 only; 7.0 percent caliber .50 only; 4.3 percent fragmentation devices; and the remaining percentage mixed threat incidents. Including the overlapping from mixed threat incidents, 88.4 percent of the total sorties received caliber .30 hits, 8.4 percent of the total received caliber .50 hits, and 5.2 percent of the total involved hits by fragments from explosive projectiles.

Within the caliber .30 category, sorties hit by rifles appear to outnumber those hit by automatic weapons by a factor of almost three to one; however, weapon type was not specified in almost 40 percent of the caliber .30 cases.

Table D-II presents the distribution of total individual hits by threat. Caliber .30 weapons caused 78 percent of the total hits, and caliber .50 weapons caused 12 percent. The remaining ten percent were caused by fragments from explosive rounds and an AAA projectile airburst.

Tables D-III and D-IV present monthly sorties hit and total hits, respectively, for each of the weapon types. For most of the 30-month study, the number of aircraft was maintained relatively constant, but the number of sorties hit varied erratically. Two-thirds of the total cases occurred during the second half of 1967 and the first half of 1968. The first quarter of 1968 and 1969 involved relatively numerous cases involving caliber .30 and .50 weapons; the second quarter of 1968 and the first quarter of 1969 involved 11 of the 19 total HE projectile incidents.

Quarterly totals of caliber .30 incidents increased steadily through 1967, to a high of 58 cases during the first quarter of 1968. Quarterly totals of caliber .30 incidents declined since that time to a low of 10 cases for the last quarter in the reporting period. Unfortunately, a comparable decline in caliber .50 incidents was not realized; thirty-eight percent of the total caliber .50 incidents occurred in the last 6-month period of the study.

As stated previously, the overall average number of hits per sortie hit was 2.42. Table IV shows specific averages for the various weapons over the period of study.

Table IV. (C) Average Number of Hits per Sortie Hit by Weapon Type (U)

	Cal. .30	Cal. .50	.30 & .50	HE FRAGMENTS	ALL WEAPONS
1967	1.93	3.00	1.95	1.50	1.96
1968	2.24	2.73	2.29	8.38	2.64
1969*	2.38	4.27	2.77	2.11	2.96

* First half only.

These data indicate a general growth in the number of hits received in an average encounter with all reported enemy weapons.

For all sorties hit, hit multiples were as follows:

Number of Hits	Percent of Sorties
1	58
1 or 2	77
1, 2 or 3	85
5 or less	91
over 5	9

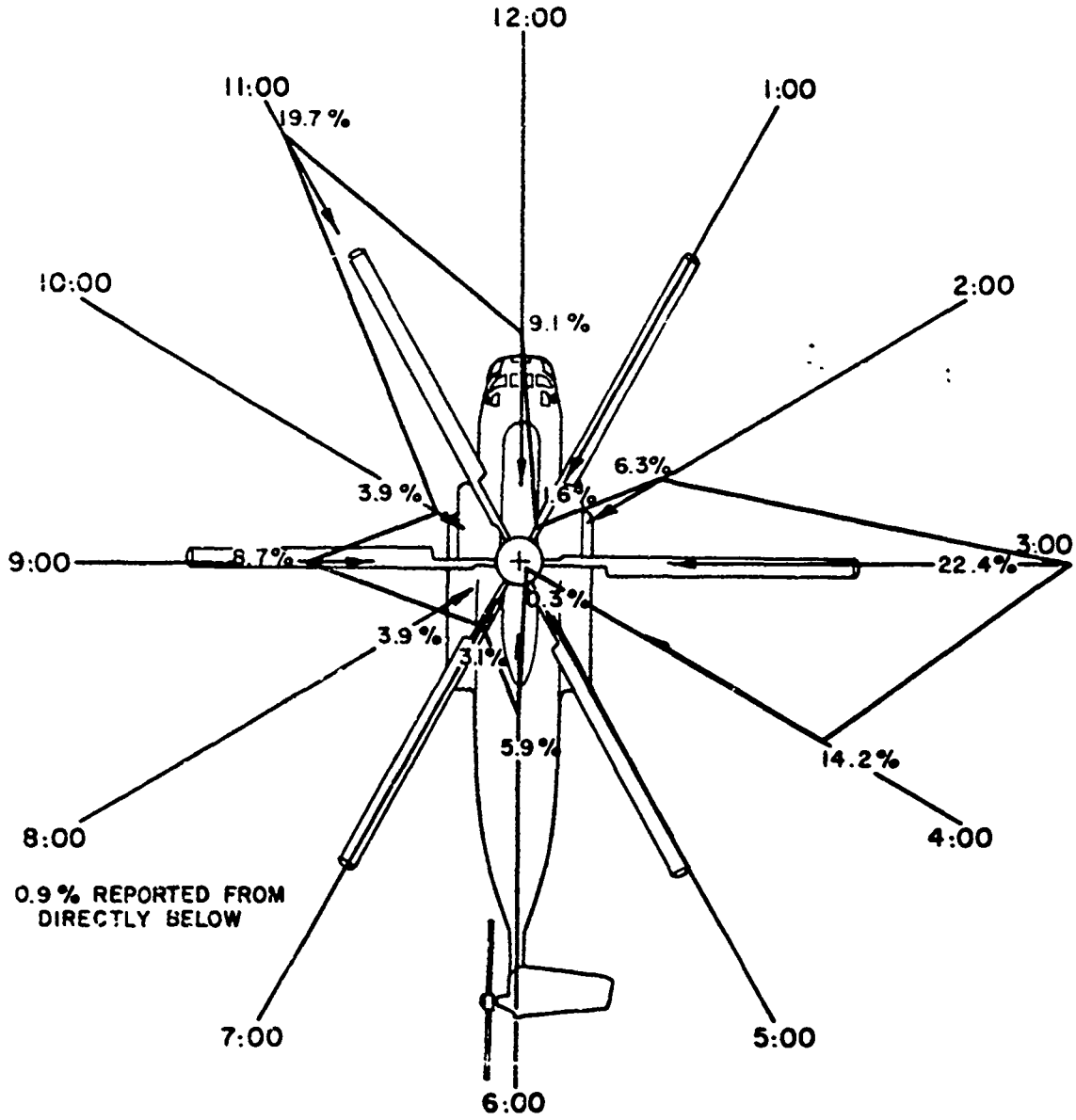
Table D-V presents hit multiples versus threat. With very few exceptions, in cases where more than one hit occurred, if sufficient damage occurred to produce an adverse aircraft reaction, only one of the hits was responsible for the reaction. Over half (58 percent) of all the reported cases involved only one hit; another 19 percent involved two. The highest number of hits in one incident for fragments was 27, occurring all at once. The highest number of hits by bullets in one incident was 19 (caliber .30) and two other incidents involved 18 (one caliber .30 incident and one caliber .50 incident); however, in all three, an initial hit(s) caused a forced landing which results in additional hits while on the ground.

The large majority of multiple hits came from caliber .30 weapons. The percentages of multiple-hit incidents achieved by each separate threat roughly approximated the percentage of occurrence for that threat (from Table D-I); i.e., caliber .30 weapons were encountered in 88 percent of the reported cases and obtained 81 percent of the multiple hits; caliber .50 weapons were encountered in 8.2 percent of the incidents and achieved 8.6 percent of the multiple hits. It is noteworthy that the caliber .30 "unknown weapon" group achieved a respectable number of multiple hits and probably included a high proportion of automatic weapons.

Table D-VI presents hit multiples versus flight phase. The probability of multiple hits was somewhat higher for operations close to the ground; however, no large contrasts are seen among the individual flight phases in tendencies to receive high numbers of hits. Of the 42 percent of the total cases to receive multiple hits, the majority were hit "en route" (48 percent received multiple hits while en route at 1000 feet or less, and 39 percent received multiple hits while en route over 1000 feet). Two-thirds of the cases hit while hovering were hit by multiple hits, but fortunately these cases amounted to only 3.5 percent of the total sorties hit.

Reported enemy weapon range data is tabulated in Table D-VII. Unfortunately, range was reported in less than one-fourth of the reported cases. No significant observation is possible at this time other than noting that observed ranges from 50 to 200 meters predominated. No hits were reported from a range of 50 meters or less. Better reporting of range estimates would have been valuable to a threat analysis, but most report formats do not include a requirement for this information.

Direction-of-fire data were reported for about one-third of the individual hits reported; these data are presented in Table D-VIII. The general patterns of direction-of-fire data for caliber .30 weapons and for caliber .50 weapons are reasonably consistent with that for total hits, which is plotted in an azimuth presentation in Figure 3. By quadrant, the right side of this helicopter received 42.9 percent of the total hits and the front received 30.4 percent; the left side received 16.5 percent and the rear received only 9.3 percent. The relatively high proportion of hits reported at 3, 4, and 11 o'clock positions are not the results of one or several cases involving a great many hits, but were accumulated through numerous cases. The reasons for this predominantly right-side and frontal distribution are not apparent within the scope of the data reported. It could be suggested, however, that the location of the pilot and personnel door on the right side possibly affects the manner in which all models are maneuvered in the vicinity of the landing zone, a frequent source of ground fire.



NOTE: ONLY HITS WITH DIRECTION REPORTED ARE SHOWN. HITS RECEIVED WHILE ON GROUND NOT INCLUDED. DISTRIBUTION IS FOR 30 % OF TOTAL HITS, 32.5 % OF HITS WHILE AIRBORNE.

Figure 3 (C). Distribution of Reported Hits by Direction (U).

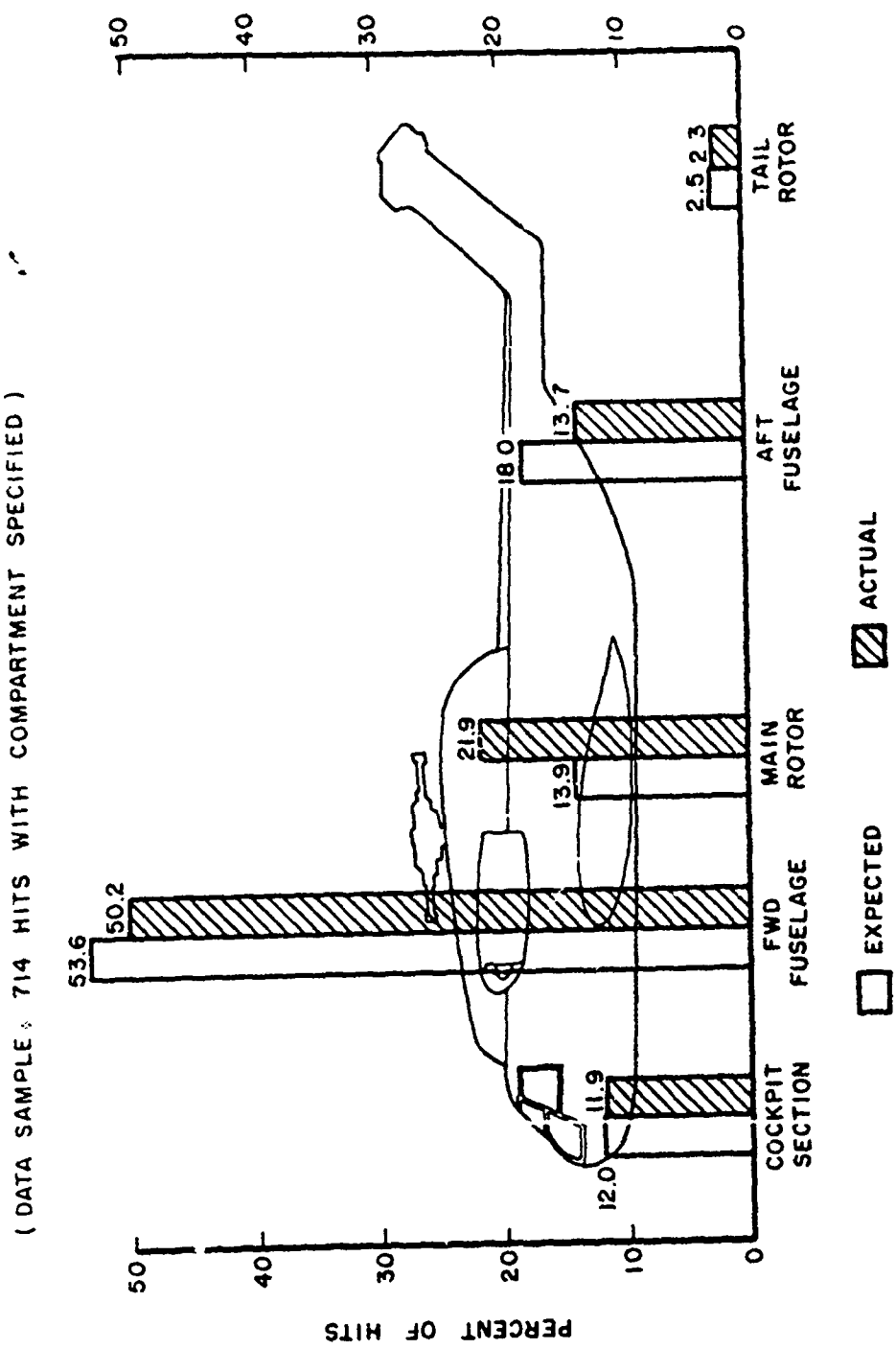


Figure 4 (C). Percent of Total Hits on Major CH/HH-53 Compartments (U).

Further, USAF models carry the rescue hoist over the personnel door, requiring disengagement of the right side gun during rescue pick-ups, while the left and rear guns remain available for suppressive fire.

Distribution of hits by aircraft section or compartment is presented in Table D-IX and in Figure 4. The actual distribution observed for the various threats is compared to the predicted distribution, assuming a uniform pattern of hits distributed by presented area. This hypothesis appears correct since reasonably close correlation between expected and actual distribution is exhibited. Similar correlations were obtained for the individual weapon types.

Studies on many other helicopters have virtually all yielded the same results; hits are uniformly distributed and do not reflect any concentration due to aiming or other factors.

(CONFIDENTIAL) 5. HITS AND RESULTS BY SYSTEMS AND COMPONENTS

Many of the hits reported for the CH-53A and HH-53B helicopters caused inconsequential damage to skin and structure; however 287 (out of the 834 total) reported damage to systems, equipment, and components.

These hits break down as follows:

	Number of Hits
Main rotor blades	128
Fuel System	32
Engine Compartments	29
Hydraulic Systems	18
Equipment	16
Transmission System	13
Electrical System	11
Mechanical Controls	8
Avionics	8
Armor	8
Tail Rotor Blades	6
Instruments	5
Landing Gear	5
TOTAL	287

The hits are classified by system in Appendix E. A discussion of each category follows:

5.1 Fuel System

The CH-53A (and HH-53B) fuel system, shown in Figure 5, consists of two suction-type fuel systems with cross-feed provisions. The two main fuel cells, each with a capacity of 311 gallons, are housed in the sponsons. The lower third of each cell is caliber .30 self-sealing; all lines and fittings are at the top to minimize potential leakage. Manual fuel control valves allow fuel to be drawn from either or both cells for direct or cross-feed engine supply. An engine-driven fuel boost pump on each engine accessory gearbox draws the fuel from the cells (under a suction head in the supply line) and delivers fuel with a positive head to the engine main fuel pump. If either or both engine-driven boost pumps fail, the engines are capable of continued operation. For range extension, non-self-sealing auxiliary fuel tanks are installed in the cabin. In addition, the HH-53B is fitted with a refueling probe, left and right drop tanks, and associated lines. HH-53B main fuel cells are completely caliber .50 self-sealing.

Fuel system hits are summarized in Table E-I. There were 25 cases involving 32 fuel system hits.

Key to Figure 5

1. Hand Pump Drain Line
2. Hand Fuel Pump
3. Engine Supply (Right)
4. Right Fuel Boost Pump
5. Pressure Refueling Line (Right)
6. Tank Pressure Line (Right)
7. Fuel Pressure Switch
8. Tank Precheck Line (Right)
9. APP Feed Line (Right)
10. Right Fuel Selector Valve
11. Front Tank Vent
12. Right Fuel Cell
13. Rear Tank Vent (Right)
14. Scupper Drain (Right)
15. Rear Tank Vent (Left)
16. Left Fuel Cell
17. Fuel Gaging Probes (Left)
18. Scupper Drain (Left)
19. Pressure Refueling Line (Left)
20. Tank Pressure Line (Left)
21. Tank Precheck Line (Left)
22. Pressure Refueling Line (Left)
23. Tank Precheck Line (Right)
24. Pressure Refueling Panel
25. Heater Feed Line (Right)
26. Engine Supply Line
27. Front Tank Vent (Left)
28. Tank Pressure Line (Right)
29. Left Fuel Selector Valve
30. Left Fuel Boost Pump
31. Fuel Gaging Probes (Right)
32. Vent Outlet (Water Operation)
33. Cap (Anti-Siphon Valve)
34. Vent Outlet (Normal Operation)

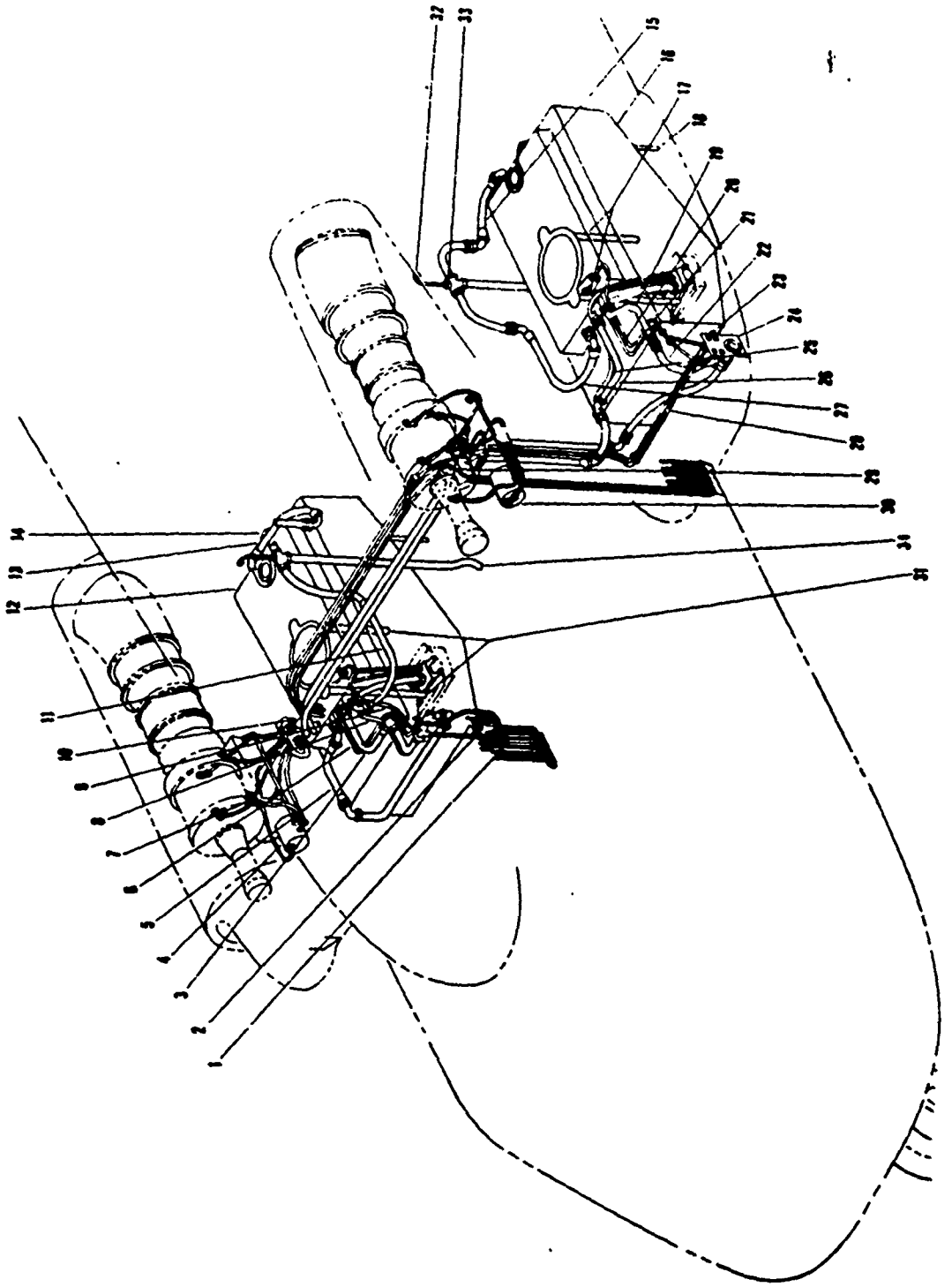


Figure 5. (U) Fuel System (U)

A total of 19 hits (all caliber .30) were taken in the self-sealing main fuel cells, occurring in a total of 16 cases. Details regarding resultant leakage were generally lacking; however, the helicopters continued performing their missions in 14 of the cases, including one case involving two such hits. One case (single hit - Case 80099) resulted in a mission abort; another (Case 80008) involved three hits on the main fuel cells and three additional hits on the drop tanks (the aircraft was a USAF HH-53B) resulting in a mission abort when all fuel was lost from both drop tanks. The main cells, however, lost very little if any fuel.

In addition to the above three hits on drop tanks in Case 80008, one more hit on a drop tank was reported. It too caused a mission abort (Case 70101) when part of the tank fuel load was lost. It is interesting to note that Case 70101 involved additional fuel system damage in the form of a pierced fuel supply line for one engine which was operating under suction conditions and did not leak significantly*.

The second incidence of damage to a fuel supply line was reported in Case 90020 and led to a forced landing (after flying on a single-engine power to a secure area) after a caliber .30 bullet passed through the line and caused the number one engine to fail hrough fuel starvation.

Damages to a fuel transfer line (probably empty), a fuel vent line (obviously empty of liquid), a fuel line of unspecified function, and a fuel heater line were incurred without adverse affect. The latter was reported to be bent, but not punctured.

Three cases of damage to unspecified fuel system components, including one by a caliber .50 bullet, were reported as leading to forced landings. In one case, the fuel indicator "went to zero," but no further details are available on any of the three incidents.

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* In view of vulnerability test results on a T64 engine operating with a simulation of this system, this line must have sustained a very small cut, possibly by shrapnel and not by the bullet, or cross-feed procedures were employed but not mentioned in the report.

During the reporting period no in-flight fires were reported as resulting directly from a bullet or fragment impact on the CH-53A or HH-53B helicopters.

5.2 Engines

Powerplants for the CH-53A and HH-53B helicopters include two each T64 turboshaft engines. There is no significant difference in outward appearance between the T64-3 engine used on the HH-53B and the -6 or -12 models used in the CH-53A. Figure 6 shows a left-front view of the T64-6 engine.

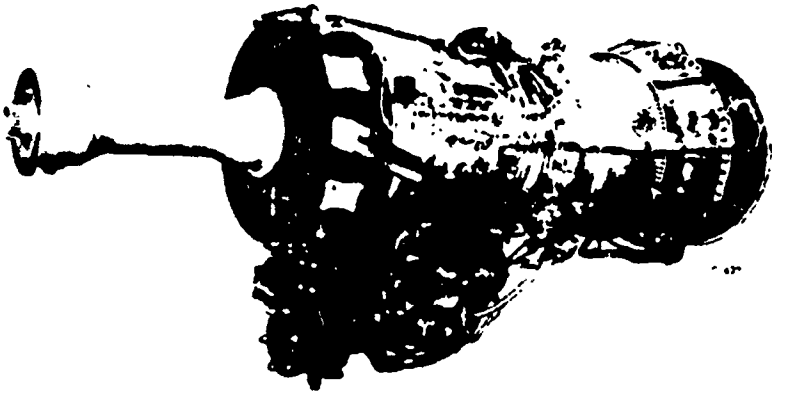

Figure 6. T64 Engine

The T64 engines incorporate a variable-vane compressor, a two-stage gas generator turbine, and a two-stage power turbine. Output power is transmitted from the power turbine by means of a through-shaft which runs the length of the engine and protrudes out of the front of the inlet frame to drive a torque shaft. Both engines on the helicopter are identical and interchangeable. An oil tank holding 2.8 gallons of MIL-L-23699 oil mounts over each engine inlet frame; oil for each engine is cooled by an engine/nose gearbox oil cooler located beside the respective inlet duct.

Each engine is protected from sand and dust ingestion by an Engine Air Particle Separator (EAPS) unit fitted to the inlet duct. A high-rate, discharge-type fixed fire extinguishing system provides a means of extinguishing fires in either the left or right engine compartments upon selection and activation by a cockpit selector switch and control handle. Extinguishing agent is bromotrifluoromethane (CF_3Br). Armor is incorporated into the outboard nacelle panels to partially protect the engines from ground-fire impacts.

