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UNITED STATES ARMY

TRAINING AND DOCTRINE COMMAND

UNITED STATES ARMY MATERIEL COMMAND

LIGHT HELICOPTER FAMILY
TRADE-OFF ANALYSIS

APPENDICES S AND T

VOLUME VIII

ACN: 69396

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Force	Logistics	Requirement	LHX	MEF	MARC	Sustain	Helicopter
Structure	RAM	Requirements	TOE	TOD	FD/SC	Failure	Aviation
Reliability	LOG	Personnel	TOA	AMC	SCAT	Analysis	Tilt rotor
Maintainability	RAM/LOG	Authorized	AOE	TAMC	Mean	Aircraft	Manpower
AVUM	AVIM	Maintenance	MOS	ALDT	Repair	(Cont'd on reverse.)	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This volume of the Light Helicopter Family (LHX) Trade-Off Analysis (TOA) report contains the reports of two separate but related analyses. The first is the Force Structure analysis that identifies the foreseeable impact of the LHX on the Army's aircraft and manpower requirements. The study concludes that: (1) The total LHX force structure requirements are: (a) LHX-SCAT - 3,072 aircraft; (b) LHX-Utility - 1,951 aircraft; and (2) Depending on LHX candidate, maintenance personnel savings of 8-10% are achievable. The second analysis is of reliability, availability, and maintainability/logistics (Cont'd on reverse.)

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ITEM 20 (Cont'd):

(RAM/LOG). The RAM/LOG analysis intended to identify and quantify the minimum values of RAM and associated supportability goals that the LHX would need to achieve. The RAM/LOG findings/conclusions included:

(1) Optimum unit size:

(a) 11 aircraft per attack helicopter battalion company, and
(b) 10 aircraft per aviation reconnaissance squadron troop.

(2) 5.7 to 5.8 aircraft flying hours per aircraft per day are the objective flight program,

(3) 1.0-hour mean time to repair,

(4) 3.6-maintenance man-hours/flight hour maintenance ratio,

(5) 7.1 to 8.7 hours mean time between expected maintenance actions (minimum acceptable values), and

(6) 8.4 hours mean time between mission abort failure (minimum acceptable value).

NOTE: The first two RAM/LOG findings were optimized during the analysis. The last four findings are what will then be necessary in order to achieve the optimized values.

ITEM 19 (Cont'd):

Utility	Mission abort	MTBMAF	Army
Availability	MMH/FH	MTTR	Authorization
Manhours	MTBMA	AH-1S	
Hours	FH/Day	OH-58	
Compound	ABC	UH-1	

UNITED STATES ARMY TRAINING AND DOCTRINE COMMAND

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LIGHT HELICOPTER FAMILY TRADE-OFF ANALYSIS

APPENDICES S AND T

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LIGHT HELICOPTER FAMILY
TRADE-OFF ANALYSIS
(LHX TOA)

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GLOSSARY (U)

ABC	advancing blade concept
ABC-C	advancing blade concept-compound
AHIP	Army Helicopter Improvement Program - OH-58D
AH-1S	Cobra attack helicopter
AH-64A	Apache attack helicopter
AMB	aviation maintenance battalion
AMC	aviation maintenance company
AOE	Army of Excellence
ARB	aviation reconnaissance battalion
ART	aviation reconnaissance troop
EAC	echelons above corps
FAAO	field artillery aerial observer
HEL	helicopter
HEL-C	compound helicopter
LHX	Light Helicopter Family
LHX-S	Light Helicopter Family-Scout aircraft
LHX-SCAT	Light Helicopter Family-scout/attack aircraft
LHX-U	Light Helicopter Family-Utility aircraft
SCAT	scout-attack
SOAB	Special Operations Aviation Battalion
SOCOM	Special Operations Command
TAMC	transportation aircraft maintenance company (now the aviation maintenance company (AMC))
T/R	tilt rotor

APPENDIX S

LIGHT HELICOPTER FAMILY (LHX) FORCE STRUCTURE SUBSTUDY (U)

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APPENDIX S

LIGHT HELICOPTER FAMILY (LHX) FORCE STRUCTURE (U)

S-1. (U) PURPOSE. To identify LHX impact on force structure aircraft and maintenance manpower requirements.

S-2. (U) ASSUMPTIONS.

a. (U) Current scout and command and control (C^2) aircraft (OH and UH) will be replaced on a one-for-one basis.

b. (U) The LHX Scout-Attack (SCAT) will not replace the AH-64 in the heavy fleet.

c. (U) The LHX-Utility (LHX-U) will not replace the UH-60.

d. (U) The LHX-SCAT will replace AH-1/UH-1M in the light fleet.

e. (U) Army of Excellence (AOE) organizations will be valid in the LHX time frame.

S-3. (U) SCOPE AND METHOD.

a. (U) Scope.

(1) (U) For this analysis, AOE tables of organization and equipment (TOE) (J-series) were used as available. For those units for which AOE TOEs had not been developed, the TOE currently in the TOE bank (usually an H-series) was substituted. The year 2000 was selected as the snapshot year for the force structure analysis. Analysis was limited to TOE units.

(2) (U) An 80-percent availability rate was used on the basis of LHX reliability, availability, and maintainability (RAM) substudy findings to date. This rate allowed 10 SCATs to replace 7 AH-1's and 4 OH-58's in the attack helicopter company and maintain the integrity of the 3 scout/5 attack-mix for employment.* The Department of the Army (DA) standard combat flying-hour rate was used for the basic analysis. A sensititivity analysis involving 6 daily flying hours was conducted because the LHX RAM methodology indicated that this flying-hour rate will be achievable with this aircraft.

*Since the trade-off analysis (TOA) was completed, the LHX Project Manager's Office has indicated that RAM values achievable are such that for the attack helicopter company to employ 8 SCATs for a mission, 11 aircraft must be assigned to the company.

(3) (U) Manpower criteria came from Army Regulation (AR) 570-2 for current aircraft and from the LHX Program Manager (PM) for LHX configurations. The US Army Aviation Logistics School reviewed the LHX data and expressed no objections to it. LHX configurations included helicopter (HEL), compound HEL, advancing blade concept (ABC), compound ABC, and tilt rotor.

b. (U) Method. The following procedures were used:

(1) (U) Numbers of aircraft required.

(a) (U) Identified all TOE units in the AOE force structure receiving the LHX in the year 2000 (Aviation Modernization Plan).

(b) (U) Determined TOE aircraft requirements for units on the basis of a one-for-one substitution ratio for C^2 LHX-U and for LHX-S aircraft in the scout role in attack helicopter companies and aviation reconnaissance troops (ART).

(c) (U) Computed aircraft requirements for units with organic attack aircraft on 80-percent availability:

-- To field 8 aircraft (5 attacks and 3 scouts or 3 attacks and 5 scouts), 10 aircraft of a single type (LHX-SCAT) must be in the unit.

-- Because of AOE constraints already imposed on C^2 aircraft, no reductions in C^2 aircraft were allowed.

(d) (U) At the end of February 1985, total LHX requirements in the Aviation Modernization Plan (reference 2) were identified for use in the TOA and are shown in figure S-1. It should be noted that these requirements assume that the entire light fleet (including the AHIP) has been replaced with the LHX.

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LHX-S		
Scout replacement		
TOE	1,681	
TDA	0	
Float	261	
Subtotal		1,942
Attack replacement		
TOE	760	
TDA	86	
Float	122	
Subtotal		968
Total LHX-S		2,910
LHX-U		
TOE	1,003	
TDA	722	
Fl[illegible]	190	
Total LHX-U		1,915

Figure S-1. (U) Total LHX requirements, February 1985.

(2) (U) Maintenance personnel, DA standard combat flying hours.

(a) (U) Using available AOE TOE, the number of aviation unit maintenance (AVUM) and aviation intermediate maintenance (AVIM) personnel authorized for current aircraft at unit level was determined. If an AOE TOE was not available, the current TOE (usually the H-series) was used, if appropriate. AOE TOEs for AVIM units were available only for light and heavy divisions. Manpower and analysis review criteria (MARC) factors from AR 570-2 and AOE numbers of aircraft to be maintained were used to calculate AVIM requirements for all other AVIM units.

(b) (U) Using AR 570-2 MARC factors, the number of AVUM and AVIM personnel, less supervisors, needed to maintain current aircraft was determined by unit and military occupational specialty (MOS). Requirements could not exceed AOE authorizations.

(c) (U) Using LHX PM MARC factors, the number of AVIM and AVUM personnel, less supervisors, needed to maintain the LHX fleet was determined by unit and MOS.

(d) (U) Compared LHX maintenance personnel requirements unit by unit with current fleet requirements as constrained by AOE.

(3) (U) Maintenance personnel, 6 daily flying hours. Using MARC factors provided by the LHX PM, the number of maintenance personnel by unit and MOS for 6 flying hours was determined. This number was then compared with AOE authorizations for DA standard combat flying hours to determine the increase required.

c. (U) Measures of Effectiveness. Measures of effectiveness were as follows:

(1) (U) Aircraft required.

(2) (U) Maintenance manpower required.

S-4. (U) RESULTS.

a. (U) Aircraft.

(1) (U) Doctrine and tactics for the attack helicopter company (AHC) require a team of eight helicopters, three performing scout functions and five the attack role. In order to preserve the integrity of this team, the decision was made to replace the four scout helicopters currently in the AHC one for one with LHX-S's. This rule applied to AH-64 AHCs as well as to AH-1 AHCs. The LHX-S would replace AH-1 helicopters at a six-for-seven ratio (the same replacement ratio used for replacing AH-1's with AH-64's) and AH-64's one for one in the AHC in the air assault division. (The AH-64 will be fielded in the air assault division AHBs as a temporary measure and will be replaced by the LHX-S to comply with the requirements of that division.) These replacement ratios for the AHC's could be satisfactorily achieved with 80-percent availability. Ratios are shown in figure S-2.

	LHX-S	LHX-U
AHBs with AH-64	13 for 13 scouts (4 in each attack company and 1 in the HHC)	Not applicable
AHBs with all LHX-S's	31 for 13 OH-58's and 21 AH-1S's (10 in each attack helicopter company and 1 in the headquarters and headquarters company) (HHC)	Not applicable
Aviation reconnaissance troops	10 LHX-S's for 6 OH-58's and 4 AH-1S's	
Command aviation companies, et al.		1 for 1 UH-1/OH-58

Figure S-2. (U) Replacement ratios.

(2) (U) Aircraft savings at 80-percent availability are shown in figure S-3 (see appendix T for impact of numbers of aircraft on flying hours).

Attack helicopter battalions with LHX-S in attack and scout roles	11 in light infantry divisions
	2 in 9th MD
	1 in airborne division
	1 in 2d Infantry Division
	4 in air assault division
	19 battalions
	x3 aircraft saved per battalion
	57
	+9 float aircraft
	66 total aircraft saved

Figure S-3. (U) Projected aircraft savings at 80-percent availability.

b. (U) Aviator Personnel. Early in the LHX trade-off determination (TOD)/trade-off analysis (TOA), the decision was made not to consider any reduction of aviator personnel. In view of the threat's capability to wage war at night and in adverse weather conditions, hours of night operation can be expected to exceed current DA standard daily combat flying hours. As aircraft are staffed on a one-crew-per-ship basis, any reduction in aviator personnel would cripple, if not prevent, continued operation at a flying-hour rate higher than the DA standard.

c. (U) Maintenance Personnel.

(1) (U) Ground rules. The ground rules listed below were applied to the methodology described earlier and have a definite impact on the results reported in succeeding paragraphs.

(a) (U) Category I AVUM (2,500 available man-hours per person per year) MARC factors were used for all division units and units with organic attack helicopters.

(b) (U) Category II AVUM (2,700 available man-hours) MARC factors were used for other aviation units.

(c) (U) Category II AVIM (2,700 available man-hours) MARC factors were used for aviation maintenance company (AMC)/aviation maintenance battalion (AMB) requirements.

(2) (U) MOSs evaluated. Aircraft maintenance MOSs found in AVUM and AVIM units were evaluated. These are shown in figure S-4. No LHX-peculiar MOS's were developed for use in the TOA. As noted earlier, supervisors were not included in this evaluation.

MOS	Title
35K	Avionics mechanic
35L	Avionics communication equipment repairman
35M	Avionics navigation/flight control equipment repairman
35R	Avionics special equipment repairman
66( )	Aircraft technical inspector
67( )	Aircraft repairman
68B	Aircraft powerplant repairman
68D	Aircraft powertrain repairman
68F	Aircraft electrical repairman
68G	Aircraft structure repairman
68H	Aircraft pneudraulics repairman
68J	Aircraft fire control repairman
68M	Aircraft weapon system repairman

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Figure S-4. (U) MOSs evaluated.

(3) (U) Maintenance manpower factors.

(a) (U) Factors used for AVUM and AVIM maintenance manpower calculations for current aircraft and for LHX configurations are shown in figures S-5 and S-6, respectively. The LHX factors were provided by the LHX PM, and those for the current aircraft were taken from AR 570-2. Both sets of factors were for DA standard combat flying hours (see figure S-7).

CATEGORY I AVUM FOR COMBAT UNITS (2,500 AVAILABLE MAN-HOURS) -
DA STANDARD COMBAT FLYING HOURS

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MOS	AH-64	AH-1	OH-58	UH-1/UH-60
35K	.08	.20	.08	.22
66	.09	.20	.16	.27
67	1.1	1.54	1.05	1.06
68B	.008	.07	.03	.08
68D	.008	.07	.04	.05
68F	.008	.02	.01	.02
68G	.03	.05	.16	.08
68H	---	.02	.01	.02
68J	1.67	.65	.00	.00
68M	.5	.53	.00	.00

CATEGORY II AVUM FOR COMBAT SUPPORT UNITS (2,700 AVAILABLE MAN-HOURS)

MOS	AH-1/AH-64	OH-58	UH-1/UH-60
35K	For purposes of this study, all attack helicopter units were considered combat units.	.08	.20
66		.15	.25
67		.97	.95
68B		.02	.07
68D		.04	.05
68F		.01	.01
68G		.15	.07
68H		.01	.01
68J		.00	.00
68M		.00	.00

CATEGORY II AVIM (2,700 AVAILABLE MAN-HOURS)

MOS	AH-64	AH-1	OH-58	UH-1/UH-60
35L	.00	.00	.00	.00
35M	.004	.09	.03	.11
35R	.008	.006	.007	.006
66	.05	.05	.03	.07
67	.21	.27	.24	.32
68B	.04	.09	.17	.10
68D	.05	.08	.02	.08
68F	.02	.02	.01	.01
68G	.04	.09	.12	.11
68H	.01	.01	.01	.01
68J	.21	.08	.00	.00
68M	.07	.07	.00	.00

Figure S-5. (U) TOE maintenance manpower criteria--current aircraft.

CATEGORY I AVUM FOR COMBAT UNITS (2,500 AVAILABLE MAN-HOURS) - DA STANDARD COMBAT FLYING HOURS

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MOS	HEL	Compound HEL	ABC	Compound ABC	Tilt Rotor
35K	.0675	.0675	.0675	.0675	.0675
66( )	.1143	.11557	.11684	.11811	.12065
67( )	1.07025	1.1416	1.07025	1.1416	1.21295
68B	.0396	.0396	.0396	.0396	.0396
68D	.015	.016	.015	.016	.017
68F	.02325	.02325	.02325	.02325	.02325
68G	.03075	.03075	.03075	.03075	.0328
68H	.0077	.0077	.0077	.0077	.0077
68J	.345	.345	.345	.345	.345
68M	.153	.153	.153	.153	.153

CATEGORY II AVUM FOR COMBAT SUPPORT UNITS (2,700 AVAILABLE MAN-HOURS) - DA STANDARD COMBAT FLYING HOURS

MOS	HEL	Compound HEL	ABC	Compound ABC	Tilt Rotor
35K	.063	.063	.063	.063	.063
66( )	.1062	.10738	.10856	.10974	.1121
67( )	.99075	1.0568	.99075	1.0568	1.12285
68B	.0369	.0369	.0369	.0369	.0369
68D	.0135	.0144	.0135	.0144	.0153
68F	.02175	.02175	.02175	.02175	.02175
68G	.0285	.0285	.0285	.0285	.0304
68H	.007	.007	.007	.007	.007
68J	.315	.315	.315	.315	.315
68M	.135	.135	.135	.135	.135

Figure S-6. (U) AVUM and AVIM maintenance manpower criteria--LHX configurations (DA standard combat flying hours) (continued on next page).

CATEGORY II AVIM (2,700 AVAILABLE MAN-HOURS)

MOS	HEL	Compound HEL	ABC	Compound ABC	Tilt Rotor
35L	.0176	.0176	.0176	.0176	.0176
35M	.004	.004	.004	.004	.004
35R	.008	.008	.008	.008	.008
66( )	.0081	.00819	.00828	.00837	.00855
67( )	.06375	.068	.06375	.068	.07225
68B	.0054	.0054	.0054	.0054	.0054
68D	.02175	.0232	.02175	.0232	.02465
68F	.01275	.01275	.01275	.01275	.01275
68G	.05475	.05475	.05475	.05475	.0584
68H	.0007	.0007	.0007	.0007	.0007
68J	.1575	.1575	.1575	.1575	.1575
68M	.162	.162	.162	.162	.162

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Figure S-6. (U) (concluded)

Aircraft	Annual Flying Hours	Daily Flying Hours
Attack	780	2.17
Utility	948	2.64
Scout and Observation	816	2.27

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Figure S-7. (U) DA standard annual combat flying hours, AR 570-2.