There were 25 reported cases with 29 individual hits on the engine compartment (Table E-11). Five caliber .30 bullet hits in the engine tail pipe and nine hits against the cowling were of no consequence to engine function. Caliber .30 bullets struck the EAPS units on four separate occasions without causing degradation in engine performance; however, ingestion of debris from the wall of the EAPS unit caused minor foreign object damage to the compressor in each instance.

The only reported case involving engine oil system damage was Case 70220 in which the number one engine was shut down after a caliber .30 bullet passed through the cabin and struck the engine/nose gearbox oil cooler fan belt and idler gear, severing the fan belt. Flight was continued on the number two engine and no adverse reaction was reported (although the mission may have been accomplished before the hit occurred).

Detailed description of the damage by the remaining ten engine compartment hits is not available. These hits were incurred in eight separate incidents. In two, failure of the damaged engine resulted after single hits; in four, no loss of power resulted after single hits, or, in one case, after two caliber .30 hits on the same engine; in two, resultant power degradation, if any, was not reported.

The six cases not resulting in power loss, or with no power loss specified, did not lead to an adverse reaction, however; both of the above cases involving engine failure resulted in forced landings:

Case 80006 involved number-one engine failure on an UH-53B when it was struck by a caliber .30 bullet, and the landing was accomplished in secure landing zone after continued flight on the number two engine; Case 90043 involved failure of the number-two engine on a CH-53A when it was struck by a caliber .50 bullet while entering the landing zone; the aircraft was landed at that location and recovered later.

According to reports, at least five of the nine hits on the engine compartment cowling struck the engine armor plates. The plates reportedly stopped six caliber .30 bullets and two AAA projectile fragments effectively; one caliber .50 armor piercing (AP) bullet came from below and went through the edge of an armor plate at station 298 but missed the engine. Hits on armor protection are discussed in more detail in section 5.13 of this report.

5.3 Transmission System

The transmission system transmits engine torque to the rotary wing (main rotor) and rotary rudder (tail rotor) heads. It consists of two nose gearboxes, Auxiliary Power Plant (APP) clutch assembly, accessory gearbox, main gearbox, intermediate gearbox, tail gearbox, and interconnecting drive shafts. In addition, two engine/nose gearbox oil coolers and a main gearbox oil cooler are incorporated. The system is illustrated in Figure 7.

Power transmission originates at the forward end of the engines. The engine drive shafts (13,600 RP M) transmit power through the nose gearboxes to the main gearbox and power drive belts for the engine/nose gearbox oil cooler fans. The nose gearboxes reduce the shaft speed to 6023 RPM for main transmission input. The main gearbox provides the remaining gear reduction for the main rotor shaft to 185 RPM and a gear reduction for the tail drive shaft to 3011 RPM. The main gearbox drives the main gearbox oil cooler, first stage hydraulic pump, oil pump, and the accessory gearbox. The accessory gearbox is mounted forward of the main gearbox. Two generators and the APP clutch are mounted on the front cover. The winch utility pump and second stage hydraulic pump are mounted on the rear side of the housing.

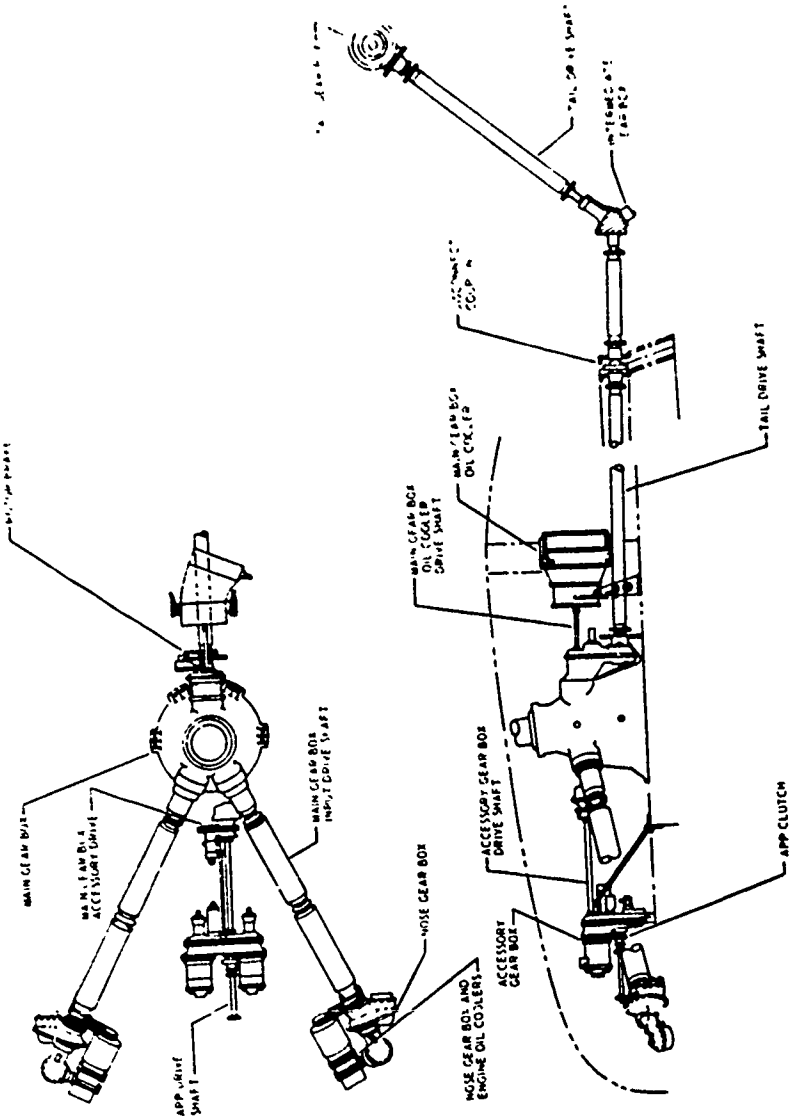

Figure 7. (U) Transmission Systems (U)

The tail rotor drive shaft transmits torque from the main gearbox through the disconnect coupling to the intermediate gearbox, reducing speed slightly to 2298 RPM and turning the angle of drive by approximately 60 degrees. The tail gearbox provides the remaining gear reduction for the tail rotor to 791 RPM and a 90 degree change in drive direction.

Lubricating oil for the above gearboxes is MIL-L-23699 oil. Main and nose gearbox lubricant is radiator-cooled; the others have no external cooling provisions. Although each engine and the corresponding nose gearbox share a common oil cooler, oil flow for each is separated within the radiator.

The APP drive shaft is fabricated from steel tubing; the other drive shafts are aluminum tubing. Each input shaft for the main transmission incorporates a freewheel unit which automatically disengages both engines during autorotation or one engine for single-engine operation in the event of an engine failure.

There were 12 reported cases with 13 hits on the transmission system. Five combat damage reports cited a total of six hits on the main transmission. In Case 80044 a caliber .30 bullet penetrated the transmission and caused a small oil leak; no adverse reaction resulted. In Case 80164 a caliber .50 bullet struck the transmission; damage was not specified, but the aircraft continued on its mission. In Case 80155 a caliber .30 bullet entered the bottom of the aricraft and struck the bottom of the transmission, apparently failing to cause an oil leak or other significant damage; this aircraft also continued on its mission. In Case 80101 a caliber .30 bullet punctured the transmission casing and caused a small oil leak; the aircraft was landed and a patch was improvised, whereupon the mission was resumed without further difficulty. Two hits were registered by fragments from an AAA projectile in Case 80045 and led to a mission abort; one fragment hit a transmission mount and another gouged the casing after striking a second-stage hydraulic pilot valve body. The transmission damage was

minor but the mission was aborted due to hydraulic system damage and failure.

Caliber .30 bullets struck the tail rotor drive shaft on four occasions without causing critical damage. In each case the aircraft continued on its mission. One report cited complete penetration of the shaft, another described the damage as a dent one-quarter inch deep at station 719. Damage was not described in the other two cases.

Caliber .30 bullets struck the transmission input shafts in two cases, causing similar damage. In each case the bullet hit the drive shaft coupling and shattered. In Case 70215, the impact caused two 1/4-inch cracks in the transmission and a bullet fragment made a small cut in a first-stage hydraulic line; this aircraft continued on its mission. In Case 70237 the bullet fragments severed a first-stage hydraulic line, causing pressure loss which led to a precautionary landing.

The intermediate tail rotor gearbox was hit by a caliber .30 bullet in Case 70112. Oil splashed out of the gearbox and the "chip light" came on, but the aircraft continued to fly and was grounded upon return to base.

5.4 Main Rotor

Each of the six main rotor blades consists of an aluminum spar, 26 sheet aluminum pockets, an aluminum tip cap and root cap, and a steel cuff which attaches the blade to the rotary wing head. Approximately one-half of the 26-inch chord is occupied by the spar. The spar is pressurized with nitrogen, and a pressure indicator at the root end of the blade serves as a fault detector.

CH-53 and HH-53 main rotor blades were hit more than any other system - a total of 128 times. Caliber .30 bullets were responsible for 121 of the hits without directly causing any adverse reaction. Of the eleven caliber .50 hits on the main rotor blades, two occured in Case 90044 and, combined with 16 other caliber .50 hits on the aircraft, caused a forced landing (recovered later); the remainder,

including three in one incident, did not cause mission interruption. Two hits by fragments from an AAA projectile did not degrade flying ability in Case 80045; however other damage combined to cause a mission abort in this instance. Single hits by mortar fragments occurred on three occasions without adverse effects. Damage to a main rotor blade by a single mortar fragment was involved in a mission abort, but the actual cause of this reaction was the intensity of the ground fire (Case 90010); the blade damage in this case did not hamper further flight.

Presumably 128 total hits on main rotor blades created a significant workload for the maintenance crews; however, none, including caliber .50 hits in the spars,were reported as detrimental to flight capabilities for return flights. Two cases involving single impacts by caliber .50 bullets were known to cause grounding of the aircraft (CH-53A S/N 151693 in both instances), and many of the other incidents may well have had similar results.

5.5 Tail Rotor

Each of the four rotary rudder blades consists of a hollow aluminum spar, and pockets constructed of sheet aluminum skin with reinforced aluminum ribs, an aluminum root cap, and a steel cuff. They mount to the rotary rudder head which is driven by the horizontal shaft of the tail gearbox. Pitch changes are accomplished through blade links by movements of a shaft through the tail gearbox.

No hits were reported involving the tail rotor head. Six hits were taken by tail rotor blades without affecting flight or mission. These included five hits by caliber .30 bullets and one by caliber .50.

5.6 Mechanical Control Systems

The flight controls consist of the collective, cyclic, and directional systems, comprising a series of push-pull rods, bellcranks, servos, pulleys, and cables which transmit control movements of the collective and cyclic sticks (vertical and lateral direction) and the

rudder pedals (heading control). Layout of these components is illustrated in Figure 8. Dual controls are provided. Automatic flight control can be accomplished by the Automatic Flight Control System (AFCS) and fine adjustments in collective and cyclic control are made by using stick trim system which operates through the AFCS. Control power assist is accomplished hydraulically.

The copilot's collective stick, cyclic stick, and rudder pedals are mechanically linked to those for the pilot. Stick and pedal control movement is transmitted by a push pull system through individual AFCS servocylinders for power assist and into the mixing unit. The mixing unit coordinates the cyclic and collective inputs into control movements at the hydraulically actuated primary rotary wing tandem servocylinders, which position the main rotor swashplate to regulate blade pitch. Movement of the directional control pedals is transmitted through an AFCS servocylinder and the mixing unit to a control quadrant and cable system, which regulates the hydraulically actuated rotary rudder servocylinder, through additional push-pull rods and bellcranks.

Damage — all by bullets — on mechanical control components was reported in only seven cases and involved a total of eight hits. (One additional case involved a hit on a flight control servo, a hydromechanical component, which is discussed in the next section under hydraulic system damage.)

The single hit occurring in Case 80003 resulted in non-critical damage when a caliber .30 bullet struck the bottom of the cockpit, travelled through the avionics platform, and expended against the torque tube connecting the cyclic sticks. The impact, occurring while the aircraft was 1600 feet above the ground, caused a 3/16-inch deep dent in the tube and stung the copilot's hand. The aircraft continued on its mission.

One of the caliber .50 API bullets encountered in Case 80012 grazed the right side rudder cable and cut two of the seven wire

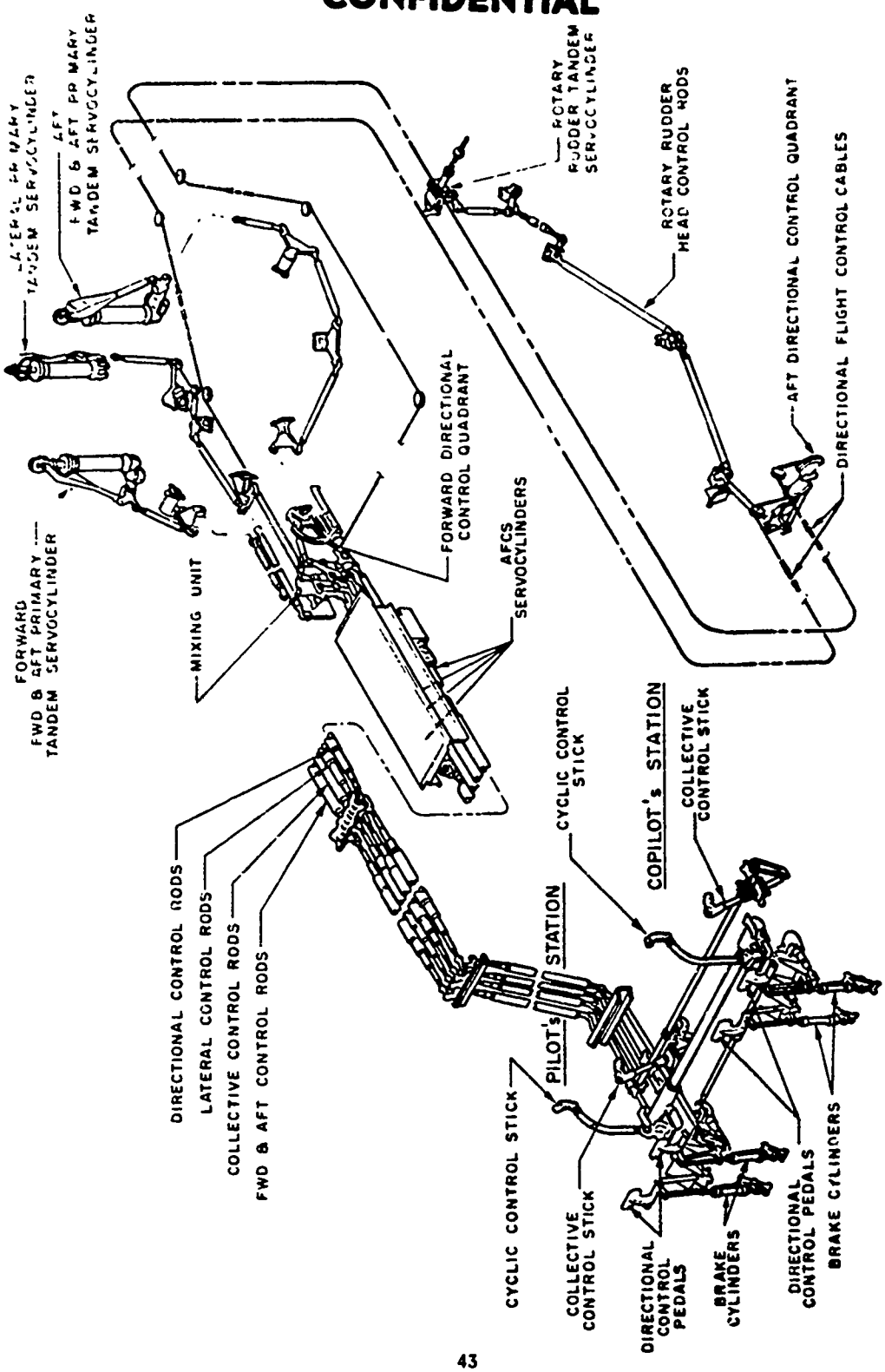

Figure 8. (U) Mechanical Control System (U)

strands. The cable remained operational and the flight was continued without interruption.

Three reports cited push-pull rod damage. Case 80015 involved a caliber .50 bullet creasing a section of the tail rotor control rod. The rod remained operational, but the mission was aborted for other reasons. In Case 80054 the aircraft was hit by several caliber .50 bullets while on approach. One round entered the forward compartment and caused "90 percent severance" of two control rods. Under partial loss of control, the aircraft was forced to continue the landing maneuver in an accelerated manner, landing with wheels up. FM antenna and fuselage skin damage was cited, but no further details were reported. In the third incident, Case 90027, two control rods were damaged by separate caliber .30 bullets while the aircraft was in a landing approach 60 feet above the ground. The landing was completed (a forced landing) successfully but no damage details were given.

Finally, in Cases 80105 and 90044 unspecified mechanical control components were hit. In the former, damage by one caliber .30 bullet caused the mission (sling load delivery) to be aborted. In the latter case, damage was caused by one of a total of 18 caliber .50 bullets hitting the aircraft. A forced landing resulted, with damages to several systems listed as causes.

Cases involving mechanical control system damage are summarized in Table III.

5.7 Hydraulic Systems

Power assistance for flight control is provided by three hydraulically independent systems:

a. The first stage hydraulic system provides power to the top (outboard) cylinders of the primary tandem servocylinders and the outboard cylinder of the rotary rudder tandem servocylinder. It consists of a reservoir, mounted in the left side of the main rotor pylon forward of the main gearbox; a 3000 psi discharge pressure pump, mounted

on the main gearbox accessory drive; manifold, filter, shut-off valve, pressure reducer, check valves, restrictors and associated lines. First stage hydraulic pressure is supplied to the primary tandem servocylinders at 3000 psi; a pressure reducer supplies 1500 psi pressure to the rotary rudder tandem servocylinder. The first stage system is electrically connected by a pressure switch to the second stage system to prevent shut-off of an operational system if the other experiences a loss of pressure.

b. The second stage hydraulic system provides power to the bottom (inboard) cylinders of the primary tandem servocylinders, to one stage of the forward-and-aft AFCS servocylinder, to one stage of the lateral (roll) AFCS servocylinder, and to the single stages of the directional (yaw) and collective AFCS servocylinders. It consists of a reservoir mounted in the right side of the main rotor pylon forward of the main gearbox, a 3000 psi discharge pressure pump, (identical to that for the first stage, system, but mounted on the accessory gearbox), manifold, filter, solenoid valves, pressure reducer, check valves, restrictors, and associated lines. Second stage hydraulic pressure is supplied to the primary tandem servocylinders at 3000 psi; a pressure reducer supplies 1000 psi pressure to the AFCS tandem servocylinders. The second stage system has identical electrical connection and pressure switch provisions as in the first stage system to protect against shutdown if the other system loses pressure.

c. The utility hydraulic system provides flight control power assistance to the inboard cylinder of the rotary rudder tandem servocylinder, and to the remaining stage in the forward-and-aft and the lateral AFCS tandem servocylinders. It consists of a reservoir mounted forward of the main gearbox, a 3000 psi discharge pressure pump located on the accessory gearbox, a manifold, filter, shutoff valve, pressure reducers, and associated lines. Pressure reducers supply 1000 psi pressure to the AFCS servocylinders and 1500 psi pressure to the rotary rudder tandem servocylinder. If pump pressure falls to less than 2000 psi, a pressure-operated priority valve

within the utility hydraulic manifold closes to assure servocylinder operation in preference to other systems powered by the utility system.

A functional arrangement of these systems is shown in Figure 9.

In addition to the above flight control functions, the utility hydraulic system also provides hydraulic power for the following systems: blade fold, pylon fold, wheel brake, landing gear, overhead door and ramp, engine start, cargo winch, and auxiliary powerplant (APP).

Each of the flight control primary tandem servocylinders consist of two independent cylinders, but sharing a common housing, piston shaft, and input linkage. The top (outboard) cylinder and bottom (inboard) cylinder are powered by separate hydraulic systems, with each system capable of normal operation without increase of control forces if the other system is not operating. Bypass valves interconnecting both stages of the power piston preclude hydraulic lock under these circumstances, allowing the unit to act as a mechanical link.

The AFCS forward-and-aft and lateral servocylinders are tandem units also. Both stages of each servocylinder share a common input and a common stop eliminator. If a servo valve should bind, a shear pin in the linkage shears and allows the alternate stage to operate, with separate bypass valves incorporated for each stage.

Each hydraulic system incorporates a pressure indicating system. Warning of pressure loss is accomplished by illumination of cockpit warning lights signalling "1ST STG SERVO OUT" (for first stage hydraulic system failure), "2ND STG SERVO OUT" (for second stage hydraulic system failure), and "2ND STG TAIL ROTOR SERVO" (for utility system failure).

Table E-IV presents a summary of reported hydraulic system hits. There were 18 such hits, and all but three produced leaks. Two incidents of hydraulic system damage each involved two hits on separate components; therefore, the total incidents of hydraulic system damage

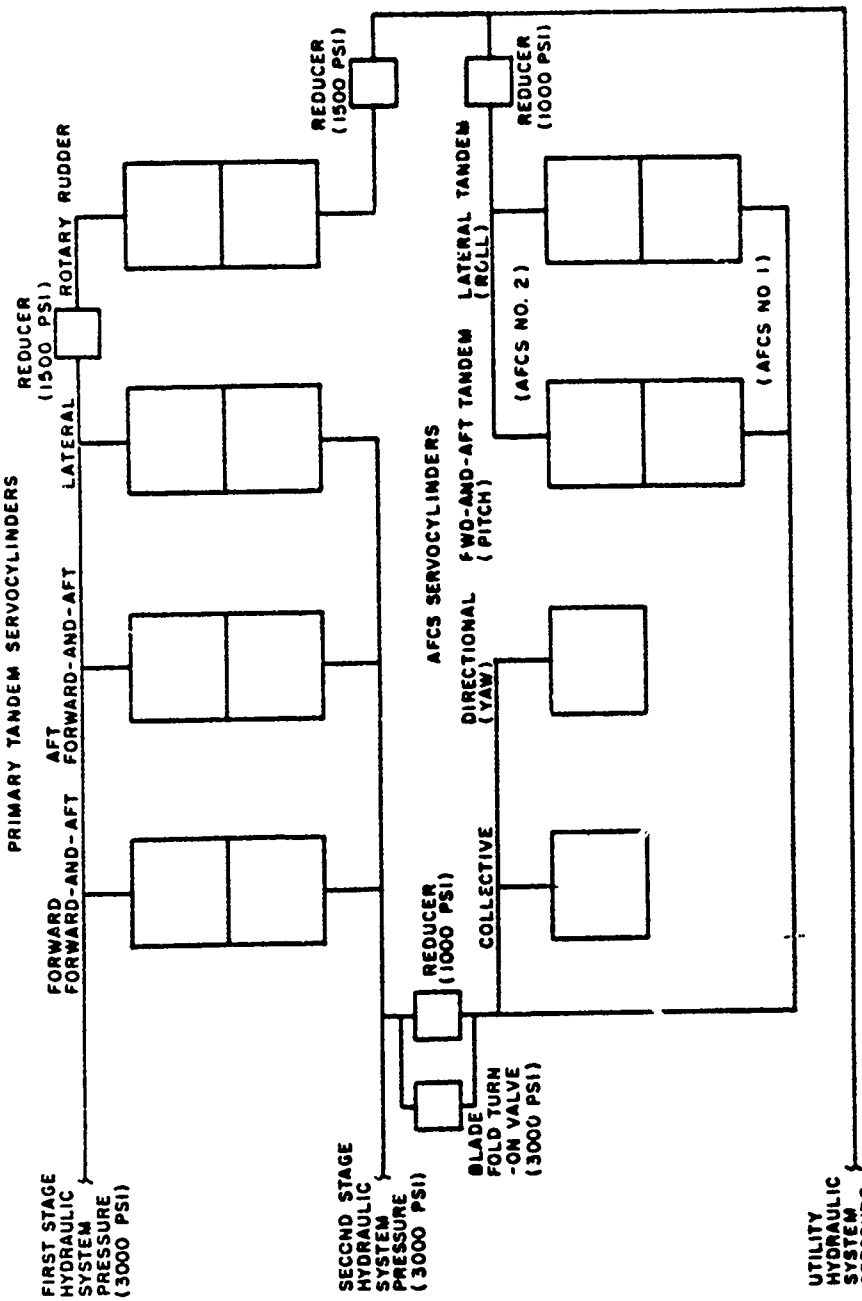

Figure 9. (U) Flight Control Hydraulic Systems (U)

was 16. Just under one-third (5) of these incidents produced adverse reactions: two mission aborts and three forced landings. (One aircraft was not recovered.)

5.7.1 First Stage Hydraulic System. The first stage hydraulic system was hit twice and both hits led to forced landings with the aircraft being recovered later. One hit severed a line and the other damaged an unspecified component.

In a third incident, loss of pressure in the first stage system and utility system led to an emergency forced landing in enemy territory, from which the aircraft was never recovered.

The case involving a broken line on a CH-53A (Case 70237) resulted from secondary damage by a fragment generated when a nearby drive shaft coupling was struck by a caliber .30 bullet. Loss of pressure caused a precautionary forced landing.

In the second case (Case 80064) a CH-53A was hit by a caliber .30 bullet while at an altitude of 2200 feet during a rescue mission, and the crew chief observed a fire in the tail section. Reversing course, the pilot began to descend as first stage hydraulic pressure fell to zero. Then intense fire was received from the intended landing site, and the approach was aborted. A second landing site 500 meters away was chosen and the landing gear was lowered. Just prior to touchdown, all control system response appeared to be lost, and the aircraft rotated 90 degrees to the right. The aircraft was then secured and evacuated. The reported fire was apparently minor and did not last significantly long. The helicopter was later recovered.

In the third incident (Case 90054) a HH-53B was en route from a rescue pick-up when it was hit by a 37mm projectile on the left side above the ramp. The projectile exploded, mangling the rear gunner's leg and tearing a large hole in the opposite side of the fuselage. A caliber .30 bullet hole in the floor was also noted. Utility hydraulic pressure was lost immediately, followed minutes later by loss of first

stage pressure, and tail rotor response was lost. At the time, altitude was 150 feet AGL; indicated airspeed was 150 knots. Flight continued one-quarter mile and into a 90 degree left turn in preparation for a landing in a clearing, and a shallow normal approach was made with "little or no collective or rudder changes necessary." After flare as power was eased on, the aircraft began a slow right turn (although full left rudder was applied). Touch-down was smooth at five knots ground speed and the aircraft rolled about 200 feet down a gentle slope before being stopped with aft cyclic and non-powered brakes. The crew and survivor were quickly rescued by another HH-53, but the damaged aircraft was not recovered due to its location.

5.7.2 Second Stage Hydraulic System. The second stage hydraulic system was hit three times in two incidents, resulting in one forced landing and one mission abort.

In Case 80045, fragments from an AAA HE projectile struck a second stage servo and a line. Damage to the servo did not produce a leak, but the line was punctured and second stage hydraulic pressure was lost. The mission was aborted, but a safe return flight followed.

In Case 80081, one of 30 hits by caliber .30 bullets damaged an unspecified hydraulic system component(s), with subsequent loss of second stage servo pressure and fluctuating first stage servo pressure. The pilot was forced to land at a nearby friendly position, where emergency repairs were performed before a return flight was accomplished.

5.7.3 Utility Hydraulic System. The utility hydraulic system was damaged by ten hits in a total of nine incidents. A single mission abort was the only adverse reaction resulting from damage to this system. Utility hydraulic pressure was lost when damage occurred to the utility hydraulic reservoir and heat exchanger, and also lines serving ramp actuators, APP, cargo winch, and landing gear brakes; however, flight and mission were not affected by the damage. The mission abort came about when a caliber .30 bullet struck and penetrated the tail rotor tandem servocylinder; however, a safe return flight

(distance unknown) was accomplished with first stage hydraulic power operating the outboard unit in the damaged tandem servocylinder*.

5.7.4 Other Hydraulic Systems. In addition to the above, damage by a caliber .50 bullet was reported occurring to an unspecified component in an unspecified flight control hydraulic system. The incident (Case 90034) resulted in a forced landing in the field, but hydraulic system damage was not the primary cause.

One additional incident is included in the category involving hydraulic system damage; however, flight controls were not involved. In Case 80014 a caliber .30 bullet struck the hydraulic reservoir serving the main rotor brake and caused a loss of fluid. The main rotor brake does not include pump-pressurized components, and therefore, the damage had no effect on flight or mission.

5.8 Electrical System

Table E-V presents a summary of electrical system hits. There were eleven hits in a total of ten incidents. Eight of the eleven hits caused damage to wiring alone. The pilot's and copilot's circuit breaker panels were each hit once and another hit damaged an unspecified electrical compartment. All hits were caused by bullets.

In eight of the ten incidents, the damage did not affect flight or mission. The other two incidents involved a mission abort and a forced landing; however, these reactions were caused by damage to other systems, and the electrical system damage (severed intercom wires and AFCS wiring) was not sufficient cause in itself to produce an adverse reaction.

5.9 Avionics Systems

Table E-VI presents a summary of the eight reported hits in this

* Similar damage was reported occurring to a CH-54 Flying Crane, which incorporates basically the same flight control hydraulic systems. Among other damages, a tail rotor hydraulic line was cut. After the pressure and return lines in the affected system were blocked off, the aircraft was capable of flight to home station for further repairs.

category. Four produced damage to antennae and couplers; four others hit the radio compartment. In all cases, flight was continued and the missions were completed.

5.10 Instrument Systems

Table E-VII presents a summary of results from hits on instruments. Five hits were reported.

In Case 70266, one of six bullets hitting the aircraft shattered the copilot's torque meter and cruise guide, without affecting flight or mission.

In Case 80008, wide-spread damage by 22 individual caliber .30 bullets caused a mission abort. Instruments damaged in this encounter included the pilot's directional indicator and radar altimeter, the J-4 compass, and the doppler radome. Damage to these components was not critical during the return flight.

5.11 Landing Gear System

Table E-VIII presents a summary of five hits on the landing gear system. Bullets deflated a nose gear tire and lodged in a nose gear wheel, and perforated main and nose gear struts without causing mission problems or being detrimental to landings upon return. The landing gear in these cases functioned normally when lowered for landing.

(A wheels-up landing was reported in Case 80054, but was not caused by damage to the landing gear. The incident resulted in antenna and fuselage skin damage and was caused by a hurried forced landing after control rods were damaged by ground fire. Refer to Section 5.6 for discussion.)

5.12 Miscellaneous Equipment

Table E-IX presents hits on miscellaneous equipment on board the aircraft. None of these 16 hits caused an adverse reaction.

5.13 Armor

The USMC CH-53A is equipped with DPSA-2 dual property steel (MIL-S-46099) pilot's and copilot's seats and DPSA-2 armor panels intended to protect the compressor and accessory section of both engines and the flight control hydraulic reservoirs. Figure 10 shows CH-53A armor panels.

The USAF HH-53B is fitted with the same DPSA-2 pilot's and co-pilot's seats as on the CH-53A. Engine and hydraulic reservoir armor, however, are 6AL4B titanium sheet, (MIL-T-46077). Additional titanium armor plates are provided to protect numerous other critical components, including: lube oil coolers, main and accessory transmissions and intermediate gearboxes, primary AFCS servocylinders, flight controls, directional controls, and fuel cell sumps. In addition, titanium panels are installed in the lower nose and cockpit floor. Figure 11 illustrates this configuration.

All CH-53A and HH-53B armor is designed to protect against caliber .30 Ball bullets. It is suspected that the seat, engine, and reservoir armor was installed on CH-53A's upon or shortly after introduction in RVN. HH-53B armor was installed at the time of introduction.

Reported hits on armor are presented in Table E-X. A total of eight reports specified 11 individual hits on armor. These hits break down to eight hits on engine armor, one hit on copilot's seat armor, one hit on hydraulic flight control servo armor, and one hit on an improvised flak "skirt" arrangement. Six of the eight cases involved CH-53A's, all of which involved hits on DPSA-2 engine armor. These installations successfully stopped caliber .30 bullets six times, including two caliber .30 hits on the same armor panel. A seventh hit, by a caliber .50 API bullet, caused an armor "failure," although the bullet failed to hit the engine. Coming from almost directly under the helicopter, the bullet struck the edge of the panel, perforated one of the mounting brackets, passed between the engine and the inner wall of the panel, exited through the top of the nacelle, and broke up against the rotor head.

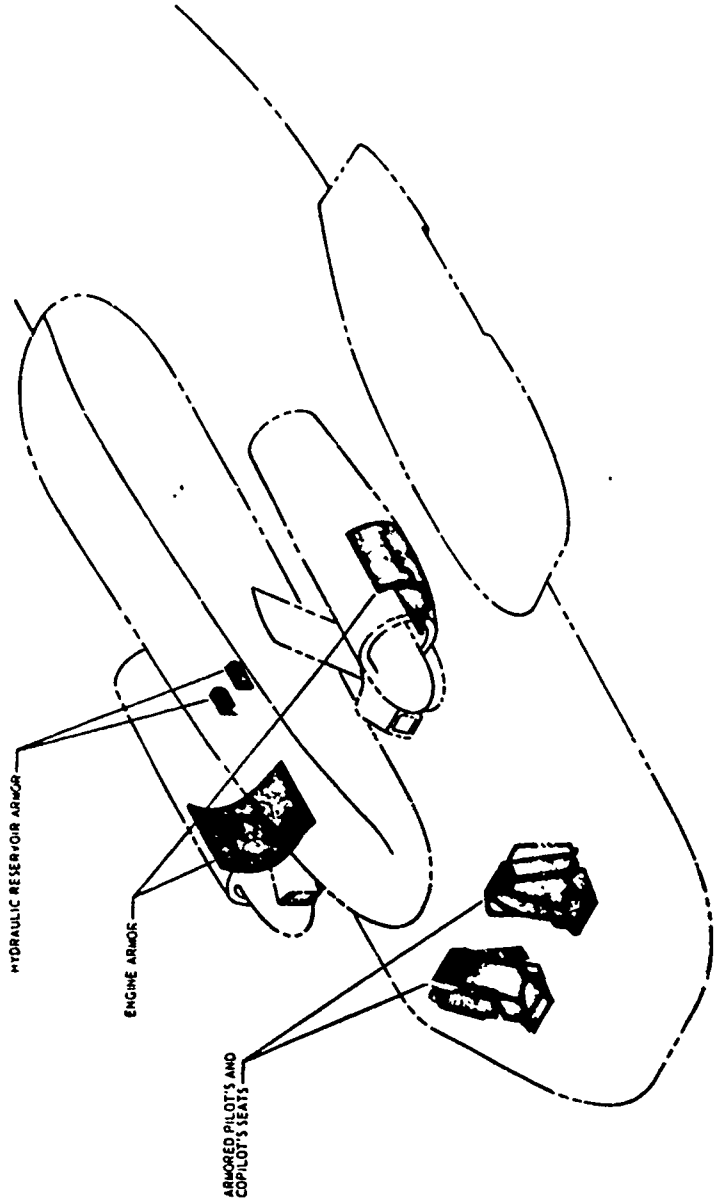

Figure 10. CH-53A Armor.

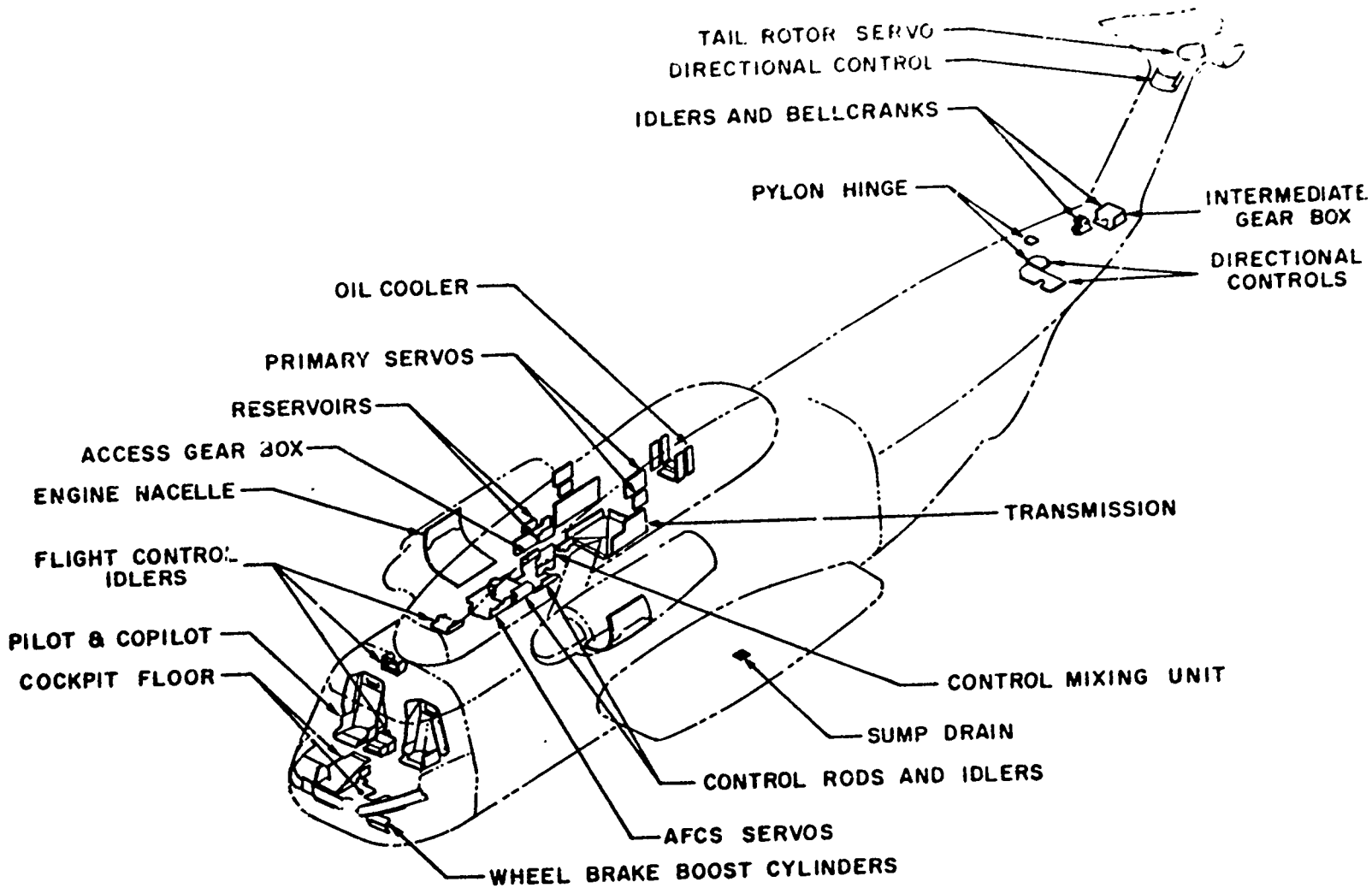

Figure 11. HH-53B Armor.

The eighth engine armor hit was included among three separate armor panels reported hit in one of the HH-53B incidents. A caliber .30 bullet and a fragment from an unknown size AA proximity-fused HE projectile were successfully stopped by the copilot's DPSA-2 seat armor and titanium engine armor, respectively; however, an additional fragment bounced off the titanium lateral servo armor and severed two hydraulic lines serving the unit, and also a number of electrical wires. The immediate purpose of the armor was accomplished, but the intent was not fulfilled because the mission was aborted when the line damage ultimately resulted in loss of second stage hydraulic pressure.

In the remaining HH-53B incident, a caliber .30 bullet passed through the fuselage floor and stopped against a flak skirt on which the tail gunner was standing.

(CONFIDENTIAL) 6. LOSSES AND ADVERSE AIRCRAFT REACTIONS

Appendix F presents reported data relative to CH/HH-53 losses and crashes, forced landings, and mission aborts.

6.1 Losses and Crashes

Data available to BRL place CH/HH-53 losses from introduction in 1967 through June 1969 at nine helicopters — eight CH-53A's and one HH-53B. These incidents are compiled in Table F-I with known details Six of these cases, however, were judged by investigators as pure accidents with no evidence of battle damage involved; four were caused by pilot error and two by materiel failures. A seventh aircraft was destroyed in a mortar attack while parked on the ground. These aircraft losses are not included in this report; accident analysis is beyond the scope of this study.

The remaining two losses involved operating aircraft. They were caused by combat damage and are relevant to this study. One was a USMC CH-53A, the other a USAF HH-53B.

The CH-53A crash (Case 80035) occurred when the helicopter received a direct hit in the transmission section from a "direct fire weapon" just prior to take-off. The aircraft flew about 90 feet down the runway, relanded, and rolled off the runway, whereupon the tail pylon folded into the main rotor blades, and the aircraft separated into three sections. The cabin section was extensively damaged and a post-crash fire was reportedly extinguished. The pilot and copilot were killed; three other crewmembers were injured but survived the crash. The exact weapon size and type, and the kind of damage inflicted were not specified in available reports; however, it is evident that control system damage occurred, thus critically impairing controllability of the helicopter during the attempted take-off and causing an uncontrolled hard landing with major structural damage. Systems damaged probably included, but were not necessarily limited to, rotary rudder controls, and impact was apparently in an excessively nose-down attitude. The decision to procede with the take-off attempt after being under fire and receiving a hit might be considered unwise, but other possible alternatives could have been equally hazardous.

The HH-53B loss (Case 90054) was not a crash, but was the result of an emergency forced landing in enemy territory where recovery was impossible. The case is described in Section 5.7. It was caused by a 37mm projectile which exploded within the fuselage and tore out numerous hydraulic lines and/or components, leading to loss of utility hydraulic pressure, then first stage pressure. The aircraft was landed safely without tail rotor control and was abandoned.

Both losses were caused by damage leading to impaired controllability. Threat in both cases was estimated or implied to be greater than caliber .30.

6.2 Forced Landings

Table F-II presents the synopses of 15 reported forced landings occurring during the study period. They included 13 CH-53A's and two HH-53B's. The following is a breakdown by damage cause:

Cause	Number of Forced Landings
Hydraulic System	4*
Engines	2**
Mechanical Controls	2
Fuel System	2***
Precautionary (minor damage)	2
Transmission Oil	1
Main Rotor System	1
Unknown Damage	1
TOTAL	15

* Includes 2 cases with double-system kills.
** Single-engine failure in both cases.
*** One with single-engine fuel starvation; one with large loss of fuel supply.

The leading cause of CH/HH-53 forced landings was loss of hydraulic pressure powering flight control systems. There were four cases in this category:

a. Case 90054 - A loss; discussed in Sections 5.7 and 6.1.

b. Case 80064 - Involved loss of first-stage pressure and fire in the tail section. After pressure-loss, aircraft controllability was sufficient to reverse course, approach and retreat from the landing zone, fly 500 meters to an alternate landing zone and land safely. (Fire was apparently minor in nature.)

c. Case 80081 - Involved loss of second-stage pressure and fluctuating first-stage pressure. After pressure-loss aircraft controllability was sufficient to land at a friendly position, where emergency repairs proved sufficient to allow a safe return to home base.

d. Case 70237 - Involved loss of first-stage pressure. After pressure-loss, aircraft controllability was adequate to make a precautionary landing, followed probably by in-field repairs.

Damage to mechanical flight control elements led to two forced landings. Both cases involved flight control rod damage. In Case 80054, caliber .50 bullet caused near-severance of two unspecified control rods; under partial control, the pilot made a very hasty landing with the landing gear retracted. Damage was light. In Case 90027, in addition to other less critical damage, caliber .30 bullets damaged two unidentified control rods, apparently without critically hampering controllability. The pilot elected to land the aircraft at that location and terminated the flight until repairs could be made.

Despite armor protection, two CH-53A's were forced to land after bullets struck an engine and caused engine failures. In Case 80006, a caliber .30 bullet killed the left engine, and the aircraft continued on single-engine power to a secure zone to land. In Case 90043, a caliber .50 bullet struck the right engine and killed it, while additional damage to the tail section occurred by fragments from a nearby B-40 rocket blast. In the latter case, the aircraft was hovering 20 feet above the ground in preparation to land when the hits and engine failure occurred; the landing was completed under single-engine power.

Damage to fuel system caused two forced landings. In Case 90020, a caliber .30 bullet cut a fuel line in the left sponson, and the left engine failed because of fuel starvation. Flight was continued on single-engine power as the aircraft retired to a secure base. In Case 90050, caliber .30 bullet-damage to unspecified elements of the fuel system caused fuel leakage and a subsequent forced landing.

Additional forced landings caused by systems damage include: Case 80101, involving oil leakage from a caliber .30 bullet-damaged main transmission (flew to secure zone and landed); and Case 70276, involving three caliber .30 bullets impacting somewhere in the main rotor system (forced to land/no details).

In addition to the twelve above-mentioned forced landings brought about by specific systems damage, one more came about after unspecified damage occurred in the cockpit, although no casualty was involved; and two more developed as precautionary landings after insignificant bullet damage occurred in the cabin section.

6.3 Mission Aborts

Fifteen mission aborts were reported for CH/HH-53's during the reporting period; these cases are presented in Table F-III. The total includes three HH-53B's and 12 CH-53A's. The following is a breakdown by damage cause:

Cause	Number of Mission Aborts
Precautionary (minor damage)	3
Fuel System	3
Hydraulic Systems	2
Mechanical Controls	1
Main Rotor System	1
Cargo Hook	1
Not Directly Caused by Damage	3
Unknown Damage	1
TOTAL	15

Fuel tank leakage caused three of the mission aborts; flight control hydraulic system damage caused two more. Control system damage and main rotor damage caused an additional two, and damage to the cargo hook (while carrying a load) caused another.

In addition to the above eight aborted missions caused by systems damage, two were aborted because of ground fire intensity in a "hot" landing zone, and three were aborted as a precaution after minor bullet damage occurred. Another mission remained incomplete when a CH-53A helicopter began evasive action when it came under fire, but started to lose control when the sling load began to oscillate. To

regain control, the load (7600 pounds of ammunition) was jettisonned and broke up on the ground, thus terminating that mission. Finally, one mission was aborted for unspecified reasons and damage.

(CONFIDENTIAL) 7. CASUALTIES

Casualties caused by bullets, fragments, and shrapnel were reported in 29 of the 345 incidents. Total casualties from these causes numbered 35, as one incident involved wounds to four passengers, one involved coincident wounds to the pilot, copilot and gunner, one involved wounds to the gunner and copilot, and the remaining 26 cases involved wounds to single individuals. These break down as follows:

Table V. (C) Wound Casualties Aboard CH/HH-53 Helicopters (U)

Personnel	Number Wounded	Type of Wounds
Pilot	2	One foot wound when caliber .50 bullet [illegible] pedal; another, arm laceration.
Copilot	4	Two minor foot wounds; one shrapnel wound; one leg wound.
Crew Chief	3	Two very serious, one minor, all by caliber .30 bullets.
Gunner	8	All minor-to-serious wounds by caliber .30 bullets and shrapnel.
Passenger	13	One serious; all by bullets including four passengers wounded by one caliber .50 bullet.
Unspecified	5	No details.
TOTAL	35	

The toll taken in the crash caused by ground fire (Case 80035) was two fatalities and three injured, however, combining these casualties with those from the five crashes judge to be pure accident (from Table F-I) produces an average of 8.9 fatalities, or 15 injured and killed per crash.

It is noteworthy that no CH/HH-53 mission aborts were caused by casualties, according to reported information. Similar studies on

other helicopters show casualties usually [illegible] half of the mission aborts.

The near-absence of wounds by metal debris from impacts in the cockpit section may have been attributable in part to the extensive use of fiberglass for fuselage skin and panels in the cockpit.

(CONFIDENTIAL) 8. FREQUENTLY HIT AIRCRAFT

In maintaining their respective number of assigned aircraft the services transferred CH/HH-53's to and from the SEA theater. A count of helicopters in this data sample by individual reported serial numbers yields a total of 76 separate aircraft. Most were hit on more than one occasion, but certain ones were reported hit more frequently than others. Ten individual aircraft — all CH-53A's — accounted for 33 percent of the reported hits (and sorties hit) within the study period. To indicate to some extent the survival potential of the CH-53A in its combat role, individual combat histories of these aircraft are synopsized below:

S/N 153276 was hit on 13 occasions by 18 hits, for one mission abort, between May 1967 and 3 March 1968. It was destroyed while parked at home base during a mortar attack on 5 March 1968.

S/N 152408 was hit on 18 occasions by 40 hits, without an adverse reaction, between February 1967 and December 1968.

S/N 152409 was hit on 14 occasions by 37 hits, without an adverse reaction, between January 1967 (first reported hit) and April 1969.

S/N 153277 was hit on 12 occasions by 35 hits, without an adverse reaction, between May 1967 and Feoruary 1968.

S/N 153714 was hit on 10 occasions by 25 hits, for one forced landing, between November 1967 and December 1968.

S/N 151698 was hit on 9 occasions by 21 hits, without an adverse reaction, between August 1967, and April 1969.

S/N 153290 was hit on 8 occasions by 18 hits, without an adverse reaction, between May 1967 and April 1968.

S/N 153707 was hit on 8 occasions by 10 hits, without an adverse reaction, between November 1967 and February 1969.

S/N 154880 was hit on 6 occasions by 37 hits, for one forced landing, between March 1969 and June 1969.

S/N 153713 was hit on 6 occasions by 11 hits, without an adverse reaction, between November 1967 and April 1968.