(b) (U) Maintenance manpower factors were converted from DA standard combat flying hours to 2,160 hours per year for the LHX configurations. Information received from the LHX PM revealed that LHX factors (MOS 67( ), 68B, 68D, 68F, 68G, and 68H) were derived from UH-60 data, using 912 annual flying hours as a base, and from AH-64 (MOS 35K, 35L, 35M, 35R, 66( ), 68J, and 68M), using 1,240 annual flying hours as a base. Ratios used to convert the factors shown in figure S-6 to the 2,160-flying-hour rate are:

$$\frac{\text{LHX -- } 2{,}160 \text{ annual flying hours}}{\text{UH-60 -- } 912 \text{ annual flying hours}} = 2.37$$

$$\frac{\text{LHX -- 2,160 annual flying hours}}{\text{AH-64 -- 1,240 annual flying hours}} = 1.74$$

(2.37 X DA annual flying-hour factor) = 2,160 annual flying-hour factor
(1.74 X DA annual flying-hour factor) = 2,160 annual flying-hour factor

(4) (U) Impact of LHX on maintenance personnel.

(a) (U) DA standard combat flying hours. Shown in figure S-8 are personnel savings/costs attributable to introduction of the LHX at the replacement ratios discussed in paragraph S-4a(1). Maintenance personnel include AVUM for all LHX units and AVIM for all supported elements except CH-47, CH-54, and fixed wing. AH-64, UH-60, OH-58, AH-1S, and UH-1 aircraft are included in AVIM calculations. (See annex S-II for details.)

1. (U) The savings in the light divisions and air assault divisions resulted, in large part, from the reduction of types and numbers of aircraft within units (pure LHX-S attack helicopter battalions (AHB)). The heavy division AHBs are programed to have both AH-64's and LHX-S's, and fewer AVUM personnel savings were realized in these units.

2. (U) Several factors contributed to the unexpectedly small maintenance manpower savings:

a. (U) The TOEs, in many cases, did not authorize sufficient maintenance personnel for current aircraft. In about one third of the TOE units analyzed, the AOE maintenance manpower authorizations were less than or equal to those required by AR 570-2 to maintain the current fleet. When the requirements calculations (paragraph (c) below) were analyzed, however, the impact on manpower of replacing the unarmed OH-58 scout and C&C aircraft with the LHX-S and the armed LHX-U offset the savings expected from relaxing TOE authorization constraints (see figure S-11).

b. The LHX-U is armed. When an armed LHX-U replaces an unarmed OH-58, the LHX maintenance personnel requirements are higher. Similarly, the LHX-S is a much more capable and complex aircraft than the OH-58 (in addition to being armed), and the MARC factors provided by the LHX-PM for the LHX do not differ substantially from the AR factors for the OH-58. Therefore, whenever the LHX replaces the OH-58, few or no personnel are saved.

c. (U) When a TOE unit is developed, the TOE board makes many subjective decisions, using the staffing required by MARC as a start point. This fact resulted in two decisions previously stated in the methodology:

-- Supervisors were not included as TOE authorized personnel for this analysis because their level of expertise must be retained for the unit to function properly.

-- LHX savings were calculated from MARC requirements for current aircraft unless these requirements exceeded the TOE authorizations. In this case, savings were calculated from TOE authorizations.

LHX Units	LHX Personnel Deltas: HEL	Compound HEL	ABC	Compound ABC	Tilt Rotor	Current Aircraft TOE Auth/Rqd
Light divisions, 11	-550	-495	-550	-495	-418	2,541
Heavy divisions, 14	-252	-210	-252	-210	-168	3,794
Air assault division, 1	-144	-124	-144	-124	-102	840
2d Infantry Division	-58	-52	-58	-52	-44	299
9th MD	-90	-80	-90	-80	-71	408
Airborne division	-66	-59	-66	-59	-51	297
Corps	-306	-284	-304	-282	-256	5,305
Echelons above corps (EAC)	-60	-48	-59	-48	-43	708
SOCOM	-31	-29	-31	-29	-29	206
Separate brigades/groups not calculated; decision pending on whether to retain in force structure						
Total	-1557	-1381	-1554	-1379	-1182	14,398
Percent savings	11%	10%	11%	10%	8%	

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Figure S-8. (U) LHX maintenance personnel deltas; total TOE authorized LHX force, AOE, year 2000; DA standard combat flying hours and 80-percent availability.

d. (U) Application of MARC factors on a unit-by-unit basis tended to drive maintenance requirements up because a fraction of a man has to be rounded up to one man. Rounding up, as opposed to rounding down, becomes particularly significant in view of the extended hours of operation on the battlefield made possible by advanced RAM and survivability characteristics of the LHX, and forecast by AirLand Battle doctrine.

e. (U) Because of their combat posture, all division TOEs are considered to be category I units (2,500 hours annual maintenance personnel manhours available per man) as opposed to category II (2,700 hours available). LHX maintenance personnel for all division units and for all units with organic LHX-S were calculated on this basis. The preliminary estimates were based for the most part on category II.

(b) (U) 2,160 annual flying hours. The number of TOE maintenance personnel required should the LHX be operated at a 2,160-annual-flying-hour rate (6 daily flying hours) is shown in figure S-9. These data were not compared with the number required to operate the current fleet (AH-1S, OH-58, and UH-1) at the same rate. Doctrine and tactics for the LHX time frame dictate an around-the-clock weather capability, and the current fleet, for practical purposes, has little or no night and adverse weather operational capability. Therefore, comparisons at 6 hours for current aircraft were considered misleading, implying a capability the current fleet does not possess, and were not made.

(c) (U) Requirements.

1. (U) The approved AOE TOEs were used for this analysis to the extent possible. As noted earlier, the AOE process reduced the amount of equipment and personnel now on hand in the expectation of enhancing effectiveness through technological advances rather than by adding more equipment. As a result, TOEs are constrained both in manpower and equipment. It was believed that these constraints tended to damp out the potential manpower savings as well as the differences among LHX configurations. Consequently, it was decided to determine the manpower impact of the LHX on a "requirements" TOE force. Results are shown in figure S-10. As noted earlier, replacing unarmed aircraft with armed aircraft offset in most part any savings realized by relaxation of constraints. Note that the percent saved is less for the requirements force than for the authorized force. See annex S-II for details.

2. (U) Results of requirements and TOE authorized/required are compared in figure S-11. Here the impact of TOE authorizations on manpower, as well as the differences among configurations, becomes more apparent without the constraints of authorizations. The tilt rotor and compound manpower requirements exceeded the TOE authorizations more times than did the helicopter and ABC, causing a sizable difference in the two totals. Further, the impact of adding air-to-air weapons to the LHX-U can be seen in the light division where the gains from relaxation of constraints on the attack helicopter battalions were offset by the additional requirement for LHX-U armament personnel. Replacement of the unarmed scout with the LHX-S in the heavy divisions also increased manpower requirements above authorizations, resulting in a smaller savings delta in the requirements force.

LHX Units	LHX Helicopter 6 FH	LHX Compound Helicopter 6 FH	LHX ABC 6 FH	LHX Compound ABC 6 FH	LHX Tilt Rotor 6 FH	Current A/C Auth
Light divisions	4,378	4,510	4,389	4,543	4,631	2,541
Heavy divisions	11,970	12,124	11,970	12,124	12,278	3,794
Air assault division	1,433	1,474	1,433	1,474	1,514	840
2d Infantry Division	497	511	497	511	527	299
9th MD						408
Airborne division	488	502	488	502	517	297
Corps	11,867	12,049	11,872	12,049	12,213	5,305
Echelons above corps (EAC)	1,367	1,406	1,367	1,406	1,433	708
SOCOM	477	491	477	491	503	206
Separate brigades/groups not calculated; decision pending on whether to retain in force structure.						
Total	33,113	33,722	33,129	33,755	34,289	14,398

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Figure S-9. (U) LHX maintenance personnel needed for 6 daily combat flying hours (2,160 annual combat flying hours).

LHX Units	LHX Personnel Deltas					Current A/C Requirements
	HEL	Compound HEL	ABC	Compound ABC	Tilt Rotor	
Light divisions	-550	-495	-550	-495	-308	2,673
Heavy divisions	-154	-70	-154	-70	-14	5,250
Air assault division	-185	-165	-185	-165	-143	883
2d infantry division	-61	-56	-61	-56	-48	303
9th MD	-96	-88	-96	-88	-79	416
Airborne division	-69	-63	-69	-63	-55	301
Corps	-347	-279	-346	-278	-205	5,799
Echelons above corps (EAC)	-49	-35	-48	-35	-29	759
SOCOM	-49	-43	-49	-43	-39	294
Separate brigades/groups not calculated; decision not yet made whether to keep them in force.						
Total	-1560	-1294	-1558	-1293	-920	16,678
Percent savings	9%	8%	9%	8%	6%	

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Figure S-10. (U) LHX requirements, maintenance personnel deltas; total TOE LHX force, AOE, year 2000; DA standard combat flying hours; 80-percent availability requirements.