(CONFIDENTIAL) 9. MAJOR OBSERVATIONS

The number of CH/HH-53 helicopters in use in the Vietnam theater during the study period was relatively low, averaging a little over 30 CH-53A's and about 6 HH-53B's. During the 30-month period studied, 345 sorties were reported hit by a total of 834 hits.

The CH-53A was used by the USMC for cargo and resupply missions and as a troop transport. Such usage required engagement with the occasionally heavy ground fire characterizing the in-country threat. The HH-53B was used by USAF in rescue missions, which entailed long periods of orbiting in a safe area while awaiting rescue assignments, which were fighter-escorted dashes, usually into the out-country environment with its higher threat levels. These large helicopters are expensive and for those operating as troop carriers, a relatively large number of lives depended on their safe operation; therefore, the craft did not "stand and fight."

"Hot" landing zones were encountered on occasion, and large HE projectile threats were a constant risk during rescue recoveries, but prudent policies apparently governed operations with these aircraft, and such exposures were accepted only with the intention of minimizing exposure time.

Despite the smallness of the data sample generated by the proportionately small number of aircraft, analysis discloses the following observations:

a. Just over one-third of the cases occurred in or near the landing zone; and, in keeping with prudent policies regarding exposure to "hot" pick-up and landing zones, a majority (55 percent) of the sorties hit occurred en route. Seventy percent of those hit en route (or 47 percent of all sorties hit) occurred above 1000 feet in altitude, and 59 percent of all sorties hit occurred at airspeeds above 75 knots. These data compare closely to like information on the CH-54 and are in distinct contrast to data on smaller helicopters.

b. The above factors are derived from the total sample, which is 97 percent CH-53A data. As such, they serve to explain in part why the average number of hits per CH-53A sorties hit was 2.27 — a relatively low average for a target as large as this aircraft. This was evidently accomplished by avoiding concentrated firepower when possible, thereby limiting hits as much as possible to those taken while traveling at cruise speeds and at higher altitudes. In this respect, however, the HH-53B did not fare as well in its mission, averaging 7.89 hits per sortie hit. Overall average for all cases was 2.42.

c. On a basis of average number of hits per sortie hit, the urgent, motivated rescue missions proved most hazardous at 7.5 hits per incident for both models. The relatively frequent sling-recovery missions were also hit heavily, averaging 3.2 hits per incident. In contrast, two-thirds of all the incidents involved resupply missions with onboard cargo, and these averaged just 2.0 hits each, when hit.

d. The USMC CH-53A was frequently carrying an external cargo by a sling when it encountered ground fire. The CH-54 studies indicated the sling load partially shielded the bottom of the aircraft, but the advantage was more than offset by a reduction in evasive maneuverability leading to the above-mentioned higher average number of hits when under such circumstances. CH-53A data tend to support this observation, and reported accounts definitely confirm the reduction in evasive maneuverability.

e. Threat encountered by the USMC CH-53A (336 cases/763 hits) was caliber .30 bullets most often fired by rifles. Including duplications

to account for mixed-threat incidents, threat was comprised of 88 percent caliber .30 weapons, 8.5 percent caliber .50 weapons, and 5 percent mortars and explosive projectiles. On a basis of total hits, the reported cases involved 78 percent caliber .30, 12 percent caliber .50, and about 10 percent fragments from mortars and projectiles.

f. Threat encountered by the USAF HH-53B in three percent of the total cases, (9 cases/71 hits) involved caliber .30 weapons in every instance, with 22 percent of the HH-53B cases (2 cases) involving additional hits by AAA projectile/fragments. On a basis of total hits, 68 percent were caliber .30, one percent was 37mm, and 31 percent were fragments, although all of the latter occurred in one incident.

g. Two-thirds of the 30-month sample of hit-incidents occurred in the last half of 1967 and the first half of 1968, with a downward trend in activity thereafter, but HE projectile incidents increased markedly at the end of the period, with over half occurring in the first quarter of 1969. The rate of caliber .50 incidents rose similarly. Compared to the overall average of 2.42, the average number of hits per sortie hit was just under 2.0 in 1967, but increased steadily to just over 3.0 at the end of the study period.

h. For reasons not revealed in reviewing combat damage reports, a preponderance of hits were received from the front and right side directions for all weapons encountered. Hits were relatively uniform in distribution by aircraft section in proportion to presented area.

i. Ground fire caused two losses during the study period — one CH-53A and one HH-53B. Hydraulic system damage (and pressure loss)and subsequent losses in controllability were cited in the HH-53B loss and strongly suspected in the CH-53A loss. The HH-53B did not crash; it was forced to land where recovery was impossible after a direct hit by a 37mm projectile. The crew and a passenger were rescued. The CH-53A loss was the result of a crash occurring during an unsuccessful take-off attempt following damage by a "direct fire" weapon of unknown size while on the ground. The latter case caused two fatalities and

three injuries. If, however, all crashes, including accidents, are considered, CH/HH-53 crashes averaged 8.9 fatalities or 15 injured and killed combined.

j. Fifteen forced landings (including the above-mentioned loss) were caused by ground fire damage. Seven were true emergencies with urgent need to land quickly under imminent threat of control loss or main transmission failure. Involved were damaged mechanical control rods, loss of primary flight control hydraulic pressure, and transmission oil leakage. Three other forced landings followed single-engine flights to secure areas after bullet-damage caused an engine to fail; two involved direct hits on the affected engines by bullets, the third involved a cut fuel feed line and fuel starvation(fuel cross-over procedures were not reported employed). The remaining five forced landings were more or less precautionary in nature. Caliber .30 bullets were capable of producing all of the above causes.

k. The fifteen reported mission aborts were caused by fuel cell and tank leakage, lost hydraulic pressure, and various other damage to the aircraft. Mission aborts caused by casualties aboard the aircraft were notably absent, although a few reports citing casualties may reflect an oversight in this respect,or else casualties were taken after mission completion.

l. General observations regarding results of damage to the major systems were as follows:

Main and tail rotor. These components proved capable of absorbing damage by caliber .30 (7.62mm) and caliber .50 (12.7mm) bullets and by fragments, including hits on blade spars, without significant degradation of flyability.

Fuel system. The CH/HH-53 engine supply lines, which operate under a suction head, reportedly received bullet damage twice with a minimum of fuel leakage and no fires. One case resulted in engine fuel starvation; in the second, the engine continued to operate.

Self-sealing fuel cells often, but not always, sealed after bullet damage; loss of fuel from non-self-sealing auxiliary tanks caused two mission aborts by UH-53B's.

Powerplant. Vulnerability tests on the T64 engine show the compressor section, and lines and components of the engine fuel and oil systems are vulnerable to caliber .30 (7.62mm) and larger bullets, and to fragments from 37mm projectiles and mortar rounds. Despite armor protection for these areas on CH-53A's and UH-53B's, calibers .30 and .50 bullets were able to hit and kill engines without encountering the armor. On the other hand, at least four successful (but short) flights were accomplished on single-engine power. None of the combat damage reports cited an in-flight engine-fire or employment of the fire extinguishing systems. (Accident data, however, reveals a case in which a bearing failure in one engine caused an in-flight fire which led to crash-destruction of the aircraft and five fatalities). Bullet damage to the engine air particle separator (EAPS) barrels did not critically damage any engines, but caused ingestion damages sufficient to warrant engine changes.

Hydraulic systems. Damage to the numerous lines and components in the three hydraulic systems in the aircraft usually resulted in puncture and loss of pressure, as would be expected. Loss of utility system pressure occurred most frequently and was usually tolerated, without landing prematurely. Loss of pressure in the first stage or second stage systems was the leading cause for forced landings, despite use of tandem servocylinders in the critical flight control elements and the provisions for mutual back-up by the two systems. Despite the redundancy, lack of adequate separation between many parts of the independent systems allowed simultaneous malfunctions of two; loss of hydraulics was considered at least a possible cause in both ground-fire-caused losses. Two minor in-flight fires were also attributed to damaged hydraulic lines or components.

It is generally axiomatic that damage to the ballistically easy-to-defeat primary hydraulic systems is increasingly critical in proportion to aircraft size, or more specifically, in proportion to the degree of reliance on power-assistance against larger aerodynamic forces. Moreover, probabilities of fire after damage are generally greater with higher operating pressures. In these respects, the CH/HH-53 (and the CH-54) carries a disadvantage not found on smaller craft with lighter aerodynamic forces.

Mechanical control system. Critical CH/HH-53 mechanical flight control elements, with the exception of the tail rotor control cable, appeared to be reasonably safe in the caliber .30 (7.62mm) environment; however, caliber .50 (12.7mm) bullets proved capable of critical damage to flight-critical control rods. Many of these rods and other elements are grouped closely together and proved vulnerable, in at least one case, to double-component damage and its accompanying possibilities of compound controllability problems.

Transmission system. Reported data regarding hits on the various transmissions and associated drive shafts indicate these items are safe from catastrophic failures in the environment of 7.62mm bullets and individual fragments from projectiles; i.e., these threats do not appear capable of shearing driveshafts of this size, or of destroying gearing within the transmissions and gearboxes driving the main and tail rotor systems. Damage resulting in holes in the casings of these units, and damage to the lines and components in the lubrication oil systems serving these units, usually resulted in loss of oil, as expected. Under such circumstances, a forced landing almost certainly resulted.

Armor installation. A significant weight penalty was paid to protect the CH-53A and HH-53B engines, hydraulic reservoir area, pilot,

* Time-to-die criteria have not been determined for oil-starvation of the CH/HH-53 main transmission and tail rotor gearboxes. Laboratory vulnerability tests on the CH-53A nose gearbox resulted in failure of the input bearing following 10 minutes of operation after loss of oil. By experimental bearing-package modification this time was extended to 35 minutes.

and copilot from 7.62mm Ball bullets (and from most non-direct hit fragmentation threats). Reported data suggest the following:

1) Engine armor stopped at least eight hits from probably striking an engine, but allowed at least two hits to do so without encountering the armor. These panels protect the highly vulnerable left engine fuel system and compressor from the outboard side and bottom directions, but do not fully protect them from frontal and rearward attack, and the turbine section and associated oil lines are left exposed. As a partial measure, this armor protected the engines as well as possible.

2) Hydraulic reservoir armor was not reported hit, but the reservoirs were emptied a significant number of times when primary flight control hydraulic system lines were cut. Presumably, reservoir damage is held to be more critical than line damage because the former drains the system immediately, while the latter leaves a limited number of stick maneuvers available from the reservoir fluid supply before power-assist is lost, or until an alternate system is employed. Loss of hydraulics, however, was cited in both losses and caused several hurried emergency forced landings.

3) Pilot and copilot seat armor apparently paid off, although only one seat hit was reported (without injury). Six minor wounds were reported occurring to pilots' and copilots' arms, legs, and feet. On the other hand, unprotected crew chiefs and gunners took 11 hits of which two were possibly fatal. Unprotected passengers accounted for at least 13 wound-casualties, being hit in various areas of the body, and at least one of these was possibly fatal.

The USAF HH-53B was fitted extensively with additional armor to protect a multitude of hydraulic and mechanical control and drive components and other vital areas. Out of a total 71 HH-53B hits, only one is reported to have hit any of this additional armor. A projectile fragment struck an armor panel covering a hydraulic valve body and failed to penetrate, but it bounded off the panel and cut hydraulic lines serving the unit, thwarting the intended purpose of the armor. Other systems provided with some degree of armor protection on the HH-53B were also hit by ground fire.

Based on all reported data, various "risks," or rates of various occurrences, are presented for the USMC CH-53A in Table VI and for the USAF HH-53B in Table VII.

Table VI (C) CH-53A Combat Risk for January 1967 through June 1969 (U)

	Flying hours	Sorties Flown	Combat Sorties	Sorties Hit	Hits
Per Flying Hour	1	2.86	2.44	.0083	.0188
Per Sortie Flown	0.35	1	0.85	.0029	.0066
Per Combat Sortie Flown	0.41*	1.17	1	.0034	.0077
Per Sortie Hit	121	345	295	1	2.27
Per Hit	53.2	152	130	0.44	1
Per Caliber 0.50 Hit	418	1196	1021	3.46	7.87
Per Mission Abort (or worse)	1560	4461	3811	12.92	29.35
Per Forced Landing (o worse)	2898	8286	7077	24.0	54.50
Per Combat Loss	40,572	115,997	99,073	336	763
Per Combat Casualty	1268	3625	3096	10.5	23.8

This value is a ratio, not an average time for this type of sortie.

Table VII (C) HH-53B Combat Risk for September 1967 through June 1969 (U)

	Flying Hours	Sorties Flown	Combat Sorties	Sorties Hit	Hits
Per Flying Hour	1	.479	.331	.0015	.0115
Per Sortie Flown	2.09	1	.691	.0030	.0240
Per Combat Sortie Flown	3.02*	1.45	1	.0044	.0348
Per Sortie Hit	685.4	328.2	226.9	1	7.89
Per Hit	86.89	41.61	28.76	.127	1
Per Caliber 0.50 Hit		None were reported			
Per Mission Abort (or worse)	1234	591	408	1.80	14.2
Per Forced Landing (or worse)	3085	1477	1021	4.5	35.5
Per Combat Loss	6169	2954	2042	9.0	71
Per Combat Casualty	2056	985	681	3.0	23.7

* *This value is a ratio, not an average time for this type of sortie.*

(CONFIDENTIAL) 10. COMMENTS ON PASSIVE DEFENSE

Complete assessment of vulnerability of the CH/UH-53 helicopter is not the purpose of this study; however, certain relevant factors are revealed in the combat damage information and are discussed below.

On the basis of reported data for operations, damage, and losses, the H-53 series helicopters produced an admirable survivability record in the RVN ground fire environment. The aircraft (USMC CH-53A's in 97 percent of the cases) were exposed to as severe a threat spectrum as other, smaller helicopters, but their rate of loss from ground fire (per sorties flown and sorties hit) was markedly lower. Only two were lost to ground fire, and neither was lost to the principal RVN threat, 7.62mm weapons (although the possiblity certainly exists). Moreover, neither loss was directly "shot down" in the usual sense; both developed from circumstances after hits were taken.

Undoubtedly some operational factors contributed substantially toward accomplishment of this record. For example, at least for the CH-53A, "hot" landing zones were often avoided; more aggressive missions, including escorting the larger craft, were undertaken by the smaller UH-1 gunships and Cobras. Prudent operational policies prevented many hits and held down the average number of hits in an incident. Thus, when hit, the CH-53A frequently was operating with considerable altitude and airspeed where, despite the encumbrance of a sling-load, conditions were more favorable for maneuvering and safe recovery if difficulties resulted from ground fire hits. Differences in operational policies not withstanding, analysis of combat damage effects shows that users of the CH-53A (and CH-54) enjoyed substantially more favorable loss rates and reactions to systems-damage than those for users of the smaller helicopters (such as the UH-1D/H and CH-46) doing similar jobs in the RVN combat environment. A number of reasons are apparent.

On a large helicopter passive defense is enhanced by many components which are inherently low in vulnerability just because of their size;

e.g., larger rotor blades and blade spars, transmission gears and shafts, and driveshafts simply require larger bullets to accomplish a "kill." Against these CH/HH-53 components the 7.62mm bullets, the principal RVN threat, lack sufficient size and energy to cause abrupt disablement by direct impact; 12.7mm bullets, the chief secondary RVN threat, have very low probabilities to do so.

The suction fuel supply system, unique at present to the CH/HH-53 helicopters, was originally a reliability - oriented innovation; however, in laboratory tests the system proved to be invulnerable to sustained fires from hits by incendiary threats. This system is held to be the prime factor responsible for the absence of ground fire - caused fuel fires, and, in turn, for the low loss rate for the CH-53A. Additional advantageous fuel system features are armor protection (against Caliber .30 Ball bullets) for the pressurized engine sections, self-sealing for the main fuel cells, and placement of connecting lines and fittings above the fuel cells. This latter feature was a safety measure against leakage, but it also provided shielding by the mass of fuel in the cells for the lines and fittings against ground-originated gunfire. Incorporation of reticulated foam within USAF HH-53B fuel cells further enhanced fuel fire protection against larger projectile threats, although the very small number of USAF combat damage reports precluded quantifying its merits.

The twin engines on these helicopters are partially armored and are separated by heavy components such as the main transmission, accessory gearbox, and APP. Although the armor panels allowed bullets to cause single-engine power loss to occur, successful single-engine flights were accomplished. No report cited hits on both engines in a single incident, and no engine fires resulted from ground fire.

A final point is noteworthy regarding the positive passive defense features in the H-53 helicopters. The installation of copilot's and pilot's seat armor, together with avoidance of "hot" landing zones, have probably reduced substantially the possibilities of a crash resulting from serious wounding of the men at the controls. According to

combat damage analyses for other aircraft, including many with seat armor installed, such possibilities exist while operating close to the ground, despite the presence of two operating personnel and dual controls. Further, evidence shows that use of fiberglass for cockpit skin and panels has greatly reduced shrapnel wounds in the cockpit area.

Certain negative features of the large helicopter are also revealed. On occasion large helicopters carry a large number of personnel. It follows that a crash can involve the loss of many lives. The highest toll of lives lost in a helicopter crash in RVN resulted from a CH-53A crash, though the incident was a non-combat accident.

The large conventional helicopter relies greatly on high-pressure hydraulic power assistance for flight control. Despite incorporation of three independent hydraulic systems and tandem servocylinders in the H-53 series helicopter, this conglomerate is vulnerable to critical loss of control from single hits by fragments and small arms. Lines within separate systems are placed parallel to and in close proximity with each other in numerous places such that a single missile is capable of disabling vital controls by "killing" its primary and back-up hydraulic service simultaneously. This technique is traditional in U. S. and foreign aircraft, but in combat this tradition becomes expensive. Proper, true separation of these "redundant" systems did would have prevented HH-53B loss, and possibly two (including the ground fire - caused CH-53A loss), in addition to several hazardous emergency forced landings. The hydraulic systems as arranged on the HH-53B helicopter have cost a considerable weight penalty to protect the vital servocylinders, and areas vulnerable to double-system kills still remain which are impractical to protect in the present configuration. Separation by rerouting these lines would solve the problem.

Although either the pilot or copilot may independently operate the aircraft through a system of dual controls, the mechanical control system is singly vulnerable from the pilot's seat aft, i.e., most of it is not truly a dual system. Disablement of any of the critical control functions can be obtained by a single hit on a single component.

All primary flight control rods are located together from the cockpit to the main transmission, thus a single impact can damage more than one control, thereby compounding possible control malfunctions.

The problems associated with ground fire damage to lubrication oil systems serving critical aircraft components are well documented. Fragmentation and small arms threats will easily defeat the casings and external lube components and lines of the two engines and six critical gearboxes within the CH/HH-53 propulsion system. Continued operation after loss of bulk oil or oil pressure can have disastrous results. Combat damage experience with these aircraft shows that on such occasions cockpit warning systems were heeded and forced landings usually resulted; however, a review of accident data reveals cases where materiel failures similar to those expected following loss of oil have caused engine turbine blade expulsion, non-extinguishable inflight engine fires, and crashes (including RVN CH-53A loss 28 July 1968; Table F-I). Turbine blade expulsion has caused a serious casualty in one reported incident, and in one other incident loss of hydraulic pressure was followed by a crash fatal to five crewmen. The engine fire extinguishing system was incapable of extinguishing a fire because the fire was too far forward in the nacelle in one case and too far aft in another. The manufacturer indicates that modification action has been initiated for modification of the CH/HH-53 nose gearboxes which will greatly improve capabilities of these components to endure the effects of loss of lubrication oil, and many other partial steps could be taken to reduce this problem in other components. Ultimately, however, the problem is best eliminated by designs which incorporate non-circulating lubricant and which rely on forced air and/or structural conductivity and other thermal management techniques for heat rejection.

A final comment is worthy of mention regarding a potential improvement to the suction fuel supply system. Small holes in these lines caused by bullets, even shrapnel, will lead to engine fuel starvation within roughly 10 to 30 seconds. Such occurrences should be prevented

(without altering the zero probability of fire in the present system) by application of self-sealants on these lines.

(CONFIDENTIAL) 11. SUMMARY

During the 30-month period studied, 345 sorties were reported hit by a total of 834 hits. CH-53A's were used by the USMC for resupply and troop transport within RVN; a smaller number of HH-53B's were used by the USAF in rescue missions, mainly out-country. The threat encountered by the two models differed accordingly. As a whole the data compare closely to the limited CH-54 experience, but contrast distinctly with the smaller helicopters.

Two losses, 15 forced landings and 15 mission aborts were reported. Only one of the losses resulted from crash, but the casualty potential of large helicopters is emphasized by one crash accident which killed 13. Both losses to ground fire involved hydraulic system damage by large projectiles. Of the forced landings, seven were true emergencies involving damage to control rods, hydraulics or main transmission.

Compared to the smaller helicopters the H-53's appear significantly less vulnerable. Single-engine flights were accomplished after damage to the other engine. The aircraft also survived hit-damage to the rotor blades and blade spars, the main and tail rotor drive shafts and transmissions, the fuel cells and lines, the mechanical controls and the crew. Advantages and weak points from the standpoint of vulnerability, and possible improvements are discussed in the previous section.

Most noteworthy on the H-53 is the relative absence of in-flight fire, which has been the leading cause of loss (and personnel fatalities) on all other aircraft. This absence of fires is attributed largely to the suction fuel boost system, which is unique to the H-53. While it was installed to improve reliability, its advantages in safety and survivability appear no less significant. It is technically feasible to equip any aircraft with such a system. In view of the findings in this report, therefore, serious consideration is recommended for use of suction systems for fuel boost in other turbine powered rotary and fixed wing aircraft.

ACKNOWLEDGEMENTS

The authors are indebted to the USAF Air Rescue Service; the Combat Damage Information Center, WPAFB Ohio; The Naval Air Safety Center, Norfolk, Va.; the Sikorsky Division of United Aircraft, Stratford, Conn. and others for input data. Also to Mr. Millard C. Mitchell of the Naval Air Development Center, Warminster, Pa. for a constructive review of the report.

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APPENDIX A

SOURCES OF DATA, SAMPLE FORMS

AIRCRAFT REACTION CODE AND DEFINITIONS

 The following page is blank.

NAVY DIRECT ENEMY ACTION REPORT

USW2FTLEGQNXFSLA34Ø
RTTEZYUW R UUUMOCØ561 271ØØØØ-UUUU--RUCILSA.
ZNY UUUUU
DE RUMHAW 426B 271Ø8
ZNY UUUUU
R 28Ø8512 Sep 67
FM MARHELVHTLRON FOUR SIX THREE
TO RUCILSA/NAVAVNSAFCEN
INFO RUENAAA/CNO
RUEDBHB/NAVAIRSYSCOMHQ
RUCTHOA/CMC
RUHHFMA/CG FMFP
RUCTNAA/CG FMFLANT
RUWJMDA/COMNAVAIRPAC
RUAGDA/COMFAIRWESTPAC
ZEN/CG FMAW
RUWJBRB/CG THIRD MAF
ZEN/MAG ONE SIX
BT
UNCLAS E F T O FOUO
FOR CNO CODE OP-ØØF AND CMC CODE AAP
PRELIMINARY/SUPPLEMENTARY MSG RPT OF ACFT INCIDENT
A. OPNAVINST 3750.6F
1. 25 SEPT 1967 1200H DAY
2. CH-53A 152413 HMH-463 31-681

PAGE TWO RUMHAW 426B UNCLAS E F T O FOUO
3. BT ØØØ 35Ø
4. FRANK J. CAPT Ø78251 USMC 7564 ACTIV GOLF
5. FOUR CREW MEMBERS NO INJURY
6. ECHO ONE (1) ROUND 5Ø CAL ENTERED THE CABIN STARBOARD SIDE AT STA 619 WL 151 AND EXPENDED AFTER STRIKING AFT SUPPORT BARCKET FOR THE H F RADIO ANTENA COUPLER AT STA 633 WL 169
7. LOGISTIC CARGO 3.5 FLIGHT TIME
8. N/A
9. THE AIRCRAFT WAS ON AN APPROACH AT THE TIME 5Ø CAL FIRE WAS RECEIVED
10. N/A
11. NONE
12. N/A
13. N/A
14. N/A
15. DIRECT ENEMY ACTION
16. N/A
BT

MACV DIR 381-34

[illegible] SERVICES
AIRCRAFT [illegible] INCIDENT AND DAMAGE REPORT

INSTRUCTIONS: 1. Aircraft receiving fire only (no hits) complete Items A through E (telephone or TWX requirement Items A through E).

2. Aircraft receiving hits complete entire form (telephone or TWX requirement Items A through G).

3. Telephone (TACC) Tan Son Nhut 2614.

4. Mail completed forms for items required to Cdr, 7th Air Force, ATTN: DI-DISB, APO 96307. Weekly consolidate mailing is required.