LHX Units	LHX Personnel Deltas										Current Aircraft	
	Helicopter		Compound Helicopter		ABC		Compound ABC		Tilt Rotor			
	Auth	Rqmts	Auth	Rqmts	Auth	Rqmts	Auth	Rqmts	Auth	Rqmts	Auth	Rqmts
Light divisions	-550	-550	-495	-495	-550	-550	-495	-495	-418	-308	2,541	2,673
Heavy divisions	-252	-154	-210	-70	-252	-154	-210	-70	-168	-14	3,794	5,250
Air assault division	-144	-185	-124	-165	-144	-185	-124	-165	-102	-143	840	883
2d infantry division	-58	-61	-52	-56	-58	-61	-52	-56	-44	-48	299	303
9th MD	-90	-96	-80	-88	-90	-96	-80	-88	-71	-79	409	416
Airborne division	-66	-69	-59	-63	-66	-69	-59	-63	-51	-55	297	301
Corps	-306	-347	-284	-279	-304	-346	-282	-278	-256	-205	5,305	5,799
Echelons above corps (EAC)	-60	-49	-48	-35	-59	-48	-48	-35	-43	-29	708	759
SOCOM	-31	-49	-29	-43	-31	-49	-29	-43	-29	-39	206	294
Separate brigades/groups not calculated; decision pending on whether to retain in force structure												
Total	-1557	-1560	-1381	-1294	-1554	-1558	-1379	-1293	-1182	-920	14398	16678

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Figure S-11. (U) Comparison of LHX personnel deltas, TOE authorized (figure S-8) versus LHX requirements (figure S-10).

ANNEX I TO APPENDIX S

REFERENCES (U)

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ANNEX I to APPENDIX S

REFERENCES (U)

1. AR 570-2, Organization and Equipment Authorization Tables--Personnel, 15 September 1978, with changes 1 through 10.

2. Aviation Modernization Plan (draft), US Army Aviation Center, February 1985.

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ANNEX II TO APPENDIX S

SUPPORTING DATA (U)

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Units Receiving or Maintaining LHX	Current Aircraft Assigned Per Unit					LHX Aircraft Assigned Per Unit				
	AH-1	AH-64	OH-58A/C	UH-1	UH-60	AH-64	AHIP	UH-60	LHX-S	LHX-U
Light division (11)										
01106J400(1) HHT, CAB			6							6
01185J400(1) Atk Hel Bn	21		13		3			3	31	
17105J400(1) Avn Recon Bn (2 ARTs)	8		12		1			1	20	
01412X500(1) AMC					2			2		
Heavy division (14)										
17205J410(1) Cav Sqdn	8		12		4			1	20	
01287J400(1) Cmd Avn Co			12	6	3		6	3		12
01385J520(2) Atk Hel Bn (Scout)		18	13		3	18		3	13	
55429X430(1) AMC					2			2		
Air assault division (1)										
01795J500(1) Cmd Avn Bn			15	30						45
01127J500(2) Med Hel Co				1						1
01385J520(4) Atk Hel Bn		18	13		3			3	31	
17105J510(1) Avn Recon Sqdn (4 ARTs)	16		24		10			10	40	
_____(1) AMB					6			6		
2d Infantry Division										
01185J400(1) Atk Hel Bn	21		13		3			3	31	
_________(1) Avn Recon Bn (3 ARTs)	12		18		1			1	30	
_________(1) Cmd Avn Co			12	6	3		6	3		12
_________(1) AMC					2					2

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Figure S-II-1. (U) TOE Aircraft in LHX and AVIM units, year 2000, 80-percent availability, DA standard combat flying hours (continued on next page).

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Units Receiving or Maintaining LHX	Current Aircraft Assigned Per Unit					LHX Aircraft Assigned Per Unit				
	AH-1	AH-64	OH-58A/C	UH-1	UH-60	AH-64	AHIP	UH-60	LHX-S	LHX-U
9th Motorized Division										
01185J400(2) Atk Hel Bn	21		13		3			3	31	
17105J400(1) Avn Recon Bn	8		12		1			1	20	
(2 ARTs)										
________(1) Cmd Avn Co			6	16			6			16
________(1) AMC					2			2		
Airborne division (1)										
01106J400(1) HHC, DAB				12						12
________(1) Atk Hel Bn										
________(1) Avn Recon Sqdn	12		18		3			3	30	
(3 ARTs)	21		13		3			3	31	
________(1) AMC					2			2		
SOCOM										
01316J400(2) Lt Atk Avn Co	12									
(AH-6)									12	
01318J400(2) Lt Cbt Avn Co			15							15
________(2) AMC					2			2		
________(2) SO Avn Bn				1						1
01127J500(1) Med Hel Co				1						1
Corps										
01797J500(10) Cmd Avn Co										
(UH-1)				15						15
17265J310(5) RCAS*	26		27		21			21	53	
01385J520(26) Atk Hel Bn										
(Scout)		18	13			18		3	13	
01127J500(19) Med Hel Co				1						1

*Eighty-percent availability not applied to RCAS.

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Figure S-II-1. (U) (continued)

Units Receiving or Maintaining LHX	Current Aircraft Assigned Per Unit					LHX Aircraft Assigned Per Unit				
	AH-1	AH-64	OH-58A/C	UH-1	UH-60	AH-64	AHIP	UH-60	LHX-S	LHX-U
17105J510(1) Avn Recon Sqdn (4 ARTs)	16		26		10			10	42	
01798J500(5) Cmd Avn Co (OH-58)			15							15
AMB(1) I Corps					4			4		
AMB(1) III Corps					4			4		
AMB(1) V Corps					4			4		
AMB(1) VII Corps					4			4		
AMB(1) XVIII Abn Corps					4			4		
EAC										
01277J500(1) Cmd Avn Co (DS)				12						12
01385J520(2) Atk Hel Bn		18	13		3	18		3	13	
01127J500(4) Med Hel Co				1						1
55259H000(6) Hvy Hel Co				1						1
01037S600(7) Theatre Avn Co			5	5						10
AMC(1) NATO					2			2		
AMC(1) NEA					2			2		
AMC(1) SWA					2			2		
Theatre defense										
Scout Gp(1) (Alaska)				10						10
Scout Gp(1) (Alaska)				5						5
Avn Det(1) (Alaska)				3						3
01127J500(1) Med Hel Co (Alaska)				1						1
AVIM(1) (Alaska)					2			2		
GSAC(1) (Panama)				14						14
AVIM(1) (Panama)					1			1		

Sep bdes/groups - Omitted; decision yet to be made on retention in force structure; if retained, USAAVNC position is 5 LHX-U per unit.

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Figure S-II-1. (U) (concluded)

NOTE: AMC/B includes maintenance for attack, scout, observation, and utility helicopters only.

Units Receiving or Maintaining LHX, Year 2000	Maintenance Personnel Required/Authorized for Current Aircraft	LHX Personnel Deltas (Per Unit)				
		HEL	Compound HEL	ABC	Compound ABC	Tilt Rotor
Light division (11)						
01106J400(1) HHT, CAB	8*	0	0	0	0	0
01185J400(1) Atk Hel Bn	95*	-28	-25	-28	-25	-22
17105J400(1) Avn Recon Bn (2 ARTs)	49	- 6	- 4	- 6	- 4	- 3
01412X500(1) AMC	79	-16	-16	-16	-16	-13
Heavy division (14)						
17205J410(1) Cav Sqdn	48*	- 5	- 3	- 5	- 3	- 2
01287J400(1) Cmd Avn Co	45	- 3	- 2	- 3	- 2	- 1
01385J520(2) Atk Hel Bn (Scout)	85*	0	0	0	0	0
55429X430(1) AMC	93	-10	-10	-10	-10	- 9
Air assault division (1)						
01795J500(1) Cmd Avn Bn	102*	-17	-14	-17	-14	-10
01127J500(2) Med Hel Co	9	+ 1	+ 1	+ 1	+ 1	+ 1
01385J520(4) Atk Hel Bn (all LHX eventually)	85*	-18	-15	-18	-15	-12
17105J510(1) Avn Recon Sqdn (4 ARTs)	118	-16	-13	-16	-13	- 9
________(1) AMB	262**	-41	-39	-41	-39	-37

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Figure S-II-2. (U) TOE-authorized maintenance personnel, year 2000, 80-percent availability, DA standard combat flying hours (80-percent availability allows for one-for-one scout six-for-seven attack replacement) (continued on next page).