A. REPORT IDENTIFICATION:

1. Unit Reporting_____

2. Complete A/C SN._____

3. Date/Time of Incident_____

4. A/C Type, Model, Series_____

5. Coord. of Fire (UNT GRID)_____

B. AIRCRAFT ACTIVITY: (Circle one underlined item only)

1. Take off from: a. Landing Zone b. Pickup Zone c. Base

2. Landing to: a. Landing Zone b. Pickup Zone c. Base

3. Target Attack: a. Approach b. Withdrawal c. On Target

4. Enroute: a. Level b. Climb c. Descend

C. ALTITUDE: Estimated Aircraft & Absolute Altitude When Hit (Feet)_____
_____.

D. TYPE FIRE RECEIVED:

1. Weapon Type: a. Small Arms b. Auto Weapon

c. Other (Specify)_____

2. Caliber: a. Cal. .30 b. Cal. .50 c. 20mm

d. 37mm e. Airburst f. Other (Specify)_____

SAMPLE

E. INTENSITY OF FIRE (Circle one):

1. Light (1-10 Rounds) 2. Moderate (11-25 Rounds)

3. Intense (25 Rounds or More)

F. HITS: Number of Individual Hits_____.

G. AIRCRAFT REACTION (Circle one):

1. Continued to Fly; Mission Completed.
2. Continued to Fly; Mission Not Completed.
3. Forced to Land; Insp/Quick Fix/Took Off.
4. Forced to Land; Later Destroyed.
5. Forced to Land; Later Recovered.
6. Crashed; Aircraft Recoverable.
7. Crashed; Aircraft Not Recoverable.

H. CAUSES: System Hit Causing Aircraft Reaction (Circle One)

1. Engine
2. Transmission
3. Fuel System
4. Controls
5. Main Rotor
6. Power Train
7. Casualties

I. ARMAMENT:

1. Was any aircraft armament being employed at time of hit? Yes No
2. What type weapon(s) were being employed at time of hit? (Specify) _____.
3. What type aircraft armament systems aboard aircraft? (Specify) _____.

J. MISSION TYPE (Circle one):

1. Vis Recon	7. Flr Drop	14. Combat Cgo
2. Armd Esct	8. Psywar	15. Log TC
3. Tac Recy	9. Cmd & Cnt	16. Log Cgo
4. FAC	10. Defol	17. Close Air Spt
5. Cas Evac	11. RDF/Elec	18. Photo/Infra-red
6. Lolax	12. SLAR	19. Other (Specify)
	13. Combat TC	

K. AIR SPEED: Air Speed at time of hit (knots)?_____

L. FORMATION: 1. Type_____ 2. Position_____

M. GROUND FIRE INFORMATION:

1. Source Observed? Yes No

2. Direction of Enemy Fire (O'clock position)_____

3. Type of Projectile that hit aircraft? (Circle one)

a. Steel Jacket b. Tracer c. Incendiary

d. Armor Piercing e. Other (Specify)

4. Estimated Range of Source (Meters)_____

5. Aircraft Heading _____

N. NUMBER & TYPE ESCORT A/C:

	Armed Type-Number	Unarmed Type-Number
Fixed Wing		
Rotary Wing		

O. NUMBER ON BOARD A/C: 1. Passengers _____ 2. Crew _____

P. POSITION OF CASUALTIES:

	Fatal	Non-Fatal	Location - Cause
1. Pilot			
2. Co-Pilot			
3. Crew Chief			
4. Gunner			
5. Passengers			
6. Observer			

(For additional casualties use the remarks section.)

Q. PROJECTILE ENTRANCE LOCATION (Write in Number of Hits):

	Top	Bottom	Left	Right	Center
1. Nose & Cockpit	___	_____	___	_____	_____
2. Pass. Comp.	___	_____	___	_____	_____
3. Engine Comp.	___	_____	___	___	_____
4. Wing or Main Rotor System	___	_____	___	_____	_____
5. Tail Empennage or Tail Rotor	___	_____	___	_____	_____

R. EXTENT OF DAMAGE & REMARKS: (Describe damaged components, especially those causing A/C reactions other than continue to fly. Include effectiveness of self-sealing tanks, body armor, and recommended tactics that might prevent similar damage.)

SAMPLE

ABBREVIATED AIRCRAFT ACCIDENT/COMBAT DAMAGE REPORT FORM FOR COMBAT AREA

REPORTS CONTROL SYMBOL

THRU	TO	FROM:

SECTION A - LOCATION AND TIME

1 DATE OF ACCIDENT	2 TIME	3 PLACE OF ACCIDENT

SECTION B - AIRCRAFT

1 AIRCRAFT SERIAL NUMBER	2 TYPE MODEL AND SERIES	3 UNIT ASSIGNED

SECTION C - DAMAGE CLASSIFICATION

1 COMBAT (S OR DAMAGE (as a direct result of hostile action)	2 ACCIDENT (Major or Minor as defined by AR 385-40)

SECTION D - OPERATOR AND/OR OPERATORS

WAS PILOT AT CONTROLS AT THE TIME OF THE ACCIDENT ☐ PILOT ☐ INSTRUCTOR PILOT ☐ COPILOT ☐ ACFT COMMANDER

LAST NAME FIRST NAME MIDDLE INITIAL	2 GRADE	3 SERVICE NUMBER	4a ARD OR DUTY

4 AGE	5 SERVICE (Army Air Force, Navy)	6 ORGANIZATION TO WHICH ASSIGNED	

7 PRESENT AERONAUTICAL RATING	8 DATE RECEIVED	9 DUTY STATUS AT TIME OF ACCY

10 LAST NAME FIRST NAME MIDDLE INITIAL	11 GRADE	12 SERVICE NUMBER	13a ARD OR DUTY

9 AGE	14 SERVICE (Army Air Force, Navy)	15 ORGANIZATION TO WHICH ASSIGNED	

16 PRESENT AERONAUTICAL RATING	17 DATE RECEIVED	18 DUTY STATUS AT TIME OF ACCY

SECTION E - INJURIES

OCCUPANT AT TIME OF ACCIDENT	NUMBER FATAL	NUMBER INJURED	NUMBER NOT INJURED	LOCATION OF INJURY	CAUSE OF INJURY
1 PILOT					
2 COPILOT					
3 ACFT COMDR					
4 INST PILOT					
5 CE					
6 GUNNER					
7 OBSERVER					
8 PASSENGERS					

SECTION F - CREW EXPERIENCE

1 HOURS FLYING TIME	TOTAL TIME	TOTAL FIXED WING			TOTAL ROTARY WING			TOTAL THIS TYPE ACFT	2 INST QUAL		3 TOTAL TIME PRESENT TOUR	
		IP	P	CP	IP	P	CP		FW	RW	MONTHS	FLYING TIME
PILOT												
COPILOT												
ACFT COMDR												
INST PILOT												

SECTION G - CAUSE FACTORS

1 CREW ERROR	☐ ESTABLISHED	☐ SUSPECTED	☐ NONE	☐ UNKNOWN
2 MATERIEL FAILURE	☐ ESTABLISHED	☐ SUSPECTED	☐ NONE	☐ UNKNOWN
3 FIR CONTROL NUMBER:	DATE SUBMITTED:			
4 MAINTENANCE ERROR	☐ ESTABLISHED	☐ SUSPECTED	☐ NONE	☐ UNKNOWN

SECTION H - DAMAGE

1 EXTENT OF DAMAGE ☐ TOTAL LOSS ☐ REPARABLE	2 AMOUNT OF DAMAGE (Dollars)	3 MAN HRS TO REPAIR

SECTION I - WEATHER

1 WEATHER CONDITION	2 PRESSURE ALT	3 DENSITY ALT.

SECTION J - DESCRIPTION OF MISHAP (continue on page 2)

Terse details of mission, flight maneuvers, operators' actions/error, maintenance deficiency, material failure and supervisory error.

SAMPLE

USARV FORM 15 SEP 66 232

PAGE 1

(FOR FORM 66 126 JAN 66) PREVIOUS USARV EDITIONS ARE OBSOLETE

SAMPLE

ABBREVIATED AIRCRAFT ACCIDENT/COMBAT DAMAGE REPORT FORM FOR COMBAT AREA

SECTION J - DESCRIPTION OF MISHAP *(continued)*

SECTION K - FINDINGS

List all established and contributing cause factors. (Identify units or activity responsible for cause factors.)

Recommendations to prevent recurrence

1 INVESTIGATING OFFICER	2 RANK	3 BRANCH	4 AERONAUTICAL RATING

SECTION L - STATEMENT OF APPOINTING AUTHORITY/UNIT COMMANDER

Statement of concurrence or nonconcurrence of appointing authority/unit commander and actions taken to prevent recurrence.

1 DATE	2 SIGNATURE

SECTION M - APPPOVAL BLOCK

1 APPROVED

SAMPLE

	2 SIGNATURE

USARV FORM 15 SEP 66 232

AM 40 126 JAN 66] PREVIOUS USARV EDITIONS ARE OBSOLETE

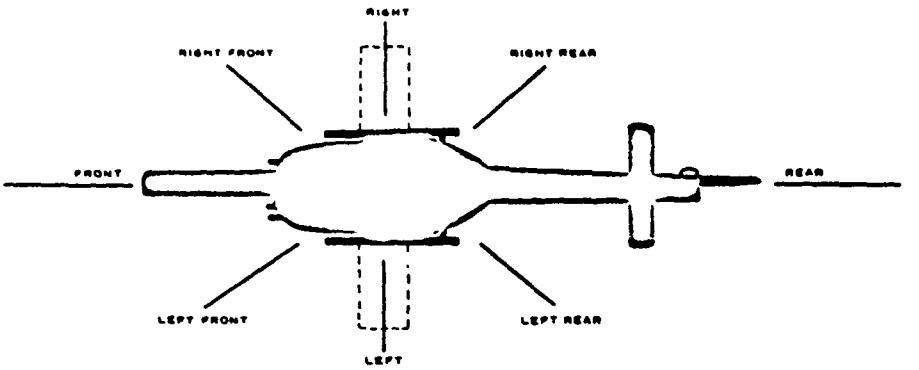
SAMPLE

ABBREVIATED AIRCRAFT ACCIDENT/COMBAT DAMAGE REPORT FORM FOR COMBAT AREA

SECTION N - AIRCRAFT COMBAT DAMAGE

NUMBER HITS ON AIRCRAFT	8 MISSION (purpose of flight):
1 TOTAL	
2 RIFLE	
3 MG	
4 UNKNOWN	
5 OTHER	
	7 NUMBER ACFT ON MISSION / 8 ALTITUDE (feet above ground)

9 LOCATION WHERE HITS FROM ENEMY FIRE WERE RECEIVED ON THE AIRCRAFT (Check applicable box)



- ☐ FRONT
- ☐ RIGHT FRONT
- ☐ RIGHT SIDE
- ☐ RIGHT REAR
- ☐ REAR
- ☐ LEFT REAR
- ☐ LEFT SIDE
- ☐ LEFT FRONT
- ☐ TOP
- ☐ BOTTOM

10 FLIGHT CONDITION	CHECK APPLICABLE ITEM	REMARKS
NORMAL CRUISE (en route)		
LANDING		
TAKING OFF		
HOVERING		
SLOW CRUISE		
11 FLIGHT ATTITUDE	**CHECK APPLICABLE ITEM**	**REMARKS**
STRAIGHT AND LEVEL		
NOSE UP		
NOSE DOWN		
TURNING RIGHT		
TURNING LEFT		
12 WAS CRASH LANDING REQUIRED	☐ YES ☐ NO	

13 DAMAGE TO COMPONENTS OR SYSTEMS WHICH PREVENTED FURTHER FLIGHT (check applicable items)

- ☐ CONTROL SYSTEM
- ☐ ROTOR SYSTEM
- ☐ WING S
- ☐ EMPENNAGE
- ☐ ELECTRICAL SYSTEM
- ☐ HYDRAULIC SYSTEM
- ☐ FUEL SYSTEM
- ☐ OIL SYSTEM
- ☐ ENGINE
- ☐ POWER TRANSMISSION SYSTEM
- ☐ PROPELLER(S)

14 EXTENT OF DAMAGE ☐ TOTAL LOSS ☐ REPARABLE | 15. AMOUNT OF DAMAGE (Dollars)

S A M P L E

SIKORSKY FIELD REPRESENTATIVE'S REPORT

COMBAT DAMAGE INCIDENT REPORT

Where additional space is needed, indicate with an asterisk and continue on the reverse side, referencing Line No.

Line No.

1 Aircraft Type_____ Aircraft serial number_____

2 Unit_____ Date of Incident_____

3 Incident occurred on_____ flight of day. Incident was the__ during the flight.

4 Mission type_____ Location_____

5 Formation type_____

6 Number of aircraft in formation_____ Position of aircraft_____

7 Pass number_____ Flight Phase_____

8 Number & type of armed escorts_____

9 Was prestrike performed?_____ Type of crew protection_____

10 Was incident detected when it occurred?_____ Was enemy fire observed?_____

11 Was fire returned?_____ Was return fire effective?_____

12 What type of projectile hit?_____

13 Number of hits_____

14 Aircraft reaction to hit_____

15 Number of hits responsible for aircraft kill_____

16 Aircraft altitude above ground at which incident occurred_____ ft.

17 Airspeed_____ kts.

18 Direction of enemy fire_____ o'clock. From abov or below_____

19 Weapon caliber and type_____

20 Ammunition type_____ Range of enemy fire_____ Yards

21 For each hit during the incident list:

Hit No.	Projectile Entrance Compartment & Station No.	W/L	B/L	Side	Projectile Exit Compartment & Station No.	W/L	B/L	Side
(1)								
(2)								

S A M P L E

S A M P L E

SIKORSKY FIELD REPRESENTATIVE'S REPORT

Line No.

22 Give for each hit the system hit, the component hit, components damaged, whether leakage, sever or other malfunction occurred and effect of hit on the mission

23 Did fire or explosion occur on aircraft?_____ What caused it?_____

24 Was armor protection hit?_____ Where?_____

25 Was armor adequate?_____

26 List Injuries, casualties and causes_____

Date

Field Representative
Sikorsky Aircraft

S A M P L E

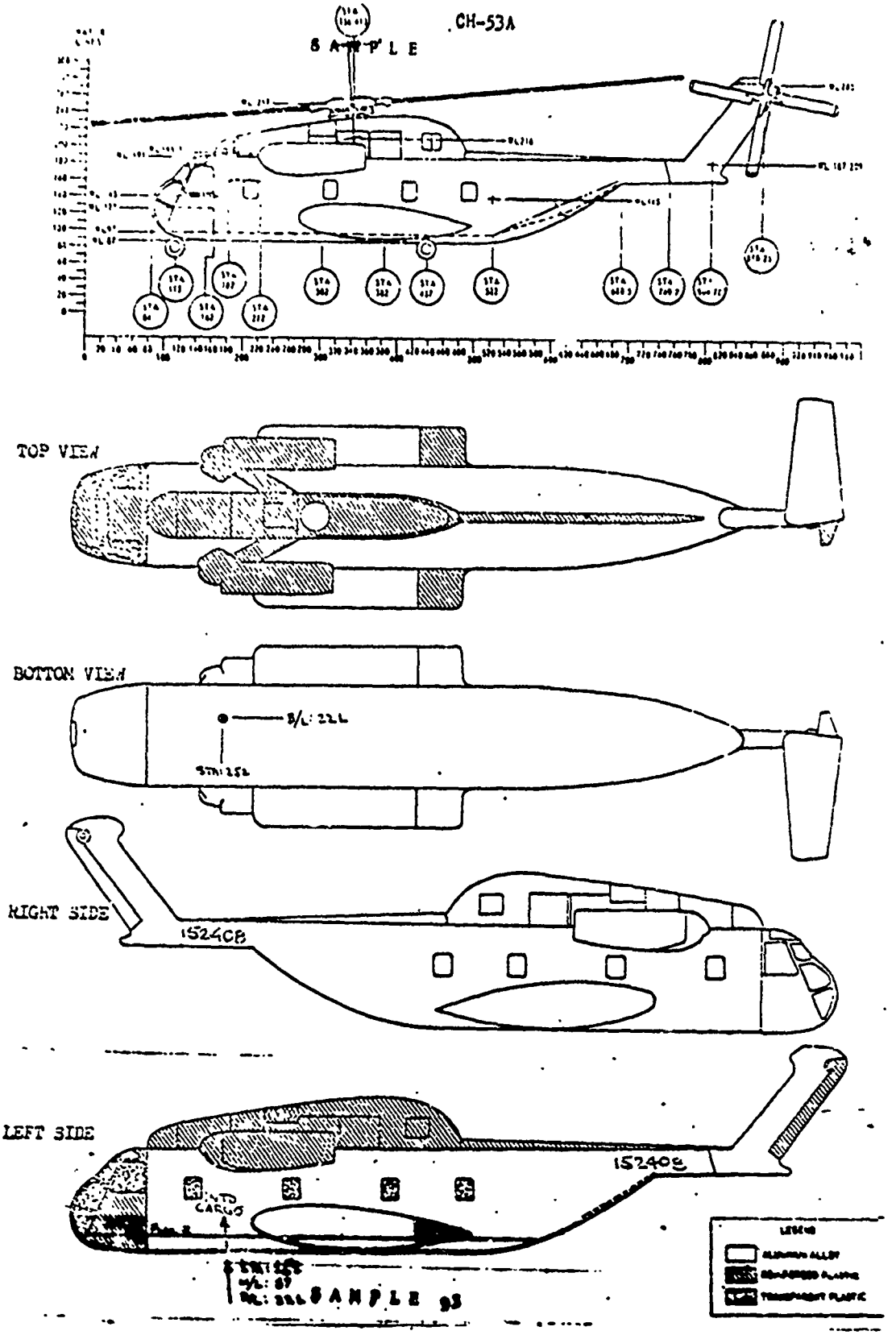

CH-53A
SAMPLE
TOP VIEW
BOTTOM VIEW
RIGHT SIDE
LEFT SIDE
152408
152408
SAMPLE 93

TABLE A-I (U) SOURCES OF DATA

Data Source	Number of Reports 1967 Jan-Jun	1967 Jul-Dec	1968 Jan-Jun	1968 Jul-Dec	1969 Jan-Jun	Total	Percent of Cases Reported
Direct Enemy Action Summaries	27	51	97	29	32	236	68.4
Joint Services AA Fire Incident & Damage Report - Parts I & II (MACV)	9	31	2	12	25	79	22 9
Joint Services AA Fire Incident & Damage Report - Part I Only (MACV)	6	-	6	-	-	12	3.5
Marine Weekly "Recaps"	22	46	-	-	-	68	19.7
Sikorsky Field Representative Reports	1	21	7	-	-	29	8 4
Crash Facts Message	-	-	2	-	-	2	0.6
USARV Form 232	-	-	2	-	-	2	0.6
3Rd ARRGP Battle Damage Reports	-	-	-	1	2	3	0.9

NOTE: 275 cases reported through one source.
56 cases reported through two sources.
12 cases reported through three sources.
2 cases reported through four sources.
0 cases reported through all sources.

(UNCLASSIFIED) AIRCRAFT REACTION CODE AND DEFINITIONS

DEFINITIONS

For Purpose of Coding in the Aircraft Combat
Data Analysis Information Recall Program

HOSTILE INCIDENT: Any hit(s) by any projectile(s) or missile(s) on an aircraft (or its contents) with power on - usually in flight but including hits while awaiting on the ground powered and manned. Excludes hits on parked aircraft, pure accidents on combat (or non-combat) missions or in combat territory and accidents caused by combat events other than weapon hits.

CRASH: A hostile incident resulting in an uncontrollable landing, i.e., the aircraft is incapable of being governed, guided or restrained at touch-down.

FORCED LANDING: A hostile incident, not a crash or mission abort, resulting in a landing prior to its intended time or in prevention of takeoff as intended or subsequent landing in place other than original destination (includes various shades between emergency hard landings with severe damage to pure precautionary landings for damage inspection and resumption of flight and mission).

MISSION ABORT: A hostile incident which disrupts intended mission or flight plans but does not prevent return to home base, i.e., not a crash or forced landing.

CONTINUED TO FLY (CF): A hostile incident which disrupts neither the intended mission nor the flight plans to destination (s) and return home.

AIRCRAFT GROUNDED (AG): Special case of "continued to fly" with damage of a type or magnitude that the aircraft cannot reasonably undertake another flight without being repaired.

REACTION CODES (EMPLOYED WITH THIS REPORT)

LB: Forced to land; aircraft destroyed as a result of the incident.

LE: Forced to land; aircraft destroyed by enemy.

LS: Emergency forced landing; successful autorotation or power-on landing with serious damage implied either by hit or in landing; later recovered and/or repaired.

L9: Forced to land; aircraft evacuated.

L8: Forced to land; aircraft repaired later, possibly after evacuation or in field delivery of parts and maintenance crew.

L6: Forced to land; aircraft flown to nearby secure area and repaired there.

L3: Forced to land; quick fix without additional tools or parts, followed by continued flight to base.

L2: Forced to land; aircraft inspected; flight resumed without repairs.

LO: Forced to land without obvious reason (extent of damage inconsistent with necessity of forced landing).

LU: Forced to land; outcome unknown.

MA: Mission aborted due to projectile damage to aircraft.

ML: "Aircraft flown to nearby secure area." (Precautionary landing-type reaction -- no other information.)

MX: Mission abort not due directly to combat damage, (e.g., aborted after being hit principally because of weather, ground fire intensity, or other factors).

MP: Mission abort without obvious reason. (Nature of damage inconsistent with mission abort.)