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Units Receiving or Maintaining LHX, Year 2000	Maintenance Personnel Required/Authorized for Current Aircraft	LHX Personnel Deltas (Per Unit)				
		HEL	Compound HEL	ABC	Compound ABC	Tilt Rotor
2d Infantry Division (1)						
01185J400(1) Atk Hel Bn	95*	-28	-25	-28	-25	-22
________(1) Avn Recon Bn (3 ARTs)	69**	- 9	- 7	- 9	- 7	- 5
________(1) Cmd Avn Co	37**	- 3	- 2	- 3	- 2	- 1
________(1) AMC	98**	-18	-18	-18	-18	-16
9th Motorized Division (1)						
01185J400(2) Atk Hel Bn	95*	-28	-25	-28	-25	-22
17105J400(1) Avn Recon (2 ARTs)	52	- 6	- 4	- 6	- 4	- 3
________(1) Cmd Avn Co						
________(1) AMC	122**	-25	-24	-25	-24	-23
Airborne division (1)						
01106J400(1) HHC, CAB	36**	-10	- 9	-10	- 9	- 8
01185J400(1) Atk Hel Bn	95*	-28	-25	-28	-25	-22
________(1) Avn Recon (3 ARTs)	69**	- 9	- 7	- 9	- 7	- 5
________(1) AMC	97**	-19	-18	-19	-18	-16
SOCOM						
01316J400(2) Lt Atk Avn Co	12*	0	0	0	0	0
01318J400(2) Lt Cbt Avn Co	17*	0	0	0	0	0
________(2) AMC	121**	-17	-16	-17	-16	-16
________(2) SO Avn Bn	9**	+1	+1	+1	+1	+1
01127J500(1) Med Hel Co	9	+1	+1	+1	+1	+1

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Figure S-II-2. (U) (continued)

Units Receiving or Maintaining LHX, Year 2000	Maintenance Personnel Required/Authorized for Current Aircraft	LHX Personnel Deltas (Per Unit) HEL	Compound HEL	ABC	Compound ABC	Tilt Rotor
Corps						
________(10) Cmd Avn Co (UH-1)	41**	-11	-10	-11	-10	- 9
17265J310(5) RCAS	135*	0	0	0	0	0
01385J520(16) Atk Hel Bn (Scout)	85*	0	0	0	0	0
01127J500(19) Med Hel Co	9	+ 1	+ 1	+ 1	+ 1	+ 1
17105J510(1) Avn Recon Sqdn (4 ARTs)	118	-16	-13	-16	-13	- 9
________(5) Cmd Avn Co (OH-58)	24**	+ 6	+ 7	+ 6	+ 7	+ 8
_____(1) AMB, I Corps	318**	-43	-42	-43	-42	-40
_____(1) AMB, III Corps	341**	-42	-42	-42	-42	-41
_____(1) AMB, V Corps	318**	-43	-42	-43	-42	-40
_____(1) AMB, VII Corps	318**	-43	-42	-43	-42	-40
_____(1) AMB, XVIII Abn Corps	297**	-58	-57	-57	-56	-55
EAC						
01277J500(1) Cmd Avn Co (DS)	30*	- 5	- 4	- 5	- 4	- 4
01385J520(2) Atk Hel Bn	85*	0	0	0	0	0
01127J500(4) Med Hel Co	9	+ 1	+ 1	+ 1	+ 1	+ 1
55259H000(6) Hvy Hel Co	3*	0	0	0	0	0
01037S600(7) Theatre Avn Co	23**	- 2	- 1	- 2	- 1	- 1
_____(1) AMC, NATO	48**	-13	-12	-13	-12	-10
_____(1) AMC, NEA	83**	- 6	- 6	- 6	- 6	- 6
_____(1) AMC, SWA	22**	- 1	- 1	- 1	- 1	0

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Figure S-II-2. (U) (continued)

UNCLASSIFIED

Units Receiving or Maintaining LHX, Year 2000	Maintenance Personnel Required/Authorized for Current Aircraft	LHX Personnel Deltas (Per Unit) HEL	Compound HEL	ABC	Compound ABC	Tilt Rotor
Theatre defense						
________(1) Scout Gp (Alaska)	30**	- 9	- 8	- 9	- 8	- 8
________(1) Scout Gp (Alaska)	17**	- 2	- 2	- 2	- 2	- 1
________(1) Avn Det (Alaska)	13**	- 1	- 1	- 1	- 1	- 1
01127J500(1) Med Hel Co (Alaska)	9	+ 1	+ 1	+ 1	+ 1	+ 1
________(1) AVIM Alaska Def Bde	18**	- 2	- 2	- 2	- 2	- 2
________(1) AVIM Panama Def Bde	14**	0	0	0	0	0
________(1) GSAC (Panama)	39**	-12	-10	-11	-10	- 9

Sep bdes/groups - not calculated; decision to be made on retention in for structure; if retained, USAAVNC position is 5 LHX-U per unit.

NOTE: ( ) following SRC/title is number of units in the year 2000 force.

*TOE constrained; current aircraft requirements exceed TOE authorized.
**Base TOE not available or not adequate; calculation with MARC factors only.

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Figure S-II-2. (concluded)

Units Receiving or Maintaining LHX	Maintenance Personnel Required* for Current Aircraft	LHX Personnel Deltas (Per Unit) HEL	Compound HEL	ABC	Compound ABC	Tilt Rotor
Light division (11)						
01106J400(1) HHC, Avn Bde	13	+ 3	+ 4	+ 3	+ 4	+ 4
01185J400(1) Atk Hel Bn	99	-31	-29	-31	-29	-26
17105J400(1) Avn Recon Bn (2 ARTs)	52	- 6	- 4	- 6	- 4	- 3
01412X500(1) AMC	79	-16	-16	-16	-16	-13
Heavy division (14)						
17205J410(1) Cav Sqdn	49	- 6	- 3	- 6	- 3	- 2
01287J400(1) Cmd Avn Co	45	- 3	- 2	- 3	- 2	- 1
01385J520(2) Atk Hel Bn (Scout)	94	+ 4	+ 5	+ 4	+ 5	+ 6
55429X430(1) AMC	93	-10	-10	-10	-10	-10
Air assault division (1)						
01795J500(1) Cmd Avn Bn	109	-22	-19	-22	-19	-15
01127J500(2) Med Hel Co	9	+ 1	+ 1	+ 1	+ 1	+ 1
01385J520(4) Atk Hel Bn (all LHX eventually)	94	-27	-24	-27	-24	-21
17105J510(1) Avn Recon Sqdn (4 ARTs)	118	-16	-13	-16	-13	- 9
01405J500(1) AMB	262	-41	-39	-41	-39	-37
2d Infantry Division (1)						
01185J400(1) Atk Hel Bn	99	-31	-29	-31	-29	-28
________(1) Avn Recon Sqdn (3 ARTs)	69	- 9	- 7	- 9	- 7	- 5
________(1) Cmd Avn Co	37	- 3	- 2	- 3	- 2	- 1
________(1) AMC	98	-18	-18	-18	-18	-16

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Figure S-II-3. (U) Maintenance personnel requirements, year 2000, 80-percent availability, DA standard combat flying hours (continued on next page).

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Units Receiving or Maintaining LHX	Maintenance Personnel Required* for Current Aircraft	LHX Personnel Deltas (Per Unit) HEL	Compound HEL	ABC	Compound ABC	Tilt Rotor
9th Motorized Division (1)						
01185J400(2) Atk Hel Bn	99	-31	-29	-31	-29	-26
17105J400(1) Avn Recon (2 ARTs)	52	- 6	- 4	- 6	- 4	- 3
(1) Cmd Avn Co	44	- 3	- 2	- 3	- 2	- 1
(1) AMC	122	-25	-24	-25	-24	-23
Airborne division (1)						
01106J (1) HHC, CAB	36	-10	- 9	-10	- 9	- 8
01185J400(1) Atk Hel Bn	99	-31	-29	-31	-29	-26
(1) Avn Recon (3 ARTs)	69	- 9	- 7	- 9	- 7	- 5
(1) AMC	97	-19	-18	-19	-18	-16
SOCOM						
01316J400(2) Lt Atk Avn Co	41	-15	-14	-15	-14	-13
01318J400(2) Lt Cbt Avn Co	32	+ 6	+ 7	+ 6	+ 7	+ 8
(1) AMC	121	-17	-16	-17	-16	-16
(2) SO Avn Bn	9	+ 1	+ 1	+ 1	+ 1	+ 1
01127J500(1) Med Hel Co	9	+ 1	+ 1	+ 1	+ 1	+ 1
Corps						
(10) Cmd Avn Co (UH-1)	41	-11	-10	-11	-10	- 9
17265J310(5) RCAS	187	-29	-25	-29	-25	-21
01385J520(26) Atk Hel Bn (Scout)	94	+ 4	+ 5	+ 4	+ 5	+ 6
01127J500(19) Med Hel Co	9	+ 1	+ 1	+ 1	+ 1	+ 1

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Figure S-II-3. (U) (continued)

Units Receiving or Maintaining LHX	Maintenance Personnel Required* for Current Aircraft	LHX Personnel Deltas (Per Unit) HEL	Compound HEL	ABC	Compound ABC	Tilt Rotor
17105J510(1) Avn Recon Sqdn (4 ARTs)	118	-16	-13	-16	-13	- 9
(5) Cmd Avn Co (OH-58)	24	+ 6	+ 7	+ 6	+ 7	+ 8
(1) AMB, I Corps (less CH-47)	318	-43	-42	-43	-42	-40
(1) AMB, III Corps (less CH-47)	341	-42	-42	-42	-42	-42
(1) AMB, V Corps (less CH-47)	318	-43	-42	-43	-42	-40
(1) AMB, VII Corps (less CH-47)	318	-43	-42	-43	-42	-40
(1) AMB, XVIII Abn Corps (less CH-47)	297	-58	-57	-57	-56	-55
EAC						
01277J500(1) Cmd Avn Co (DS)	33	- 8	- 7	- 8	- 7	- 7
01385J520(2) Atk Hel Bn (Scout)	94	+ 4	+ 5	+ 4	+ 5	+ 6
01127J500(4) Med Hel Co	9	+ 1	+ 1	+ 1	+ 1	+ 1
55259H000(6) Hvy Hel Co	9	+ 1	+ 1	+ 1	+ 1	+ 1
01037S600(7) Theatre Avn Co	23	- 2	- 1	- 2	- 1	- 1
(1) AMC, NATO	48	-13	-12	-13	-12	-10
(1) AMC, NEA	83	- 6	- 6	- 6	- 6	- 6
(1) AMC, SWA	22	- 1	- 1	- 1	- 1	- 1

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Figure S-II-3. (U) (continued)

UNCLASSIFIED

Units Receiving or Maintaining LHX	Maintenance Personnel Required* for Current Aircraft	LHX Personnel Deltas (Per Unit) HEL	Compound HEL	ABC	Compound ABC	Tilt Rotor
Theatre defense						
______(1) Scout Gp (Alaska)	30	- 9	- 8	- 9	- 8	- 8
______(1) Scout Gp (Alaska)	17	- 2	- 2	- 2	- 2	- 1
______(1) Avn Det (Alaska)	13	- 1	- 1	- 1	- 1	- 1
01127J500(2) Med Hel Co (Alaska)	9	+ 1	+ 1	+ 1	+ 1	+ 1
______(1) AVIM (Alaska)	18	- 2	- 2	- 2	- 2	- 2
______(1) AVIM (Panama)	14	0	0	0	0	0
______(1) GSAC (Panama)	39	-12	-10	-11	-10	- 9

Sep bdes/groups - not calculated; decision yet to be made on retention in force structure; if retained, USAAVNC position is 5 LHX-U per unit.

NOTE: ( ) following SRC/title is number of units in the year 2000 force.

UNCLASSIFIED

*Calculated using MARC factors only.

Figure S-II-3. (U) (concluded)

UNCLASSIFIED	LHX Maintenance Personnel Deltas													
	35K	35L	35M	35R	66( )	67( )	68B	68D	68F	68G	68H	68J	68M	Total
Light Division (11)														
HHC, Avn Bde (1)	0	0	0	0	0	0	0	0	0	0	0	+2	+1	+3
Atk Hel Bn (1)	-3	0	0	0	-3	-13	-1	-1	0	-2	+1	-3	-6	-31
Avn Recon Bn (1)	-1	0	0	0	-1	-4	0	0	0	-1	0	+2	-1	-6
Avn Maint Co (1)	0	+1	-3	0	-2	-12	-8	-2	0	-4	0	+7	+7	-16
Heavy Division (14)														
Cmd Avn Co (1)	-1	0	0	0	-1	-6	0	0	0	-1	0	+4	+2	-6
Atk Hel Bn (2)	0	0	0	0	-1	0	0	0	0	-2	0	+5	+2	+4
Cav Sqdn (1)	-1	0	0	0	-1	-4	0	0	0	-1	0	+2	-1	-6
Avn Maint Co (1)	0	+1	-2	+1	-1	-12	-9	0	+1	-4	+1	+7	+7	-10

Figure S-II-4. (U) Impact of introduction of LHX helicopter on MOSs required in light and heavy divisions (80-percent availability; DA standard combat flying hours).

ANNEX III TO APPENDIX S

INPUT DATA (U)

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ANNEX III TO APPENDIX S

INPUT DATA (U)

S-III-1. (U) Figure S-III-1 is a reproduction of the MARC factors as provided to the Light Helicopter Family (LHX) Trade-Off Analysis study group by the LHX Project Manager's Office in May 1984.

4-24-84

[illegible] Execution begins...

AVUM CAT I

mos	hel	cpd hel	abc	cpc abc	tlt rtr
35k	.0675	.0675	.0675	.0675	.0675
66()	.1143	.11557	.11684	.11811	.12065
67()	1.07025	1.1416	1.07025	1.1416	1.21295
68b	.0396	.0396	.0396	.0396	.0396
68d	.015	.016	.015	.016	.017
68f	.02325	.02325	.02325	.02325	.02325
68g	.03075	.03075	.03075	.03075	.0328
68h	.0077	.0077	.0077	.0077	.0077
[illegible]	.345	.345	[illegible]	[illegible]	[illegible]

MORE...

68m	.153	.153	.153	.153	.153

AVUM CAT II

MOS	HEL	CPD HEL	ABC	CPD ABC	TLT RTR
35k	.063	.063	.063	.063	.063
66()	.1062	.10738	.10856	.10974	.1121
67()	.99075	1.0568	.99075	1.0568	1.12235
68b	.0369	.0369	.0369	.0369	.0369
68d	.0135	.0144	.0135	.0144	.0153
68f	.02175	.02175	.02175	.02175	.02175
68g	.0285	.0285	.0285	.0285	.0304
68h	.007	.007	.007	.007	.007
68j	.315	.315	.315	.315	.315

UNCLASSIFIED

MORE...

68m	.135	.135	.135	.135	.135

AVIM

mos	hel	cpc hel	abc	cpd abc	tlt rtr
35l	.0176	.0176	.0176	.0176	.0176
35m	.004	.004	.004	.004	.004
35R	.008	.008	.008	.008	.008
66()	.0081	.00819	.00828	.00837	.00855
67()	.06375	.068	.06375	.068	.07225
68B	.0054	.0054	.0054	.0054	.0054
68D	.02175	.0232	.02175	.0232	.02465
68F	.01275	.01275	.01275	.01275	.01275
68G	.05475	.05475	.05475	.05475	.0584

MORE...

68H	.0007	.0007	.0007	.0007	.0007
68J	.1575	.1575	.1575	.1575	.1575
68M	.162	.162	.162	.162	.162

EX-01 ...Execution ends
Ready

Figure S-III-1. (U) LHX MARC factors.

S-III-2. (U) Figure S-III-2 details the Table of Organization and Equipment (TOE) (Army of Excellence (AOE)) force structure in effect as of 28 February 1985.

Unit	Number in Force
Light Infantry Division	11
HHC, Cbt Avn Bde (1)	
Atk Hel Bn (AH-1) (1)	
Avn Recon Sqdn (2 ARTs) (1)	
AMC (1)	
Heavy Divisions	14
Cmd Avn Co (1)	
Atk Hel Bn (AH-64) (2)	
Cav Sqdn (2 ARTs) (1)	
AMC (1)	
Airborne Division	1
HHC, Cbt Avn Bde (1)	
Atk Hel Co (AH-1) (1)	
Avn Recon Sqdn (3 ARTs) (1)	
AMC (1)	
Air Assault Division	1
HHC, Cbt Avn Bde (1)	
Med Hel Co (2)	
Atk Hel Bn (AH-1) (4)	
Avn Recon Sqdn (4 ARTs) (1)	
Cmd Avn Bn (1)	
AMB (1)	
2d Infantry Division	1
Atk Hel Bn (AH-1) (1)	
Avn Recon Bn (3 ARTs) (1)	
Cmd Avn Co (1)	
AMC (1)	
9th Motorized Division	1
Atk Hel Bn (2)	
Air Recon Bn (2 ARTs) (1)	
Cmd Avn Co (1)	
AMC (1)	

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Figure S-III-2. (U) TOE force structure as of February 1985 (concluded on next page).

Unit	Number in Force
Corps	
Cmd Avn Co (UH-1)	10
Cmd Avn Co (OH-58)	5
Cmd Avn Co (Scout)	5
Med Hel Co	19
Atk Hel Bn (AH-64)	26
Regt Cbt Avn Sqdn	5
Avn Recon Sqdn (4 ARTs)	1
Echelons above corps* (EAC)	
Theater Avn Co (4 NATO, 1 NEA, 2 SWA)	7
Cmd Avn Co (DS) (1 NATO)	1
Med Hel Co (2 NATO, 2 NEA)	4
Hvy Hel Co (3 NATO, 3 SWA)	6
AMC (1 NATO, 1 NEA, 1 SWA)	3
Theater Def (Alaska)	1
Scout Gps (2)	
Avn Det (1)	
Med Hel Co (1)	
AVIM Unit (1)	
Theater Def (Panama)	1
Gen Spt Avn Co (1)	
AVIM Unit (1)	
SOCOM	
SCAB	1
Lt Atk Avn Co	2
Lt Cbt Avn Co	2
AVIM Unit	2
Med Hel Co	1
HHC, SOAB	2
Separate brigades/groups	**

*Not fully processed through AOE.
**Decision pending as to whether these will be included in force structure. Currently, 275 aircraft are organic to separate brigades/groups.

UNCLASSIFIED

Figure S-III-2. (U) (concluded)

S-III-3. (U) The following pages contain the unit wiring diagrams and the substitution rules followed for the LHX force structure. This force was current as of 28 February 1985 and was used for the TOE maintenance manpower analysis. Even though shown here, the separate brigades/groups were omitted from the TOE maintenance manpower analysis because the decision had not been taken at the time of this writing as to whether to retain them in the force structure. Should they be retained, the USAAVNC recommendation would be that each be resourced with five LHX-U's.

USAAVNC

LIGHT INFANTRY DIVISION

- HHC - PROGRAMMED FOR COMMAND, CONTROL, LIAISON, AND STAFF TRANSPORT.
  6 - LHX-U.

- ATK BN - PROGRAMMED TO HAVE LHX-SCOUT PHASE OUT BOTH THE OH-58C AND AH1S IN THE SCOUT/ATTACK ROLE. MISSION - LIGHT ATTACK TO DESTROY ENEMY FORCES AND CONDUCT AERIAL ESCORT FOR AIR ASSAULT MISSIONS.