(CONFIDENTIAL) APPENDIX B

OPERATIONS, CHRONOLOGY OF OCCURRENCES, MISSION (U)

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TABLE B-I (C) SOUTHEAST ASIA INVENTORY AND UTILIZATION FOR CH-53A and HH-53B BY MONTH (U)

		USMC CH-53's			USAF HH-53's			CH-53 & HH-53		
Year	Month	No. of Sorties	Flying Hours	No.of A/C	No.of Sorties	Flying Hours	No.of A/C	No. of Sorties	Flying Hours	No.of A/C
1967	Apr	not reported		Unk						
	May	not reported		Unk						
	Jun	52	Unk	Unk						
	Jul	not reported		Unk	(HH-53 monthly			(Incomplete		
	Aug	119	Unk	Unk	data unavailable			without HH-53		
	Sep	1042	Unk	Unk	for 1967)			data)		
	Oct	545	Unk	Unk						
	Nov	Unk	Unk	Unk						
	Dec	Unk	Unk	Unk						
Total (12 Mo.)		26,538	10,621	Unk	179	261	Unk	26,717	10,882	Unk
1968	Jan	3,624	1,178	30	137	247	5	3,761	1,425	35
	Feb	3,670	1,895	29	444	689	5	4,114	2,584	34
	Mar	2,853	1,012	28	112	271	6	2,965	1,283	34
	Apr	2,729	1,023	28	129	250	6	2,858	1,273	34
	May	2,352	967	30	138	340	6	2,490	1,307	36
	Jun	3,947	1,066	30	121	190	5	4,068	1,256	35
Subtotal (6 Mo.)		19,175	7,141	Avg. 29	1,081	1,987	Avg. 5.5	20,256	9,128	Avg. 34.5
	Jul	4,399	1,646	25	190	310	6	4,589	1,956	31
	Aug	4,149	1,843	29	183	373	6	4,332	2,216	35
	Sep	5,177	1,383	33	188	367	6	5,365	1,750	39
	Oct	6,255	1,590	30	142	367	6	6,397	1,957	36
	Nov	6,565	1,826	28	140	384	6	6,705	2,210	34
	Dec	8,012	1,870	29	144	401	6	8,156	2,271	35
Subtotal (6 Mo.)		34,557	10,158	Avg. 29	987	2,202	Avg. 6	35,544	12,360	Avg. 35
Total (12 mo.)		53,732	17,299	Avg. 29	2,068	4,189	Avg. 6	55,800	21,488	Avg. 35

TABLE B-I (C) SOUTHEAST ASIA INVENTORY AND UTILIZATION FOR CH-53A and HH-53B BY MONTH (U)(Continued)

		USMC CH-53's			USAF HH-53's			CH-53 & HH-53		
Year	Month	No. of Sorties	Flying Hours	No.of A/C	No. of Sorties	Flying Hours	No.of A/C	No. of Sorties	Flying Hours	No.of A/C
1969	Jan	6,696	1,738	29	83	234	6	6,779	1,972	35
	Feb	4,897	1,695	31	99	223	5	4,996	1,918	36
	Mar	4,247	2,808	31	113	305	7	4,360	3,113	38
	Apr	5,894	1,930	31	159	340	7	6,053	2,270	38
	May	6,288	1,836	30	123	314	8	6,411	2,150	38
	Jun	7,705	2,645	26	130	303	8	7,835	2,948	34
Total (6 mo.)		35,727	12,652	Avg. 30	707	1,719	Avg. 7	36,434	14,371	Avg 37
Grand Total For Study		115,997	40,572	--	2,954	6,169	--	118,951	46,741	

TABLE B-II (C) SORTIES BY MISSION TYPE (U)

Year	Month	USMC CH-53A Combat **	USMC CH-53A Combat Support	USMC CH-53A Non-Combat	USMC CH-53A Support *	USMC CH-53A Total Sorties	USAF HH-53B Combat Support	USAF HH-53B Non-Combat	USAF HH-53B Support *	USAF HH-53B Total Sorties	CH-53 and HH-53 Combat **	CH-53 and HH-53 Combat Support	CH-53 and HH-53 Non-Combat	CH-53 and HH-53 Support *	CH-53 and HH-53 Total Sorties
1967		Breakdown by Month N/A					Mission Breakdown N/A			179	Totals Incomplete				
Total (12 Mo.)		187	4,636	1,435	20,280	26,538	Not Available			179	187	Totals Incomplete			26,717
1968	Jan		121	226	3,277	3,624	93	44		137		214	270	3,277	3,761
	Feb		130	257	3,283	3,670	349	95		444		479	352	3,283	4,114
	Mar	20	418	207	2,208	2,853	73	39		112	20	491	246	2,208	2,965
	Apr	23	2,445	154	107	2,729	28	101		129	23	2,473	255	107	2,858
	May		2,070	201	81	2,352	65	73		138		2,135	274	81	2,490
	Jun		3,792	147	8	3,947	45	76		121		3,837	223	8	4,068
Subtotal (6 Mo.)		43	8,976	1,192	8,964	19,175	653	428		1,081	43	9,629	1,620	8,964	20,256
	Jul	16	4,319	64	0	4,399	83	107		190	16	4,402	171	0	4,589
	Aug		4,009	92	48	4,149	68	115		183		4,077	207	48	4,332
	Sep		3,085	816	1,276	5,177	99	89		188		3,184	905	1,276	5,365
	Oct		3,961	1,405	889	6,255	78	64		142		4,039	1,469	889	6,397
	Nov		4,579	1,439	547	6,565	101	39		140		4,680	1,478	547	6,705
	Dec		5,867	1,641	504	8,012	119	25		144		5,986	1,666	504	8,156
Subtotal (6 Mo.)		16	25,820	5,457	3,264	34,557	548	439		987	16	26,368	5,896	3,264	35,544
Total (12 Mo.)		59	34,796	6,649	12,228	53,732	1,201	867		2,068	59	35,997	7,516	12,228	55,800

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TABLE B-II (C) SORTIES BY MISSION TYPE (U) (Continued)

Year	Month	USMC CH-53A Combat **	USMC CH-53A Combat Support	USMC CH-53A Non-Combat	USMC CH-53A Support *	USMC CH-53A Total Sorties	USAF HH-53B Combat Support	USAF HH-53B Non-Combat	USAF HH-53B Support *	USAF HH-53B Total Sorties	CH-53 and HH-53 Combat **	CH-53 and HH-53 Combat Support	CH-53 and HH-53 Non-Combat	CH-53 and HH-53 Support *	CH-53 and HH-53 Total Sorties
1969	Jan		4,809	1,465	422	6,696	81		2	83		4,890	1,465	424	6,779
	Feb	12	3,595	1,059	231	4,897	95		4	99	12	3,690	1,059	235	4,996
	Mar		2,939	1,133	175	4,247	113			113		4,052	1,133	175	4,360
	Apr		4,127	1,576	191	5,894	159			159		4,286	1,576	191	6,053
	May		4,412	1,570	305	6,288	123			123		4,535	1,570	306	6,411
	Jun		5,232	2,037	436	7,705	130			130		5,362	2,037	436	7,835
Subtotal (6 Mo.)		12	25,114	8,840	1,761	35,727	701		6	707	12	25,815	8,840	1,767	36,434
Grand Total		258	64,546	16,924	34,269	115,997	--	--	--	2,954	258	--	--	--	118,951

Logistics and Troop Carrier Missions.

**Flown by CH-53's only.*

TABLE B-III (C) CH-53A AND HH-53B COMBAT-RELATED SORTIES
AS PERCENT OF TOTAL SORTIES FLOWN (U)

	1968				1969			
	CH-53A Sorties		HH-53B Sorties		CH-53A Sorties		HH-53B Sorties	
	Combat-Type	Percent of Total	Combat-Type	Percent of Total	Combat-Type	Percent of Total	Combat-Type	Percent of Total
Jan	3,398	93.8	93	67.9	5,231	78.1	83	100.0
Feb	3,413	93.0	349	78.6	3,838	78.4	99	100.0
Mar	2,646	92.7	73	65.2	3,114	73.3	113	100.0
1st Qtr Total	9,457	93.2	515	74.3	12,183	76.9	295	100.0
Apr	2,575	94.4	28	21.7	4,318	73.3	159	100.0
May	2,151	91.5	65	47.1	4,718	75.0	123	100.0
Jun	3,800	96.3	45	37.2	5,668	73.6	130	100.0
2nd Qtr Total	8,526	94.4	138	35.5	14,704	73.9	412	100.0
1st Half Total	17,983	93.8	653	60.4	26,887	75.3	707	100.0
Jul	4,335	98.5	83	43.7				
Aug	4,057	97.8	68	37.2				
Sep	4,361	84.2	99	52.7				
3rd Qtr Total	12,753	92.9	250	44.6				
Oct	4,850	77.5	78	54.9				
Nov	5,126	78.1	101	72.1				
Dec	6,371	79.5	119	82.6				
4th Qtr Total	16,347	78.5	298	70.0				
2nd Half Total	29,100	84.2	548	55.5				
Yearly Total	47,083	87.6	1,201	58.1				

1967 data for HH-53B mission breakdown not available.

1967 yearly average data for CH-53A only: 25,103 combat-type sorties; 94.6 percent of total sorties.

TABLE B-IV (C) SORTIES HIT BY YEAR (U)

	Sorties Hit			
	1967	1968	1969	Total
USAF HH-53B	1	6	2	9
USMC CH-53A	138	144	54	336
Total Sorties	139	150	56	345

	Total Hits			
USAF HH-53B	5	63	3	71
USMC CH-53A	267	333	163	763
Total Hits	272	396	166	834

	Average Hits Per Sortie Hit			
USAF HH-53B	5.00	10.50	1.50	7.89
USMC CH-53A	1.93	2.31	3.02	2.27
Total	1.96	2.64	2.96	2.42

TABLE B-V (C) COMBAT-RELATED SORTIES FLOWN PER REPORTED SORTIE HIT (U)

	1967			1968			1969		
	Sorties Flown	Sorties Hit	S/SH	Sorties Flown	Sorties Hit	S/Sh	Sorties Flown	Sorties Hit	S/Sh
Jan		5		3,491	19	184	5,314	13	409
Feb		4		3,762	36	105	3,937	10	394
Mar		2		2,719	14	194	3,227	19	170
1st Qtr Total		11		9,972	69	145	12,478	42	297
Apr	Monthly & Quarterly	10		2,603	28	93	4,477	7	640
May	Sortie Breakdown not	18		2,216	5	443	4,841	2	2,421
Jun	Available.	10		3,845	6	641	5,798	5	1,160
2nd Qtr Total		38		8,664	39	222	15,116	14	1,080
1st Half Total		49		18,636	108	173	27,594	56	493
Jul		9		4,418	2	2,209			
Aug		11		4,125	4	1,031			
Sep		19		4,460	3	1,487			
3rd Qtr Total		39		13,003	9	1,445			
Oct		12		4,928	10	493			
Nov		27		5,227	3	1,742			
Dec		12		6,490	20	325			
4th Qtr Total		51		16,645	33	504			
2nd Half Total		90		29,648	42	706			
Yearly Total	25,103	139	181	48,284	150	322	27,594*	56	493

Grand Total: Combat-related sorties flown - 100,981; Sorties Hit - 345; Combat-related sorties flown/sortie hit - 293.

*Six-month total for 1969.

TABLE B-VI (C) SORTIES HIT BY MISSION VS THREAT (U)

Number of Sorties Hit

Mission	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk	Total
Air-Landed Assault	6	6	5	17	2	2		21
Medical Evacuation			1	1		1		2
Reconnaissance	1			1				1
Recovery (Sling Load)	14	7	2	23				23
Rescue	1	5	3	9		2*		10
Resupply	64	13	9	86	9	3		96
Resupply (Sling Load)	13	8	7	28	2	1		30
Test Flight		1		1				1
Training		1		1				1
Troop Lift	7	1		8		1		8
Troop Extraction	1			1				1
Unknown	11	3	115	129	16	9	1	151
Total	118	45	142	305	29	19	1	345**

Includes one direct hit by HE projectile.
**Includes nine sorties hit by mixed threats.*

Percent of Sorties Hit

Mission	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk	Total
Air-Landed Assault	5.61	14.29	18.52	9.65	15.38	20.00		10.84
Medical Evacuation			3.70	0.57		10.00		1.03
Reconnaissance	0.93			0.57				0.51
Recovery (Sling Load)	13.08	16.67	7.40	13.07				11.86
Rescue	0.93	11.90	11.11	5.11		20.00		5.15
Resupply	59.81	30.95	33.33	48.86	69.23	30.00		49.48
Resupply (Sling Load)	12.15	19.05	25.94	15.91	15.38	10.00		15.46
Test Flight		2.38		0.57				0.51
Training		2.38		0.57				0.51
Troop Lift	6.54	2.38		4.55		10.00		4.14
Troop Extraction	0.93			0.57				0.51
Total	100.00	100.00	100.00	100.00	100.00	100.00		100.00

TABLE B-VII (C) TOTAL HITS BY MISSION VS THREAT (U)

Number of Hits

Mission	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk	Total
Air-Landed Assault	8	12	6	26	8	2		36
Medical Evacuation			1	1		1		2
Reconnaissance	1			1				1
Recovery (SL)	26	35	12	73				73
Rescue	1	41	10	52		23*		75*
Resupply	94	29	20	143	45	9		197
Resupply (SL)	24	19	11	54	3	1		58
Test Flight		3		3				3
Training		5		5				5
Troop Lift	18	3		21		2		23
Troop Extraction	2			2				2
Unknown	18	6	242	266	41	51	1	359
Total	192	153	302	647	97	89	1	834

**Includes one direct hit by HE projectile.*

Percent of Hits

Mission	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk	Total
Air-Landed Assault	4.60	8.16	10.00	6.82	14.29	5.26		7.58
Medical Evacuation			1.67	0.26		2.63		0.42
Reconnaissance	0.57			0.26				0.21
Recovery (SL)	14.94	23.81	20.00	19.16				15.37
Rescue	0.57	27.89	16.67	13.65		60.54		15.79
Resupply	54.02	19.78	33.33	37.54	80.36	23.68		41.48
Resupply (SL)	13.79	12.93	18.33	14.18	5.36	2.63		12.21
Test Flight		2.04		0.79				0.63
Training		3.40		1.31				1.05
Troop Lift	10.34	2.04		5.51		5.26		4.84
Troop Extraction	1.15			0.52				0.42
Total	100.00	100.00	100.00	100.00	100.00	100.00		100.00

TABLE B-VIII (C) AVERAGE NUMBER OF HITS PER SORTIE HIT BY MISSION VS THREAT (U)

Mission	.30 Rifle	.30 Auto Wpn	.30 Unk Wpn	All .30	.50	HE Frags	HE Dir. Hit	Total
Air-Landed Assault	1.33	2.00	1.20	1.53	4.00	1.00		1.71
Medical Evacuation			1.	1.		1.		1.
Reconnaissance	1.			1.				1.
Recovery (By Sling)	1.86	5.00	6.00	3.17				3.17
Rescue	1.00	3.20	3.33	5.78		22.00	1.0	7.50
Resupply	1.47	2.23	2.22	1.66	5.00	3.00		2.05
Resupply (Sling)	1.85	2.38	1.57	1.93	1.50	1.00		1.93
Test Flight		3.		3.				3.
Training		5.		5.				5.
Troop Lift	2.57	3.00		2.63		2.00		2.88
Troop Extraction	2.			2.				2.
Unknown	1.64	2.00	2.12	2.08	2.56	5.67		2.38
All Missions	1.63	3.40	2.14	2.13	3.34	4.89	1.00	2.42

TABLE B-IX (C) CREW KNOWLEDGE OF AIRCRAFT HIT (U)

A. Crew Knew When Hit

	Sorties	Percent
Yes	155	44.93
No	34	9.86
Unspecified	156	45.21
Total	345	100.00

B. Observed Ground Fire

	Sorties	Percent
Yes	42	12.17
No	79	22.90
Unspecified	224	64.93
Total	345	100.00

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APPENDIX C

FLIGHT CONDITIONS (U)

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TABLE C-I (C) SORTIES HIT BY FLIGHT PHASE VS THREAT (U)

Number of Sorties Hit

Flight Phase	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk Wpn	Total
Climb Out	4	2	14	20		1		21
En Route Low	19	9	22	50	2	2*		52*
En Route High	58	15	35	108	13	1		119
Orbiting	1			1	1			2
Hovering	3	3	3	9	2	3		12
Descending	8	2	24	34	3			37
Landing	7	7	6	20	4	2		25
On Ground	2		4	6		5		11
Taking Off	6	6	14	26	2	3	1	31
Unknown	10	1	20	31	2	2		35
Total	118	45	142	305	29	19*	1	345**

*Includes one direct hit by HE projectile.
**Includes nine sorties hit by mixed threats.

Percent of Sorties Hit

	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk Wpn	Total
Climb Out	3.70	4.55	11.48	7.30		5.88		6.77
En Route Low	17.59	20.45	18.03	18.25	7.41	11.77		16.77
En Route High	53.70	34.09	28.68	39.42	48.15	5.88		38.39
Orbiting	0.93			0.36	3.70			0.65
Hovering	2.78	6.82	2.46	3.28	7.41	17.65		3.87
Descending	7.41	4.55	19.67	12.41	11.11			11.94
Landing	6.48	15.91	4.92	7.30	14.81	11.77		8.06
On Ground	1.85		3.28	2.19		29.40		3.55
Taking Off	5.56	13.64	11.48	9.49	7.41	17.65	100.00	10.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE C-II (C) TOTAL HITS BY FLIGHT PHASE VS THREAT (U)

Number of Hits

Flight Phase	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk	Total
Climb Out	5	5	34	44		1		45
En Route Low	40	43	34	117	14	3*		134
En Route High	94	28	77	199	23			222
Orbiting	1			1	4			5
Hovering	3	20	13	36	6	35		77
Descending	19	24	61	104	13			117
Landing	7	9	26	42	27	8		77
On Ground	3		4	7		35		42
Taking Off	10	20	30	60	2	5	1	68
Unknown	10	4	23	37	8	2		47
Total	192	153	302	647	97	89*	1	834

*Includes one direct hit by HE projectile.

Percent of Hits

Flight Phase	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk	Total
Climb Out	2.75	3.36	12.19	7.21		1.15		5.72
En Route Low	21.98	28.86	12.19	19.18	15.73	3.45		17.03
En Route High	51.64	18.79	27.60	32.62	25.84			28.20
Orbiting	0.55			0.16	4.49			0.64
Hovering	1.65	13.42	4.64	5.90	6.74	40.23		9.78
Descending	10.44	16.11	21.86	17.05	14.61			14.87
Landing	3.85	6.04	9.32	6.89	30.34	9.20		9.78
On Ground	1.65		1.43	1.15		40.23		5.34
Taking Off	5.49	13.42	10.75	9.84	2.25	5.74	100.00	8.64
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE C-III (C) AVERAGE NUMBER OF HITS PER SORTIE HIT BY FLIGHT PHASE VERSUS THREAT (U)

Flight Phase	.30 Rifle	.30 Auto Wpn	.30 Unk Wpn	All .30	.50	HE Frags	HE Dir Hit	Total
Unknown	1.00	4.00	1.15	1.19	4.00	1.00		1.34
Climb Out	1.25	2.50	2.43	2.20		1.00		2.14
En Route Low	2.10	4.78	1.55	2.34	7.00	2.00	1.00	2.58
En Route High	1.62	1.87	2.20	1.84	1.77			1.87
Orbiting	1.00			1.00	4.00			2.50
Hover	1.00	6.67	4.33	4.00	3.00	11.67		6.42*
Descending	2.38	12.00	2.54	3.06	4.33			3.16
Landing	1.00	1.29	4.33	2.10	6.75	4.00		3.08
On Ground	1.50		1.00	1.17		7.00		3.82**
Taking Off	1.67	3.33	2.14	2.31	1.00	1.67		2.19
Overall	1.63	3.40	2.14	2.13	3.34	4.89	1.00	2.42

Average for Hover - 4.67 excluding HE.
**Average for On Ground - 1.16 excluding HE.*

TABLE C-IV (C) SORTIES HIT BY ALTITUDE VS THREAT (U)

Number of Sorties Hit

Altitude Feet	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk	Total
Unspecified	13	1	24	38	3	3	1	45
Zero	2		4	6		5		11
1 - 25	1	2	5	8	3	5		13
26 - 50	1		9	10		2		11
51 - 100	7	5	7	19	1			20
101 - 200	6	6	9	21	1	3*		24
201 - 300	6	3	9	18				18
301 - 400	3	2	3	8				8
401 - 500	4	3	4	11				11
501 - 750	4	2	2	8	1			9
751 - 1000	13	4	16	33	3			35
1001 - 1500	25	7	26	58	3			61
1501 - 2000	11	6	11	28	5			32
2001 - 3000	15	3	13	31	6			36
Over 3000	7	1		8	3	1		11
Total	118	45	142	305	29	19	1	345**

Includes one direct hit by HE projectile.
**Includes nine sorties hit by mixed threats.*

Percent of Sorties Hit

Altitude Feet	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk	Total
Zero	1.90		3.39	2.24		33.33		3.67
1 - 25	0.95	4.54	4.24	3.00	11.54	33.33		4.33
26 - 50	0.95		7.63	3.74		13.33		3.67
51 - 100	6.67	11.36	5.93	7.12	3.85			6.67
101 - 200	5.71	13.64	7.63	7.86	3.85	13.33		8.00
201 - 300	5.71	6.82	7.63	6.74				6.00
301 - 400	2.86	4.55	2.54	3.00				2.67
401 - 500	3.81	6.82	3.39	4.12				3.67
501 - 750	3.81	4.54	1.69	3.00	3.85			3.00
751 - 1000	12.38	9.09	13.56	12.36	11.54			11.66
1001 - 1500	23.81	15.91	22.03	21.72	11.54			20.33
1501 - 2000	10.48	13.64	9.32	10.49	19.22			10.66
2001 - 3000	14.29	6.82	11.02	11.61	23.07			12.00
Over 3000	6.67	2.27		3.00	11.54	6.67		3.67
Total	100.00	100.00	100.00	100.00	100.00	100.00		100.00

TABLE C-V (C) TOTAL HITS BY ALTITUDE VS THREAT (U)

Number of Hits

Altitude/Feet	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk	Total
Unspecified	13	4	27	44	9	12	1	66
Zero	3		4	7		35		42
1 - 25	1	11	15	27	13	13		53
26 - 50	7		31	38		3		41
51 - 100	14	31	31	76	18			94
101 - 200	12	29	15	56	1	4*		61
201 - 300	10	9	13	32				32
301 - 400	4	7	3	14				14
401 - 500	10	20	9	39				39
501 - 750	5	4	19	28	1			29
751 - 1000	30	12	31	73	15			88
1001 - 1500	44	12	61	117	5			122
1501 - 2000	15	9	23	47	8			55
2001 - 3000	17	5	20	42	20			62
Over 3000	7			7	7	22		36
Total	192	153	302	647	97	89*	1	834

Includes one direct hit by HE projectile.

Percent of Hits

Altitude/Feet	.30 Rifle	.30 Auto Wpn	30 Unk	All .30	All .50	All HE	Unk	Total
Zero	1.68		1.45	1.16		45.46		5.47
1 - 25	0.56	7.38	5.45	4.48	14.77	16.88		6.90
26 - 50	3.91		11.28	6.30		3.90		5.34
51 - 100	7.82	20.81	11.28	12.60	20.45			12.24
101 - 200	6.70	19.46	5.45	9.29	1.14	5.19		7.94
201 - 300	5.59	6.04	4.72	5.31				4.17
301 - 400	2.23	4.70	1.09	2.32				1.82
401 - 500	5.59	13.43	3.27	6.47				5.08
501 - 750	2.79	2.68	6.91	4.64	1.14			3.78
751 - 1000	16.76	8.05	11.28	12.11	17.05			11.46
1001 - 1500	24.58	8.05	22.19	19.40	5.68			15.88
1501 - 2000	8.38	6.04	8.36	7.79	9.09			7.16
2001 - 3000	9.50	3.36	7.27	6.97	22.73			8.07
Over - 3000	3.91			1.16	7.95	28.57		4.69
Total	100.00	100.00	100.00	100.00	100.00	100.00		100.00

TABLE C-VI (C) AVERAGE NUMBER OF HITS PER SORTIE HIT BY ALTITUDE VERSUS THREAT (U)

Altitude, Feet	.30 Rifle	.30 Auto Wpn	.30 Unk Wpn	All .30	.50	HE Frags	HE Dir Hit	Total
Unspecified	1.00	4.00	1.13	1.16	3.00	4.00	1.00	1.47
Zero	1.50		1.00	1.17		7.00		3.82
1 - 25	1.00	5.50	3.75	3.86	4.33	2.60		4.42
26 - 50	7.00		10.33	3.80		1.50		3.73
51 - 100	2.00	6.20	4.43	4.00	18.00			4.70
101 - 200	2.00	4.83	1.75	2.75	1.00	1.50	1.	2.57
201 - 300	1.67	3.00	1.44	1.78				1.78
301 - 400	1.33	3.50	1.00	1.75				1.75
401 - 500	2.50	6.67	2.25	3.55				3.55
501 - 750	1.25	2.00	9.50	3.50	1.00			3.22
751 - 1000	2.31	3.00	1.94	2.21	5.00			2.51
1001 - 1500	1.76	1.71	2.35	2.02	1.67			1.97
1501 - 2000	1.36	1.50	2.09	1.68	1.60			1.72
2001 - 3000	1.13	1.67	1.54	1.35	3.33			1.72
Over 3000	1.00			1.00	2.33	22.00		3.27*
Overall Avg.	1.63	3.40	2.13	2.12	3.34	4.89	1.	2.42

Average for "Over 3000" - 1.40 excluding HE.

TABLE C-VII (C) SORTIES HIT BY AIRSPEED VS THREAT (U)

Number of Sorties Hit

Speed (Knots)	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk	Total
Unspecified	34	13	21	68	5	6	1	79
Zero	5	3	7	15	3	8		23
1 - 50	9	9	20	38	2	3		43
51 - 75	10	6	25	41	2			42
76 - 100	24	9	35	68	11			77
101 - 150	36	5	34	75	6	2*		81
Total	118	45	142	305	29	19*	1	345**

Includes one direct hit by HE projectile.
**Includes nine sorties hit by mixed threats.*

Percent of Sorties Hit

Speed (Knots)	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk	Total
Zero	5.95	9.38	5.79	6.33	12.50	61.54		8.65
1 - 50	10.72	28.12	16.53	16.03	8.33	23.08		16.16
51 - 75	11.90	18.75	20.67	17.30	8.33			15.79
76 - 100	28.57	28.12	28.92	28.69	45.84			28.95
101 - 150	42.86	15.63	28.09	31.65	25.00	15.38		30.45
Total	100.00	100.00	100.00	100.00	100.00	100.00		100.00

TABLE C-VIII (C) TOTAL HITS BY AIRSPEED VS THREAT (U)

Number of Hits

Speed (Knots)	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk	Total
Unspecified	44	45	22	111	11	18	1	141
Zero	6	20	17	43	13	43		99
1 - 50	23	42	71	136	20	5		161
51 - 75	16	16	58	90	2			92
76 - 100	48	22	75	145	36			181
101 - 150	55	8	59	122	15	23*		160
Total	192	153	302	647	97	89*	1	834

*Includes one direct hit by HE projectile.

Percent of Hits

Speed (Knots)	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	All HE	Unk	Total
Zero	4.05	18.52	6.07	8.02	15.12	60.57		14.29
1 - 50	15.54	38.89	25.36	25.38	23.25	7.04		23.23
51 - 75	10.81	14.81	20.71	16.79	2.33			13.27
76 - 100	32.43	20.37	26.79	27.05	41.86			26.12
101 - 150	37.17	7.41	21.07	22.76	17.44	32.39		23.09
Total	100.00	100.00	100.00	100.00	100.00	100.00		100.00

TABLE C-IX (C) AVERAGE NUMBER OF HITS PER SORTIE HIT BY AIRSPEED VERSUS THREAT (U)

Airspeed, Knots	.30 Rifle	.30 Auto Wpn	.30 Unk Wpn	All .30	.50	HE Frags	Unk Wpn	Total
Unspecified	1.29	3.46	1.05	1.64	2.20	2.83	1.00	1.77
Zero	1.20	6.67	2.43	2.87	4.33	5.38		4.30
1 - 50	2.56	4.67	3.55	3.58	10.00	3.67		3.74
51 - 75	1.60	3.67	2.32	2.20	1.00			2.19
76 - 100	2.00	2.44	2.14	2.13	3.27			2.35
101 - 150	1.53	1.60	1.74	1.63	2.50	22.00		1.99
Overall Avg.	1.63	3.40	2.13	2.12	3.34	4.89	1.00	2.42

TABLE C-X (C) SORTIES HIT BY ALTITUDE VS AIRSPEED - CALIBER .30 (U)

Number of Sorties Hit

Altitude, Feet	Specified Airspeed, Knots						
	A/S Unk	0	1 - 50	51 - 75	76 - 100	101 - 150	Total
Unknown	33	1		2	2		38
Zero		6					6
1 - 25		6	1				7
26 - 50	1		4			6	11
51 - 100	3		8	5	1	2	19
101 - 200	1	2	5	3	6	4	21
201 - 300	3		2	8		5	18
301 - 400	1		1	1	3	2	8
401 - 500	1		4	2	3	1	11
501 - 750	2			1	4	1	8
751 - 1000	3		5	5	9	11	33
1001 - 1500	6		3	7	20	22	58
1501 - 2000	5		2	3	10	8	28
2001 - 3000	7		1	3	10	10	31
Over 3000	2		2	1		3	8
Total	68	15	38	41	68	75	305

Percent of Sorties Hit

Altitude, Feet	Specified Airspeed, Knots						
	A/S Unk	0	1 - 50	51 - 75	76 -100	101 - 150	Total
Zero		42.86					2.24
1 - 25		42.86	2.63				2.62
26 - 50	2.86		10.53			8.00	4.12
51 - 100	8.57		21.06	12.83	1.52	2.67	7.12
101 - 200	2.86	14.28	13.16	7.69	9.09	5.33	7.86
201 - 300	8.57		5.26	20.51		6.67	6.74
301 - 400	2.86		2.63	2.56	4.55	2.67	3.00
401 - 500	2.86		10.53	5.13	4.55	1.33	4.12
501 - 750	5.71			2.56	6.06	1.33	3.00
751 - 1000	8.57		13.16	12.83	13.63	14.67	12.36
1001 - 1500	17.14		7.89	17.95	30.30	29.33	21.72
1501 - 2000	14.29		5.26	7.69	15.15	10.67	10.49
2001 - 3000	20.00		2.63	7.69	15.15	13.33	11.61
Over 3000	5.71		5.26	2.56		4.00	3.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE C-XI (C) TOTAL HITS BY ALTITUDE VS AIRSPEED - CALIBER .30 (U)

Number of Hits

Altitude, Feet	A/S Unk	0	Specified Airspeed, Knots 1 - 50	51 - 75	76 - 100	101 - 150	Total
Unknown	37	1		4	2		44
Zero		7					7
1 - 25		25	2				27
26 - 50	7		15			16	38
51 - 100	8		55	8	1	4	76
101 - 200	3	8	9	10	19	7	56
201 - 300	7		6	8		11	32
301 - 400	2		1	4	5	2	14
401 - 500	9		13	5	11	1	39
501 - 750	3			1	23	1	28
751 - 1000	11		14	12	15	21	73
1001 - 1500	6	2	11	28	33	37	117
1501 - 2000	7		5	6	20	9	47
2001 - 3000	9		3	3	16	11	42
Over 3000	2		2	1		2	7
Total	111	43	136	90	145	122	647

Percent of Hits

Altitude, Feet	A/S Unk	0	Specified Airspeed, Knots 1 - 50	51 - 75	76 - 100	101 - 150	Total
Zero		16.67					1.16
1 - 25		59.52	1.47				4.48
26 - 50	9.46		11.03			13.11	6.30
51 - 100	10.81		40.43	9.30	0.70	3.28	12.60
101 - 200	4.05	19.05	6.62	11.63	13.29	5.74	9.29
201 - 300	9.46		4.41	9.30		9.02	5.31
301 - 400	2.70		0.74	4.65	3.50	1.64	2.32
401 - 500	12.16		9.56	5.81	7.69	0.82	6.47
501 - 750	4.05			1.16	16.08	0.82	4.64
751 - 1000	14.87		10.29	13.95	10.49	17.21	12.11
1001 - 1500	8.12	4.76	8.09	32.57	23.07	30.32	19.40
1501 - 2000	9.46		3.68	6.98	13.99	7.38	7.79
2001 - 3000	12.16		2.21	3.49	11.19	9.02	6.97
Over 3000	2.70		1.47	1.16		1.64	1.16
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE C-XII (C) SORTIES HIT BY ALTITUDE VS AIRSPEED - CALIBER .50 (U)

Number of Sorties Hit

Altitude, Feet	A/S Unk	0	Specified Airspeed, Knots 1 - 50	51 - 75	76 - 100	101 - 150	Total
Unknown	3						3
Zero							
1 - 25		3					3
26 - 50							
51 - 100			1				1
101 - 200						1	1
201 - 300							
301 - 400							
401 - 500							
501 - 750					1		1
751 - 1000				1	1	1	3
1001 - 1500					1	2	3
1501 - 2000	2		1		1	1	5
2001 - 3000					5	1	6
Over 3000				1	2		3
Total	5	3	2	2	11	6	29

Percent of Sorties Hit

Altitude, Feet	A/S Unk	0	Specified Airspeed, Knots 1 - 50	51 - 75	76 - 100	101 - 150	Total
Zero							
1 - 25		100.00					11.54
26 - 50							
51 - 100			50.00				3.85
101 - 200						16.67	3.85
201 - 300							
301 - 400							
401 - 500							
501 - 750					9.09		3.85
751 - 1000				50.00	9.09	16.67	11.54
1001 - 1500					9.09	33.33	11.54
1501 - 2000	100.00		50.00		9.09	16.67	19.23
2001 - 3000					45.45	16.67	23.08
Over 3000				50.00	18.18		11.54
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE C-XIII (C) TOTAL HITS BY ALTITUDE VS AIRSPEED - CALIBER .50 (U)

Number of Hits

Altitude, Feet	A/S Unk	0	Specified Airspeed, Knots 1 - 50	51 - 75	76 - 100	101 - 150	Total
Unknown	9						9
Zero							
1 - 25		13					13
26 - 50							
51 - 100			18				18
101 - 200						1	1
201 - 300							
301 - 400							
401 - 500							
501 - 750					1		1
751 - 1000				1	12	2	15
1001 - 1500					3	2	5
1501 - 2000	2		2		3	1	8
2001 - 3000					11	9	20
Over 3000				1	6		7
Total	11	13	20	2	36	15	97

Percent of Hits

Altitude, Feet	A/S Unk	0	Specified Airspeed, Knots 1 - 50	51 - 75	76 - 100	101 - 150	Total
Zero							
1 - 25		100.00					14.77
26 - 50							
51 - 100			90.00				20.45
101 - 200						6.67	1.14
[illegible] - 300							
[illegible] - 400							
401 - 500							
501 - 750					2.78		1.14
751 - 1000				50.00	33.33	13.33	17.05
1001 - 1500					8.33	13.33	5.68
1501 - 2000	100.00		10.00		8.33	[illegible].67	9.09
2001 - 3000					30.56	60.00	22.73
Over 3000				50.00	16.67		7.95
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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(CONFIDENTIAL) APPENDIX D

THREAT (U)

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TABLE D-I (C) FREQUENCY OF WEAPON TYPES REPORTED (U)

Projectile Type	Weapon Type	Sorties Hit	
		Number	Percent
Caliber .30 Only	Rifle	117	33.9
Caliber .30 Only	Automatic Weapon	44	12.8
Caliber .30 Only	Unknown Type	136	39.4
All Caliber .30 Only	All Types (Sub-total)	297	86.1
Caliber .50 Only	Automatic Weapon	23	6.7
HE Fragments	Mixed Types	15	4.3
Caliber .30 & Caliber 50	Mixed Weapons	5	1.4
Caliber .30 and Mortar	Mixed Weapons	1	0.3
Caliber .30 and HE	Mixed Weapons	2	0.6
Caliber .50 & Explosive Round	Mixed Weapons	1	0.3
Unknown	Unknown	1	0.3
Total	All Types	345	100.00

TABLE D-II (C) DISTRIBUTION OF HITS BY WEAPON (U)

Weapon Type	Total Hits	Percent
Caliber .30 Rifle	192	23.0
Caliber .30 Automatic Weapon	153	18.3
Caliber .30 Unknown Weapon	302	36.3
Subtotal	647	77.6
Caliber .50 Automatic Weapon	97	11.7
81mm Mortar Fragments	2	0.2
Unknown Mortar Fragments	31	3.7
37mm Projectile (direct hit)	1	0.1
Unknown Projectile Fragments	55	6.6
Unknown Weapon	1	0.1
Total	834	100.00

TABLE D-III (C) NUMBER OF SORTIES HIT - THREAT VERSUS MONTH (U)

Year	Month(s)	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	HE	Unk	Total
1967	Jan	3		2	5				5
	Feb	1		3	4				4
	Mar	1		1	2				2
1st Qtr Total		5		6	11				11
	Apr	7	2	1	10				10
	May	10	5	1	16	1	1		18
	Jun	7	3		10		1		10
2nd Qtr Total		24	10	2	36	1	2		38
1st Half Total		29	10	8	47	1	2		49
	Jul	8	1		9				9
	Aug	9	2		11				11
	Sep	15	2		17	2			19
3rd Qtr Total		32	5		37	2			39
	Oct	11	1		12				12
	Nov	18	9		27				27
	Dec	9	2	1	12				12
4th Qtr Total		38	12	1	51				51
2nd Half Total		70	17	1	88	2			90
1967 Total		99	27	9	135	3	2		139

TABLE D-III (C) NUMBER OF SORTIES HIT - THREAT VERSUS MONTH (U)
(Cont'd)

Year	Month(s)	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	HE	Unk	Total
1968	Jan		1	17	18		1		19
	Feb	6	3	19	28	6	1	1	36
	Mar	6		6	12	2			14
1st Qtr Total		12	4	42	58	8	2	1	69
	Apr		2	22	24	3	2		28
	May	1	1	2	4	1	1		5
	Jun			3	3	1	2		6
2nd Qtr Total		1	3	27	31	5	5		39
1st Half Total		13	7	69	89	13	7	1	108
	Jul		1	1	2				2
	Aug			2	2	1	1		4
	Sep			3	3				3
3rd Qtr Total			1	6	7	1	1		9
	Oct			10	10				10
	Nov			3	3				3
	Dec	5	7	7	19	1			20
4th Qtr Total		5	7	20	32	1			33
2nd Half Total		5	8	26	39	2	1		42
1968 Total		18	15	95	128	15	8	1	150

TABLE D-III (C) NUMBER OF SORTIES HIT - THREAT VERSUS MONTH (U)
(Cont'd)

Year	Month(s)	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	HE	Unk	Total
1969	Jan			12	12	1	1		13
	Feb			7	7	1	3		10
	Mar		1	12	13	6	2		19
1st Qtr Total			1	31	32	8	6		42
	Apr			4	4	2	2		7
	May			2	2	1			2
	Jun	1	2	1	4		1		5
2nd Qtr Total		1	2	7	10	3	3		14
1st Half Total		1	3	38	42	11	9		56
Grand Total (30 months)		118	45	142	305	29	19	1	345*

Includes nine sorties hit by mixed threats.

TABLE D-IV (C) TOTAL HITS - THREAT VERSUS MONTH (U)

Year	Month(s)	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	HE	Unk	Total
1967	Jan	3		4	7				7
	Feb	1		3	4				4
	Mar	1		4	5				5
1st Qtr Total		5		11	16				16
	Apr	11	7	1	19				19
	May	16	14	1	31	7	1		39
	Jun	16	8		24		2		26
2nd Qtr Total		43	29	2	74	7	3		84
1st Half Total		48	29	13	90	7	3		100
	Jul	10	2		12				12
	Aug	11	3		14				14
	Sep	21	3		24	2			26
3rd Qtr Total		42	8		50	2			52
	Oct	28	8		36				36
	Nov	33	34		67				67
	Dec	13	3	1	17				17
4th Qtr Total		74	45	1	120				120
2nd Half Total		116	53	1	170	2			172
1967 Total		164	82	14	260	9	3		272

TABLE D-IV (C) TOTAL HITS - THREAT VERSUS MONTH (U) (Cont'd)

Year	Month(s)	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	HE	Unk	Total
1968	Jan		22	27	49		1		50
	Feb	13	18	46	77	16	27	1	121
	Mar	7		8	15	3			18
1st Qtr Total		20	40	81	141	19	28	1	189
	Apr		9	55	64	18	12		94
	May	1	2	5	8	1	22		31
	Jun			4	4	1	3		8
2nd Qtr Total		1	11	64	76	20	37		133
1st Half Total		21	51	145	217	39	65	1	322
	Jul		1	1	2				2
	Aug			4	4	1	2		7
	Sep			4	4				4
3rd Qtr Total			1	9	10	1	2		13
	Oct			21	21				21
	Nov			6	6				6
	Dec	5	13	15	33	1			34
4th Qtr Total		5	13	42	60	1			61
2nd Half Total		5	14	51	70	2	2		74
1968 Total		26	65	196	287	41	67	1	396

TABLE D-IV (C) TOTAL HITS - THREAT VERSUS MONTH (U) (Cont'd)

Year	Month(s)	.30 Rifle	.30 Auto Wpn	.30 Unk	All .30	All .50	HE	Unk	Total
1969	Jan			23	23	2	1		26
	Feb			10	10	1	4		15
	Mar		3	38	41	18	5		64
1st Qtr Total			3	71	74	21	10		105
	Apr			16	16	25	7		48
	May			3	3	1			4
	Jun	2	3	2	7		2		9
2nd Qtr Total		2	3	21	26	26	9		61
1st Half Total		2	6	92	100	47	19		166
Grand Total - (30 Months)		192	153	302	647	97	89	1	834

TABLE D-V (C) FREQUENCY OF HIT MULTIPLES VERSUS THREAT (U)

Number of Hit Multiples

	Caliber .30							
Hit Multiple	Rifle	Auto Wpn	Unk	Total	Cal .50	HE Frags	Mixed Cals	Total
Unknown		1	2	3		3	1	7
One	83	15	82	180	11	6		197
Two	19	10	23	52	4	4	3	63
Three	7	5	15	27	2		1	30
Four	3	3	4	10	2	1		13
Five	1	2	2	5				5
Six	3	1	2	6				6
Seven		1	1	2	1			3
Eight	1	2	1	4				4
Nine		3	1	4	1		1	6
Ten			1	1		1	1	3
Eleven							1	1
Twelve					1			1
Thirteen							1	1
Over 15		1	2	3	1	1		5
Total	117	44	136	297	23	16	9	345

Percent

	Caliber .30							
Hit Multiple	Rifle	Auto Wpn	Unk	Total	Cal .50	HE Frags	Mixed Cals	Total
One	70.94	34.87	61.19	61.22	47.83	46.16		58.27
Two	16.24	23.25	17.16	17.69	17.39	30.77	37.50	18.63
Three	5.98	11.63	11.19	9.18	8.70		12.50	8.87
Four	2.56	6.98	2.99	3.40	8.70	7.69		3.85
Five	0.85	4.65	1.49	1.70				1.48
Six	2.56	2.33	1.49	2.04				1.78
Seven		2.33	0.75	0.68	4.35			0.89
Eight	0.85	4.65	0.75	1.36				1.18
Nine		6.98	0.75	1.36	4.35		12.50	1.78
Ten			0.75	0.34		7.69	12.50	0.89
Eleven							12.50	0.30
Twelve					4.35			0.30
Thirteen							12.50	0.30
Over 15		2.33	1.49	1.02	4.35	7.69		1.48
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE D-VI (C) FREQUENCY OF HIT MULTIPLES VERSUS FLIGHT PHASE (U)

Hit Multiple	Number of Hit Multiples										
	Climb Out	En Route Low	En Route High	Orbiting	Hover	Descent	Landing	On Ground	Take Off	Unknown	Total
Unknown		2	2					1	2	1	8
One	13	26	71	1	4	18	17	6	11	29	196
Two	3	7	25		2	6	4	2	11	3	63
Three	1	6	12		1	7	1		2		32
Four	2	2	2	1		1		1	3	1	13
Five		3	1						1		5
Six		2	1		1	2				1	6
Seven	1				1						3
Eight	1		2		1				1		4
Nine		3	1			1					6
Ten			2		1						3
Eleven					1						1
Twelve		1					1				1
Thirteen						2	2	1			5
Over 15											
Total	21	52	119	2	12	37	25	11	31	35	345

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TABLE D-VI (C) FREQUENCY OF HIT MULTIPLES VERSUS FLIGHT PHASE (U) (Cont'd)

Hit Multiple	Percent of Hit Multiples										
	Climb Out	En Route Low	En Route High	Orbiting	Hover	Descent	Landing	On Ground	Take Off	Unknown	Total
One	61.91	52.00	60.69	50.00	33.33	48.65	68.00	60.00	37.93	85.30	58.27
Two	14.29	14.00	21.37		16.67	16.22	16.00	20.00	37.93	8.82	18.63
Three	4.76	12.00	10.26		8.33	18.92	4.00		6.90		8.87
Four	9.52	4.00	1.71	50.00		2.70		10.00	10.34	2.94	3.85
Five		6.00	0.85						3.45		1.48
Six		4.00	0.85		8.33	5.41					1.78
Seven	4.76				8.33					2.94	0.89
Eight	4.76		1.71		8.33						1.18
Nine		6.00	0.85			2.70			3.45		1.78
Ten			1.71		8.33						0.89
Eleven					8.33						0.30
Twelve		2.00									0.30
Thirteen							4.00				0.30
Over 15						5.41	8.00	10.00			1.48
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

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TABLE D-VII (C) DISTRIBUTION OF HITS VERSUS RANGE (U)

Range (Meters)	Caliber .30 Rifle	Auto Wpn	Unk	Total	Cal .50	Other	Total
Number of Hits Received While Airborne:							
Unknown	159	68	288	515	52	28	595
0 - 50							
51 - 100	2	44		46	20		66
101 - 200	5	17	4	26			26
201 - 300	3	4	1	8			8
301 - 400	1	1		2			2
401 - 500	4	1		5			5
501 - 600							
601 - 700	5	2	1	8	4		12
701 - 800	1		2	3	12		15
801 - 900							
901 - 1000	5	3		8	7	6	21
1001 - 1500	2	6	2	10	1		11
1501 - 2000		7		7			7
Over 2000	2			2	1	21	24
Total Airborne	189	153	298	640	97	55	792
Number of Hits Received While on Ground:							
Unknown	3	-	4	7	-	34	42
Total Hits	192	153	302	647	97	89	834

TABLE D-VII (C) DISTRIBUTION OF HITS VERSUS RANG (U) (Cont'd)

Range (Meters)	Caliber .30 Rifle	Caliber .30 Auto Wpn	Caliber .30 Unk	Caliber .30 Total	Cal .50	HE	Total
Percent of Hits Received While Airborne:							
0 - 50							
51 - 100	6.67	51.75		36.80	44.44		33.51
101 - 200	16.67	20.00	40.00	20.80			15.20
201 - 300	10.00	4.71	10.00	6.40			4.06
301 - 400	3.33	1.18		1.60			1.02
401 - 500	13.33	1.18		4.00			2.54
501 - 600							
601 - 700	16.67	2.35	10.00	6.40	8.89		6.09
701 - 800	3.33		20.00	2.40	26.67		7.61
801 - 900							
901 - 1000	16.67	3.53		6.40	15.56	22.22	10.66
1001 - 1500	6.67	7.06	20.00	8.00	2.22		5.58
1501 - 2000		8.24		5.60			3.55
Over 2000	6.67			1.60	2.22	77.78	12.18
Total Airborne	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Percent of Hits Received While on Ground:							
Unknown	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE D-VIII (C) DISTRIBUTION OF HITS VERSUS DIRECTION (U)
(Not on Ground)

	Caliber .30				Cal		
Clock Direction	Rifle	Auto Wpn	Unk	Total	.50	Other	Total
11	4	32		36	8	6	50
12	5	4	2	11	11	1	23
01		1		1	3		4
Subtotal	9	37	2	48	22	7	77
02	7	9		16			16
03	17	3	16	36	19	2	57
04	2	10	1	13		23	36
Subtotal	26	22	17	65	19	25	109
05	1			1			1
06	7	3	5	15			15
07	1	5	1	7	1		8
Subtotal	9	8	6	23	1		24
08	1	9		10			10
09	10	12		22			22
10		1		1	9		10
Subtotal	11	22		33	9		42
Directly Below	2			2			2
Unknown	124	59	232	415	43	12	470
Unspecified	8	5	41	54	3	11	68
Total	189	153	298	640	97	55	792

TABLE D-IX (C) DISTRIBUTION OF HITS ON MAJOR CH/HH-53 COMPARTMENTS (U)

Compartments	Caliber .30 Rifle	Auto Wpn	Unk	Total	Cal .50	Other	Total
Cockpit	13	20	36	69	15	1	85
Tail Rotor Blade	3	3	6	12	2	1	15
Forward Fuselage	82	67	111	260	50	47	357
Aft Fuselage	26	16	34	76	10	12	98
Unknown Fuselage	5	22	18	45	6	16	67
Hub	1			1			1
Blade	40	16	35	91	9	6	106
Unknown Main Rotor Blade Section			17	17	2		19
Pylon Assembly	15	4	23	42	3	4	49
Landing Gear Aft			1	1			1
Unknown Other	1			1			1
Unspecified	6	5	21	32		3	35
Total	192	153	302	647	97	90	834

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(CONFIDENTIAL) APPENDIX E

HITS AND EFFECTS BY SYSTEMS AND COMPONENTS (U)

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TABLE E-I (C) FUEL SYSTEM HITS AND RESULTS (U)

Fuel System Component Hit	Number of Hits	Known Fuel Leaks	Mission Aborts	Forced Landings
Main Fuel Cell[b] (self-sealing)	19	1	1	-
Auxiliary Tank[b] (non-s.s.; HH-53B)	4	4	2[c]	-
Fuel Supply Line	2	1	0	1[d]
Fuel Transfer Line	1	-	-	-
Heater Fuel Line	1	0	-	-
Unknown Fuel Line	1	-	-	-
Fuel Vent Line	1	0	-	-
Unknown Fuel Component	3[a]	1	-	3
Total	32	7	3	4

NOTES: a. *All hits by Caliber .30 weapons except one by Caliber 0.50 on unknown component.*

b. *Case 80008/Mission Abort involved three main cell hits, three auxiliary tank hits. Fuel was lost from both drop tanks, loss from main cells small, if any.*

c. *Case 70101/Mission Abort involved remaining auxiliary tank and one full supply line hit. Fuel lost from auxiliary tank, none from supply line.*

d. *Case 90020/Forced landing; fuel starvation of No. 1 engine followed by single-engine flight to secure area.*

TABLE E-II (C) ENGINE COMPARTMENT HITS AND RESULTS (U)

Engine Components Damaged	Number of Hits	Mission Aborts	Forced Landings
Cowling	9	-	-
Exhaust Pipe	5	-	-
Air Particle Separator	4	1	-
Oil Cooler	1	-	-
Unknown Engine Component	10	-	2
Total	29	1*	2

*No power loss; mission abort due to intense ground fire.

TABLE E-III (C) MECHANICAL CONTROL SYSTEMS HITS AND RESULTS (U)

Case No.	Control Component Damaged	Weapon Altitude Airspeed	Damage Description	Result to Aircraft
80003	Cyclic Torque Tube	Cal..30 1600 feet 95 knots	Tube dented	None. Continued flight.
80012	Rudder Cable (right side)	Cal..50 2500 feet 120 knots	Partly severed	None. Two of 7 strands cut at station 450. Cable remained operable and A/C continued flight.
80045	Tail Rotor Push-Pull Rod	Cal..30 6000 feet 110 knots	Rod creased	None. Rod creased at station 830. Rod remained operable and A/C continued flight.
80054	Control Rods	Cal..50 2800 feet 100 knots	Two rods 90 percent severed	Forced Landing. Damage to rods in forward compartment caused partial control loss. A/C forced to make wheels-up landing.
80105	Unknown	Cal. .30 300 feet 120 knots	Suspect minor	Mission Aborted. Completed return flight safely.
90027	Flight Control Rod(s)	Cal. .30 60 feet 30 knots	Two hits. Suspect major damage	Forced Landing. Outcome unknown (A/C recovered in unspecified manner).