  LHX-SCAT - REPLACE ONE FOR ONE. 10 PER COMPANY AND ONE IN THE HHC.

* NOTE: THERE WILL STILL BE 3 UH60'S IN THE HHC FOR LOGISTICAL MISSIONS.

- AIR RECON SQUADRON - REQUIRES SCAT TO REPLACE THE OH58C AND AH1S IN EACH AIR TROOP.
  10 - LHX-SCAT FOR AIR RECON MISSION ONE FOR ONE TRADE OFF.

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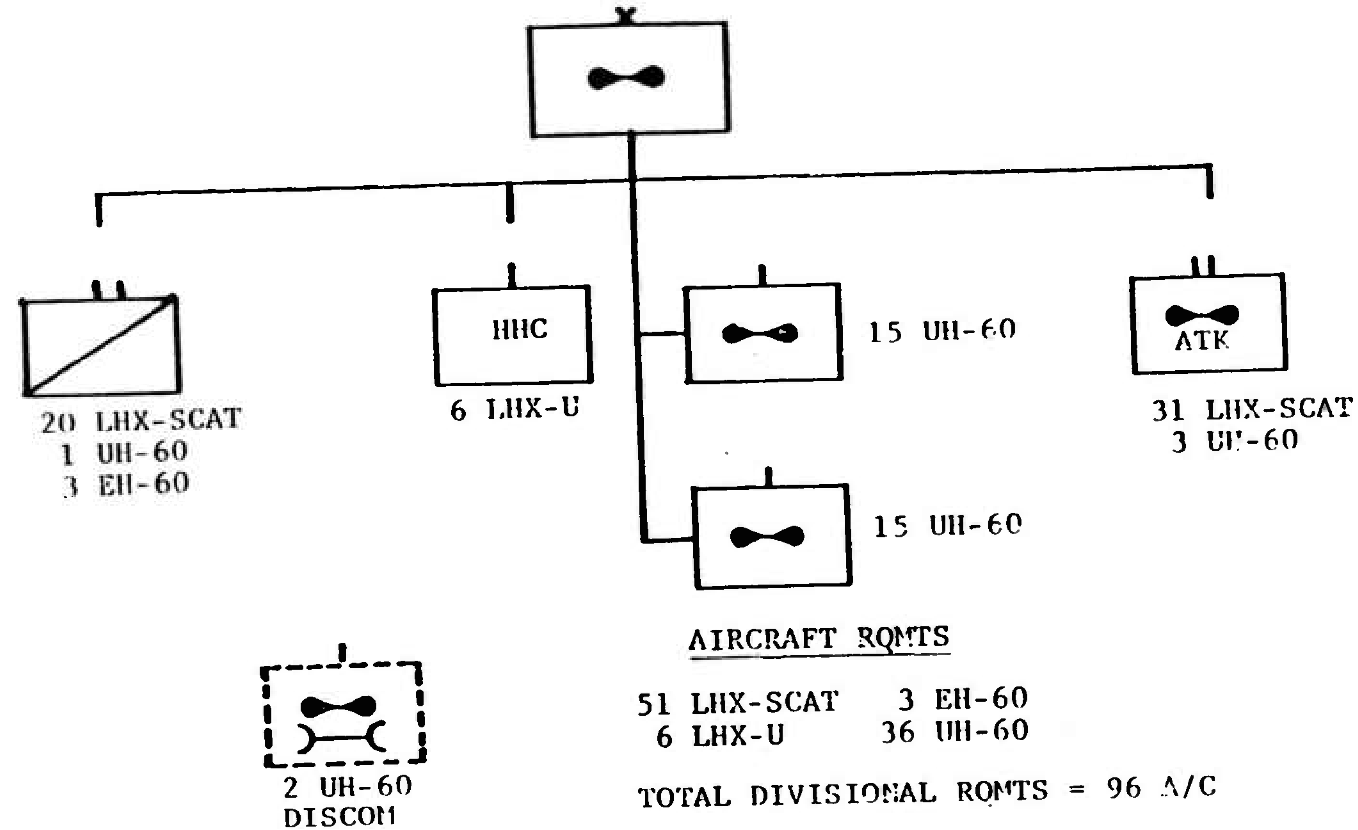
INFANTRY DIVISION
COMBAT AVIATION BRIGADE

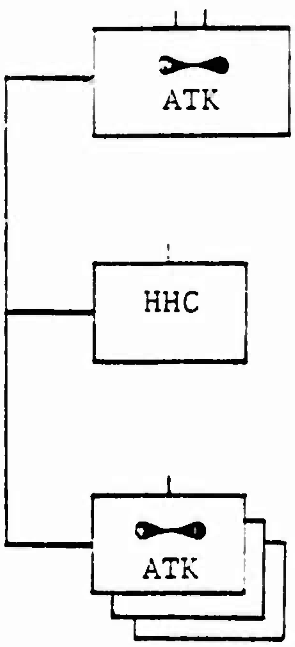


USAAVNC

UNCLASSIFIED

ATTACK HELICOPTER BATTALION

LIGHT INFANTRY DIVISION



	CURRENT	LHX RQMTS
ATK	13 SCT 21 AH-1 3 UH-60	31 LHX-SCAT 3 UH-60
HHC	1 OH-58 3 UH-60	1 LHX-SCAT 3 UH-60
ATK	4 OH-58 7 AH-15	10 LHX-SCAT

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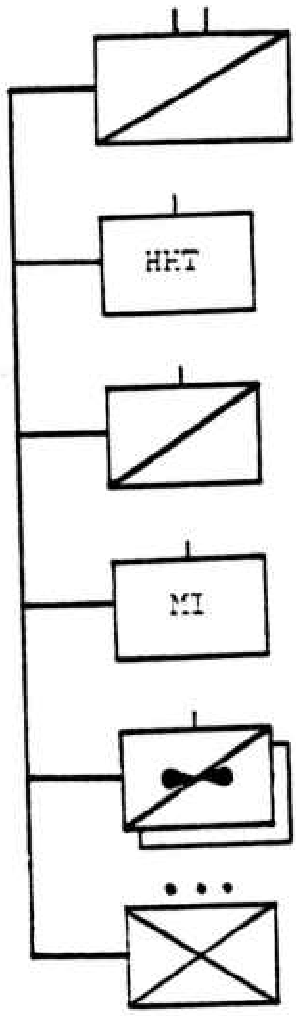
AIR RECONNAISSANCE SQUADRON

LIGHT INFANTRY DIVISION



CURRENT	LHX RQMTS
1 UH-60 3 EH-60 8 AH-1 12 SCT	1 UH-60 3 EH-60 20 LHX-SCAT
1 UH-60 3 EH-60	1 UH-60 3 EH-60
4 AH-1 6 SCT	10 LHX-SCAT

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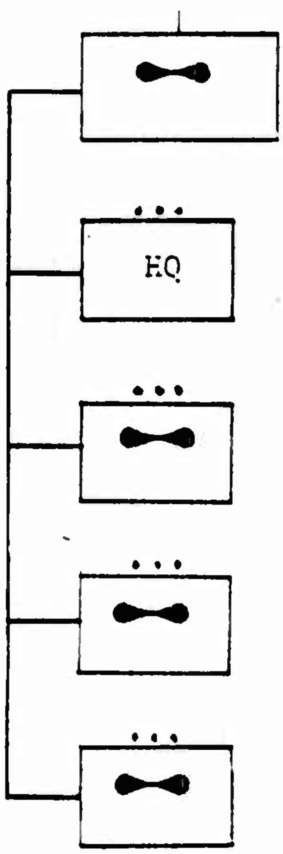
US ARMY AVIATION CENTER

COMBAT AVIATION COMPANY



CURRENT	LHX RQMTS
15 UH-60	15 UH-60
5 UH-60	5 UH-60
5 UH-60	5 UH-60
5 UH-60	5 UH-60

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USAAVNC

HEAVY DIVISION

- GSAC - PRESENTLY CALLED COMMAND AVIATION COMPANY GS
  1 PER HEAVY DIVISION   12 - LHX-U FOR COMMAND, ~~CONTRACT~~ control, LIAISON, AND STAFF TRANSPORT.
  6 - LHX-SCAT FOR THE FAAO ROLE EVENTUALLY PHASING OUT THE AHIP BEYOND THE YEAR FY2000

- ATK BN - PRESENTLY PROGRAMMED TO COMPLIMENT THE AH64 (HVY ATK HEL) IN THE SCOUT ROLE DISPLACING OH58C AND OH58D.   2 PER HVY DIV
  13 - LHX-SCAT FOR SCOUT A/C ONE FOR ONE (TRADE OFF, 4 PER COMPANY AND ONE IN THE HHC FOR COMMANDER)

- AIR CAV SQUADRON - REQUIRES SCOUTS TO REPLACE THE OH58C AND AH1S IN EACH AIR TROOP.   1 PER HEAVY DIV/2 AIR TROOPS
  10 - LHX-SACT FOR AIR RECON MISSION ONE FOR ONE TRADE OFF REPLACING 4 AH1S AND 6 OH58 PER TROOP.