TABLE E-III (C) MECHANICAL CONTROL SYSTEMS HITS AND RESULTS (U) (Cont'd)

Case No.	Control Component Damaged	Weapon Altitude Airspeed	Damage Description	Result to Aircraft
90044	Unknown	Cal. .50 100 feet 30 knots	Unspecified damage	Forced Landing. Controls damage unspecified. A/C recovered later.

TABLE E-IV (C) HYDRAULIC SYSTEMS HITS AND RESULTS (U)

Hydraulic System/Component Hit	Number of Hits	Known Leaks	Adverse Reactions: Mission Aborts	Adverse Reactions: Forced Landings
First Stage Hydraulic System:				
Hydraulic Line	1	1		1[a]
Unknown Component	1	1		1
Total - First Stage	2	2		2
Second Stage Hydraulic System:				
Hydraulic Line	1[b]	1[b]	1[b]	
Servocylinder	1[b]			
Unknown Component	1	1		1
Total - Second Stage	3	2	1	1
Utility Hydraulic System:				
Hydraulic Line(s)	6	6		
Tail Rotor Servocylinder	1	1	1	
Reservoir	1			
Heat Exchanger	1	1		
Unknown Component	1	1		
Total - Utility	10	9	1	
Main Rotor Brake Reservoir	1	1		
Unknown System/Component	2[c]			1[d]
Total - All Hydraulic Systems	18	14	2	4

NOTES: a. *Involved minor in-flight fire in tail section.*

b. *Servo and line both hit by unknown size AAA projectile fragments in single incident (Case No. 80045).*

c. *Caliber .50 (Case No. 90044); all others except Case 80045 were Caliber .30.*

d. *Case No. 90054: 37mm direct hit through side over ramp caused loss of stage one and utility systems -- Forced to land in enemy territory and lost A/C; Cases 90027 and 90044 -- Forced to land due primarily to other systems damage, recovered later.*

TABLE E-V (C) ELECTRICAL SYSTEM HITS AND RESULTS (U)

(Eleven hits - ten caliber .30 and one caliber .50)

Case No.	Component Damaged	Remarks
Wiring Hits:		
70108	Wire bundle	Bullet struck instrument panel main wiring bundle and severed 16 wires. Mission completed.
70114	Wire bundle	Bullet passed through wire bundle at station 104 during takeoff. Mission completed.
70200	(1) Wire bundle	Wires damaged. Mission completed.
70200	(2) Wire bundle	Wires damaged. Mission completed.
80008	Intercom wires	Severed wires disabling HF and intercom radios. Mission aborted due to extensive damage by 22 total hits.
80015	Wires	Bullet cut three wires and lodged in gunner's shoulder. Mission completed.
80046	Minigun wires	Bullet nicked minigun rate control box wiring harness. Mission completed.
80054	AFCS wires	Caliber .50 bullet cut unknown number of wires. Forced landing (wheels up) due to other damage.
Component Hits:		
70111	Pilot's Circuit/ Breaker Panel	Bullet penetrated panel and severed 12 wires. Mission completed.
80062	Copilot's Circuit/ Breaker Panel	Bullet expended in panel. Mission completed.
70127	Unknown Electrical compartment	Bullet hit compartment. Mission completed.

TABLE E-VI (C) AVIONICS SYSTEMS HITS AND RESULTS (U)

(Eight hits - all caliber .30)

Case No.	Component Damaged	Remarks
70103	HF antenna coupler	Mission completed.
70121	ADF antenna	Mission completed.
70132	UHF antenna	Bullet lodged in antenna. Mission completed.
70149	Radio compartment	Unknown effect. Mission completed.
70183	HF antenna coupler	Coupler severed. Mission completed.
70228	Radio compartment	Bullet passed through compartment and lodged in nose gear firewall. Mission completed.
70261	Radio compartment	Unknown effect. Mission completed.
80075	Radio compartment	Unknown effect. Mission completed.

TABLE E-VII (C) INSTRUMENT SYSTEMS HITS AND RESULTS (U)

(Five hits - all caliber .30)

Case No.	Component Damaged	Remarks
70266	Torque-meter and Cruise-Guide	Mission completed.
80008	J-4 Compass	Bullet hit compass and dropped out nose wheel well.
	ID249 Indicator	Bullet through windshield shattered pilot's directional indicator.
	APN 171 Altimeter	Bullet smashed pilot's radar altimeter.
	Doppler radome	Bullet smashed lower rotating beacon and passed through radome. Mission Aborted due to wide-spread damage.

TABLE E-VIII (C) LANDING GEAR SYSTEM HIT AND RESULTS (U)

(Five hits - three caliber .30 and two caliber .50)

Case No.	Component Damaged	Remarks
80005	Nose gear strut	Caliber .30 bullet expended in strut. Mission completed; safe landing.
80008	Nose gear tire and wheel	Caliber .30 bullet hit wheel and lodged in co-rotating wheel. Mission aborted for other reasons; safe landing.
80032	Left main gear rim	Caliber .30 bullet entered inboard rim and exited same. Mission completed; no effect on landing.
90022	Right main gear strut	Caliber .50 bullet hit right gear strut. Mission completed; no effect on landing.
90028	Left main gear strut	Caliber .50 bullet passed through left main gear oleo strut. Mission completed; no effect on landing.

TABLE E-IX (C) MISCELLANEOUS EQUIPMENT HITS AND RESULTS (U)

(Sixteen hits - all caliber .30)

Component	Number of Hits
Inert Cargo	3
Briefcase	1
Heater	1
Landing Lights	1
Static Discharge Unit	1
Cargo Hoist	2
Rotor Fairing	1
Heater Duct	1
Bracket	2
Unarmored Seats	2
M60 Machine Gun	1
Total	16

TABLE E-X (C) ARMOR HITS AND RESULTS (U)

Case No.	Model	Armor (Mat'l)	Hit By	A/C Altitude Direction of Fire Range of Fire	Armor Effect	Remarks
70141	CH-53A	L. Engine (DPSA-2)	Cal .30	400 feet L. side (9:00) 2000 Meters	O.K.	Hit armor and stopped. No damage.
70142	CH-53A	R. Engine (DPSA-2)	Cal .30	600 feet R. side 200 Meters	O.K.	Hit armor and stopped. No damage.
80012	CH-53A	L. Engine (DPSA-2)	Cal .50 API	2500 feet L. side (10:00) 800 Meters	Failed	Penetrated edge of armor and bracket, passed through top of nacelle, and splattered against rotor head No engine damage.
80023	CH-53A	R. Engine (DPSA-2)	Cal .30	300 feet Unknown Unknown	O.K.	Expended against armor. No damage.
80045	HH-53B	(1) Servo (Titanium)	Unk AAA fragment	6000 feet R. side (4:00) Proximity burst	Prevented servo damage; caused line damage.	Fragment bounced off lateral servo armor plate and severed hydraulic lines and wiring aft of forward primary servo. Lost second stage hydraulic pressure.
		(2) R. Engine (Titanium)	Unk AAA fragment	6000 feet R. side (4:00) Proximity burst	O.K.	Fragment struck armor and bounced away. No. damage.
		(3) Copilot's seat (DPSA-2)	Cal .30	275 feet L. side (5:00) Unknown	O.K.	Bullet severed fuel line and hit copilot's seat. Copilot unhurt.

TABLE E-X (C) ARMOR HITS AND RESULTS (U) (Cont'd)

Case No.	Model	Armor (Mat'l)	Hit By	A/C Altitude Direction of Fire Range of Fire	Armor Effect	Remarks
80158	HH-53B	Flak skirt	Cal .30	50 feet Below Unknown	O.K.	Gunner was standing on self-provided folded flak "skirt." Bullet came through bottom of fuselage and stopped against skirt.
90006	CH-53A	L. Engine (DPSA-2)	Cal .30 (2 hits)	250 feet L. side Unknown	O.K.	Two bullets struck port engine armor. No engine damage.
90016	CH-53A	R. Engine (DPSA-2)	Cal .30	2000 feet R. side Unknown	O.K.	Bullet was stopped by armor. No engine damage.

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(CONFIDENTIAL) APPENDIX F

AIRCRAFT KILLS - LOSSES, FORCED LANDINGS, MISSION ABORTS (U)

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TABLE F-1 (C) CH/HH-53 HELICOPTER LOSSES IN SOUTHEAST ASIA (U)
(From January 1967 Through June 1969)

A/C Type	A/C S/N	Date of Loss	BRL Case No	Mode of Destruction	Cause of Destruction	Known Details
a. Caused by Ground Fire:						
CH-53A*	153283	22 Feb 68	80035	Crash	Weapon unspecified; Uncontrolled landing and fire	A/C hit in starboard side transition section prior to takeoff at Khe San. It flew 90 feet and landed, then rolled off runway, breaking into three sections. Post-crash fire extinguished. Two killed, 3 injured.
HH-53B*	64-144[illegible]	18 Jan 69	90054	Left in enemy territory	37mm AAA and Cal.0.30	A/C hit after A-1 pilot recovery in Cambodia. The 37mm projectile came through the aft fuselage and exploded. Lost pressure in utility, then first stage hydraulics (heavy fluid leaks in cabin). Lost tail rotor response. Used shallow approach one-fourth mile to clearing, turned left 90 degrees and landed with few collective or rudder changes. Rolled 200 feet down slope. Crew and survivor rescued within 10 minutes but A/C could not be recovered.
CH-53A	153276	5 Mar 68		Destroyed on Ground	Direct hit on parked A/C	A/C hit and destroyed in mortar attack on base. No known casualties.

TABLE F-I (C) CH/HH-53 HELICOPTER LOSSES IN SOUTHEAST ASIA (U) (Cont'd)

A/C Type	A/C S/N	Date of Loss	BRL Case No	Mode of Destruction	Cause of Destruction	Known Details
b. Accidents - Not Caused by Ground Fire:						
CH-53A**	153710	8 Jan 68		Crash	Accident	Flew into mountain after change from IFR to VFR. Pilot error. Forty-three killed.
CH-53A	153278	19 Feb 68		Crash	Accident	Crashed in mountainous terrain between Phu Bai and Danang and may have had destruction completed by enemy. Eleven missing, presumed dead.
CH-53A	151697	24 Apr 68		Crash	Accident	Crashed in landing and burned. Pilot error. One casualty (burns).
CH-53A	153281	1 May 68		Crash	Accident	A/C reported down in sea. Pilot error. Four injured; one missing.
CH-53A	152413	19 May 68		Crash	Accident	Destroyed in crash. Materiel failure. Thirty-five injured.
CH-53A	153284	28 Jul 68		Crash	Accident	Crashed in rice paddy after bearing failure in No. 1 engine and in-flight fire. Five killed.

These two crashes were caused by ground fire while aircraft were operating. The seven other losses do not pertain to combat damage analyses as presented in this report.

**Listed by unofficial sources as the highest toll of lives among helicopter crashes for the entire SEA conflict, as of October 1970.*

TABLE F-II (C) CH/HH-53 FORCED LANDINGS (U)
(1967 through June 1969)
(15 cases)

Case No. A/C Type A/C S/N	Reaction Code Fire in- Flight	Casualties	Hits Cal Wpn	Flight Phase Altitude, ft. Speed, knots	Probable Cause(s)	Remarks
90054 HH-53B 64-14430	LE None	None	(1) .30 (1) 37mm	En Route 150 150	Loss of hydraulics, Tail Rotor control.	Listed under losses; destroyed by enemy. (See Table F-I, second case listed.)
80054 CH-53A 153714	LU None	None	3 .50 Auto Wpn	Approach 2800 100	Controls	While on approach to the landing zone the A/C received 3 Cal. .50 h'ts in the forward compartment. AFCS wiring and approximately 90 percent of 2 control rods were shot away. With partial control, pilot made a wheels-up landing with damage limited to broken FM antenna. Method of A/C recovery unknown.
90050 CH-53A 154876	LS None	None	2 .30 Unknown	En Route 200 100	Fuel system damage	A/C received 2 hits while flying en route at 200 feet. A Cal. .30 round passed through the tail section and struck the main rotor blade. A/C also took one round in the fuel system. Forced to land and later recovered.
90043 CH-53A 154880	LS None	None	13 .50 & Rocket Fragments	Landing 20 0	Engine Power Loss	A/C hit by .50 caliber incendiary and B-40 rocket fragments. A/C took seven .50 caliber automatic weapon hits with one round in the No. 2 engine causing engine shut down. Fragment hits were confined to the tail section. Forced to land, later recovered.

TABLE F-II (C) CH/HH-53 FORCED LANDINGS (U) (Cont'd)

Case No. A/C Type A/C S/N	Reaction Code Fire in-Flight	Casualties	Hits Cal Wpn	Flight Phase Altitude, ft. Speed, knots	Probable Cause(s)	Remarks
80064 CH-53A 152411	L9 Fire	None	3 .30 Auto Wpn	En Route 2200 Unknown	Fire in-flight Hydraulic system damage	A/C was en route at 2200 feet when it received heavy automatic weapons fire. The crew chief reported a hit and a fire in the tail section. The pilot reversed course. At this time the first stage hydraulic pressure was lost. The pilot selected a landing site but received intense small arms automatic weapons fire. Pilot then flew 500 meters to a secure zone and landed. Crew evacuated and was rescued. A/C later recovered and repaired. Fire apparently was minor in nature.
80006 CH-53A Unknown	L8 None	None	Unk .30 Unknown	Unknown Unknown Unknown	Engine Power Loss	A/C received a Cal. .30 hit in the No. 1 engine causing power failure. The A/C continued to fly to a secure zone on one engine, landing with no further damage. A/C later recovered.
90020 CH-53A 151687	L8 None	None	2 .30 Unknown	Unknown Unknown Unknown	Engine Power Loss due to fuel starvation	A/C received two Cal. .30 hits through the left sponson cutting a fuel line and causing fuel starvation to No. 1 engine. A/C flew to a secure base on single engine and shut down.

TABLE F-II (C) CH/HH-53 FORCED LANDINGS (U) (Cont'd)

Case No. A/C Type A/C S/N	Reaction Code Fire in- Flight	Casualties	Hits Cal Wpn	Flight Phase Altitude, ft. Speed, knots	Probable Cause(s)	Remarks
80101 CH-53A 153717	L3 None	None	4 .30 Auto Wpn	Taking Off 150 55	Transmission Oil Loss	A/C received fire from automatic weapon while on takeoff from landing zone. Pilot landed in a secure zone and on inspection oil was found leaking from the main transmission. Repairs were made and the mission was completed.
80102 CH-53A 153727	L2 None	None	1 .30 Auto Wpn	Landing 100 40	Precautionary (minor damage)	A/C received one Cal. .30 hit in the passenger compartment. No injury. Pilot landed, made a quick inspection and took off.
70276 CH-53A 152567	L9 None	1 WIA	3 .30 Unknown	En Route 1500 190	Main Rotor System	A/C received 3 hits in main rotor system. Forced to land, later recovered. No other details reported.
80151 CH-53A 153714	L9 None	None	1 .50 Auto Wpn	En Route 2500 100	Unknown damage	A/C received one hit in cockpit and was forced to land. No report of casualties or component damage. Possibly precautionary landing.
70271 CH-53A 153306	L0 None	None	1 .30 Auto Wpn	Takeoff 1000 50	Precaution	A/C received one hit in bottom of passenger compartment. Mission not completed; forced to land for precautionary reasons. Inspection showed damage not to be as serious as thought. A/C was on 35th run when hit.

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TABLE F-11 (C) CH/HH-53 FORCED LANDINGS (U) (Cont'd)

Case No. A/C Type A/C S/N	Reaction Code Fire in- Flight	Casualties	Hits Cal Wpn	Flight Phase Altitude, ft. Speed, knots	Probable Cause(s)	Remarks
90027 CH-53A 153733	L8 None	None	19 .30 Rifle	Approach to Landing Zone	Control Rods	A/C received 19 small arms hits while on approach to landing zone, severing hydraulic lines to the ramp and left landing gear brake, also damaging two main flight control rods, plus two hits in main rotor blades. A/C forced to land. Suspect repairs made and A/C flown home.
80081 CH-53A 152412	L6 None	None	30 .30 Rifle	En Route 300 Unknown	Lost 2nd stage hydraulic pressure; 1st stage fluctuated.	A/C received intense small arms fire at 300 feet. A/C sustained 30 hits with subsequent loss of No. 2 flight control servo pressure and had fluctuating No. 1 flight control servo pressure. Pilot landed at a friendly position. Emergency repairs were made and the A/C returned to home base.
70237 CH-53A 151696	ML None	None	1 .30 Auto Wpn	Climb-out 1800 80	Lost 1st stage hydraulic pressure	A/C received one hit on stud on drive shaft coupling, causing insignificant shaft damage and two 1/4-inch cracks in main transmission casing. Bullet shattered. Five pieces hit main rotor blade, one piece cut a 1st stage hydraulic line. Pilot made precautionary fully-controlled landing following loss of pressure. Method of repair and/or recovery not specified.

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TABLE F-III (C) CH/HH-53 MISSION ABORTS (U)
(1967 through June 1969)
(15 Cases)

Case No. A/C Type A/C S/N	Reaction Code Fire in- Flight	Casualties	Hits Cal Wpn	Flight Phase Altitude, ft. Speed, knots	Probable Cause(s)	Remarks
70101 HH-53B 66-14430	MA None	None	5 .30 Auto Wpn	En Route 150 60	Fuel Tank damage, loss of fuel	A/C received 5 hits while on training mission. One hit caused the auxiliary fuel tank to drain of all fuel; a second made hole in a main rotor blade, causing indication of loss of BIM pressure. Damage did not degrade performance, but mission was aborted due to fuel loss.
70255 CH-53A 153276	MA None	None	3 .30 Auto Wpn	Landing 200 50	Tail rotor servo.	A/C received 3 hits while landing on troop lift mission - two hits in ramp, one in tail rotor servo. Mission aborted due to servo damage, which is not further described.
80008 HH-53B 60-14432	MA None	None	22 .30 Auto Wpn	Flare to Hover 175 20	Multiple damage, loss of fuel.	A/C received 22 individual hits by caliber .30 bullets while on aircrew rescue mission. Bullets damaged instruments, antennae, and wires. Holes in auxiliary tanks caused loss of all auxiliary fuel; self-sealing cells hit twice without leaking. Blade hits caused loss of BIM pressure. Mission aborted due to fuel loss Grounded after safe return.
80045 HH-53B 66-14435	MA None	1 WIA	25 .30 Auto Wpn + AAA Frag.	En Route, Hover 6000 140	Lost 2nd stage hydraulic pressure	A/C received numerous fragment hits from 3 AAA projectile airbursts while in forward flight at 6000 feet and several caliber .30 bullet hits moments later while hovering. Mission was rescue of downed O-2 pilot. Damages included holes in main rotor blades, creased tail rotor control rod, gouged main transmission (2 places), hits on No. 2 engine

TABLE F-III (C) CH/HH-53 MISSION ABORTS (U) (Cont'd)

Case No. A/C Type A/C S/N	Reaction Code Fire in-Flight	Casualties	Hits Cal Wpn	Flight Phase Altitude, ft. Speed, knots	Probable Cause(s)	Remarks
80045 Cont'd)						armor and copilot seat, hit on forward tandem servo valve body. Also damage by a bullet which struck lateral servo armor and bounced off, then severed hydraulic lines to the unit. One crew member received arm and leg shrapnel wounds. Mission aborted due to loss of second stage hydraulic pressure.
80095 CH-53A 153309	MA None	None	4 .30 Auto Wpn	Climb-Out 1200 90	Cargo hook damage	A/C received 4 hits while climbing out of LZ with cargo sling-load. Two bullets hit port EAPS barrel, one hit sponson, and one hit cargo hook. Mission aborted after relanding and inspecting. (Weather poor.)
80099 CH-53A 153711	MA None	None	1 .30 Auto Wpn	Landing 300 60	Fuel cell damage	A/C received one hit in sponson and fuel cell. Resupply mission. Hit taken during landing attempt. Mission aborted. Returned to base.
80105 CH-53A 153727	MA None	None	1 .30 Auto Wpn	Landing 300 120	Control system damage	A/C received one bullet hit while on cargo resupply mission. Hit during landing (with no escort), mission was aborted due to unspecified type of control system damage.
80118 CH-53A 153306	MA None	None	1 .30 Auto Wpn	Landing 400 90	Main rotor system damage.	A/C received one bullet through cockpit and into main rotor system. Mission aborted.

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TABLE F-III (C) CH/HH-53 MISSION ABORTS (U) (Cont'd)

Case No. A/C Type A/C S/N	Reaction Code Fire in- Flight	Casualties	Hits Cal Wpn	Flight Phase Altitude, ft. Speed, knots	Probable Cause(s)	Remarks
80141 CH-53A 153306	MA None	None	2 Unknown Expl. Rd.	On Ground 0 0	Unknown	A/C received two hits by explosive rounds while operating on ground in landing zone. Mission apparently aborted, unknown if completed. No information regarding damage.
70131 CH-53A 151697	MX None	None	2 .30 Auto Wpn	En Route 1500 20	Ground fire intensity	A/C encountered intense automatic weapons fire while en route retrieving sling-loaded CH-46. One bullet entered right EAPS barrel and expended against EAPS brace; another penetrated tail pylon. Mission reportedly aborted, possibly as a precaution.
70154 CH-53A 153278	MX None	None	1 .30 Auto Wpn	En Route 2300 70	Lost control of sling load	A/C received one hit in left sponson while carrying 7000 lbs. of ammunition as external load. Evasive action started an oscillation of the sling load and unexpected IFR conditions developed. Pilot was forced to jettison the load, negating the mission.
70252 CH-53A 152408	MX None	None	2 .30 Auto Wpn	En Route 2000 130	Ground Fire intensity	A/C received two hits in bottom of fuselage and continued toward landing zone. On approach landing zone was under mortar attack. Landing and mission were aborted.

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TABLE F-III (C) CH/HH-53 MISSION ABORTS (U) (Cont'd)

Case No. A/C Type A/C S/N	Reaction Code Fire in- Flight	Casualties	Hits Cal Wpn	Flight Phase Altitude, ft. Speed, knots	Probable Cause (s)	Remarks
90035 CH-53A 153280	MP None	None	3 .30 Unknown	Descending 80 20	Precaution	A/C received two hits in passenger section and one in main rotor blade. Mission (logistics/no passengers) was aborted. Damage insignificant.
90038 CH-53A 153721	MP None	None	3 .50 Auto Wpn	En Route 1500 90	Precaution	A/C received three hits in passenger section. Mission (combat cargo) was aborted. Damage insignificant.
90039 CH-53A 151696	MP None	None	2 .50 Auto Wpn	Hover 20 0	Precaution	A/C received two hits in aft cabin and tail pylon. Mission (combat cargo) was aborted. Damage insignificant.

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Security Classification

DOCUMENT CONTROL DATA - R & D

Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified

1 ORIGINATING ACTIVITY (Corporate author) USA Aberdeen Research & Development Center Ballistic Research Laboratories Aberdeen Proving Ground, Maryland 21005	2a. REPORT SECURITY CLASSIFICATION Confidential 2b GROUP 3

3 REPORT TITLE

ANALYSIS OF COMBAT DAMAGE ON CH-53A AND HH-53B HELICOPTERS IN SOUTHEAST ASIA (1967 THROUGH JUNE 1969) (U)

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

5 AUTHOR(S) (First name, middle initial, last name)

Walter S. Thompson and Raymond E. Wheeler

6 REPORT DATE June 1971	7a. TOTAL NO OF PAGES 176	7b. NO OF REFS 8
8a. CONTRACT OR GRANT NO b. PROJECT NO 1F1o2203A150 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Memorandum Report No. 2098 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	

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11 SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Commanding General U.S. Army Materiel Command Washington, D.C. 20315

13 ABSTRACT

This report analyzes 345 cases of combat damage to U.S. Marine Corps CH-53A and U.S. Air Force HH-53B helicopters caused by ground fire in Southeast Asia, as reported to the Army Materiel Systems Analysis Agency and Ballistic Research Laboratories (AMSAA/BRL) through a number of data sources. Tabulated statistics and related analyses are provided for sorties flown, sorties hit, total hits, distribution of hits, circumstances of hits, and aircraft systems and components hit. Data are correlated with respect to crashes, forced landings, mission aborts, and damage-grounded aircraft. Hit frequency and hit multiples by weapon types are correlated with aircraft altitude, airspeed, and other factors; components and system damage are identified by reactions caused. Observations are compared with those from other analyses, for similarities with the CH-54, and for contrast with other helicopters. Comments on passive defense measures are included. (U)

DD FORM 1 NOV 68 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified

Security Classification

(This page is unclassified)

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Aircraft Helicopter Combat Damage Vulnerability Gunfire						