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HEAVY DIVISION

COMBAT AVIATION BRIGADE

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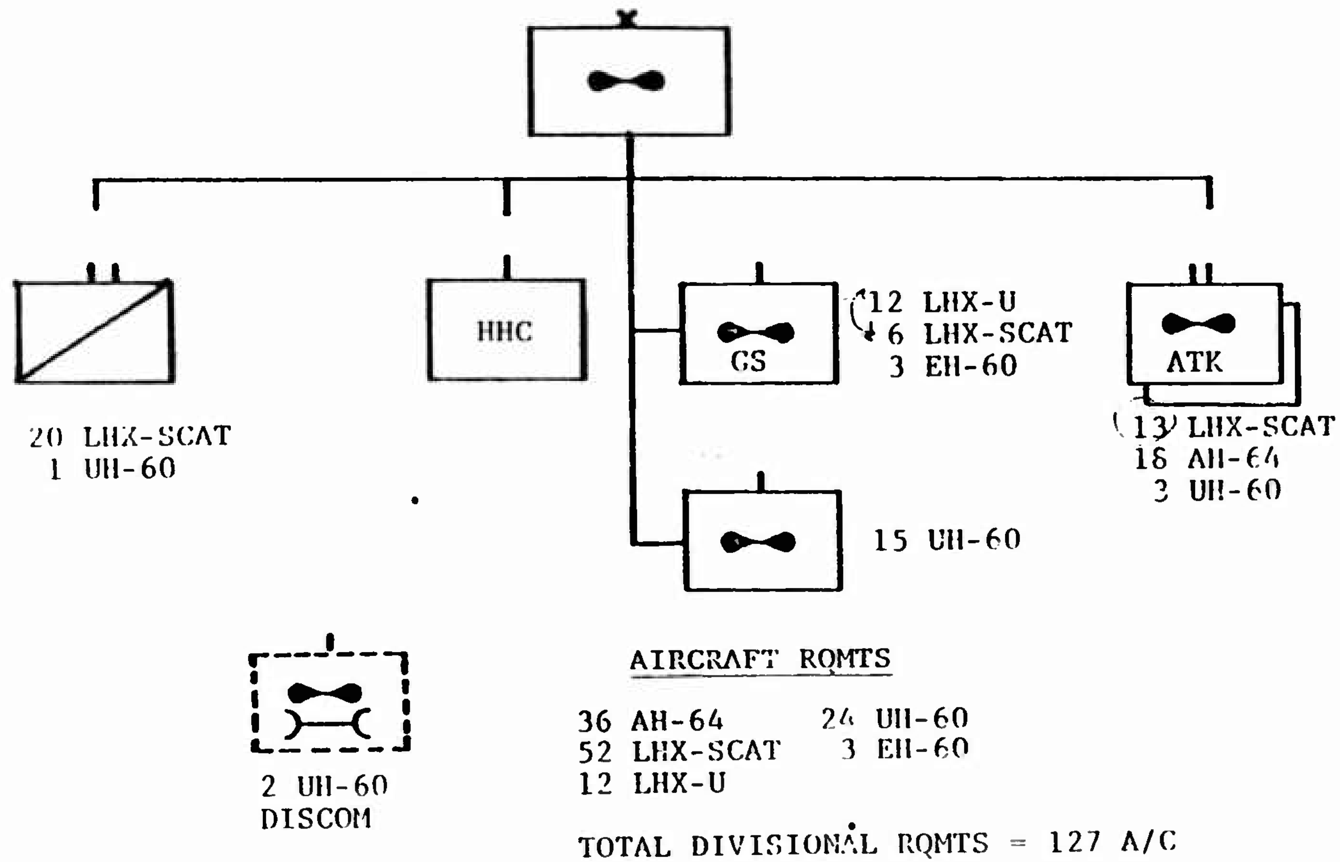
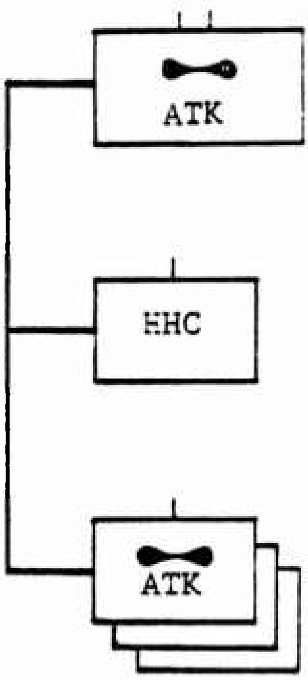


USAAVNC

ATTACK HELICOPTER BATTALION

HEAVY DIVISION



	CURRENT	LHX RQMTS
ATK	13 SCT 21 AH-1 3 UH-60	13 LHX-SCAT 18 AH-64 3 UH-60
HHC	1 SCT 3 UH-60	1 LHX-SCAT 3 UH-60
ATK	4 SCT 7 AH-1S	4 LHX-SCAT 6 AH-64

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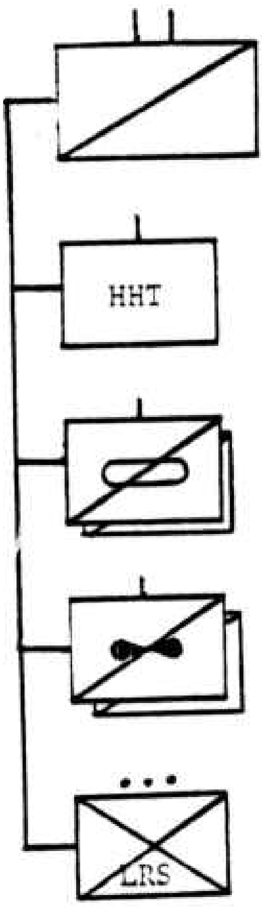
CAVALRY SQUADRON

HEAVY DIVISION



CURRENT	LHX RQMTS
1 UH-60 8 AH-1 12 SCT	1 UH-60 20 LHX-SCAT
1 UH-60	1 UH-60
4 AH-1 6 SCT	10 LHX-SCAT

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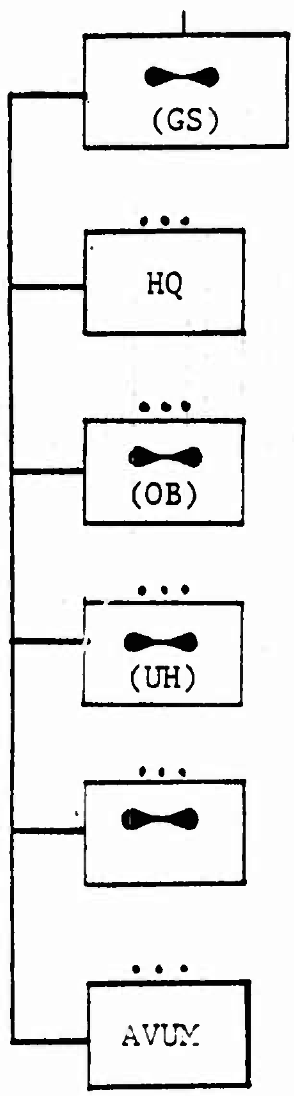
UNCLASSIFIED

COMMAND AVIATION COMPANY (GS)

HEAVY DIVISION



	CURRENT	LHX RQMTS
(GS)	6 OBSN 6 UH-1 6 SCT 3 EH-60	12 LHX-U 6 LHX-SCAT 3 EH-60
HQ		
(OB)	OBSERVATION 6 OBSN	6 LHX-U
(UH)	UTILITY 6 UH-1H	6 LHX-U
	* ARTILLARY/RECON 6 SCT	* 6 LHX-SCAT
AVUM		

* PHASE OUT OH-58D IN FAAO ROLE BEYOND THE YEAR 2000

US ARMY AVIATION CENTER

USAAVNC

AIRBORNE DIVISION

- ABN DIV - SAME AS THE LIGHT BUT WILL HAVE 12 LHX-U FOR THE HHC; WILL HAVE 3 AIR TROOPS.

- 9TH MTZ - DESIGN ALLOWS FOR MORE COMMAND AND CONTROL A/C LOCATED IN A COMBAT AVIATION BATTALION WHICH WILL HAVE A STANDARD HVY DIV CAC (GS) AND A COMMAND AVIATION SECTION FOR SUPPORT OF THE BRIGADE.

  * THE NUMBERS REFLECT THE ORIGINAL DESIGN RQMT FOR 2 ATK HEL BN'S - DA HAS CHOSEN TO RESOURCE ONLY ONE. (NO SLIDE)

- AIR ASSAULT DIV - DESIGN HAS A COMMAND AVIATION BATTALION (GS) WITH 45 LHX-U, TWO MHC (CH47) FOR AN ADDITIONAL 2 LHX-U. THIS IS BASED UPON DESIGN. RQMT FOR 4 ATK BN'S EVEN THOUGH DA HAS CURRENTLY CHOSEN TO RESOURCE 3 ATK BN'S. THE OTHER BN IS TO BE USED TO RESOURCE THE NEW DIVISIONS (6TH; 10TH)

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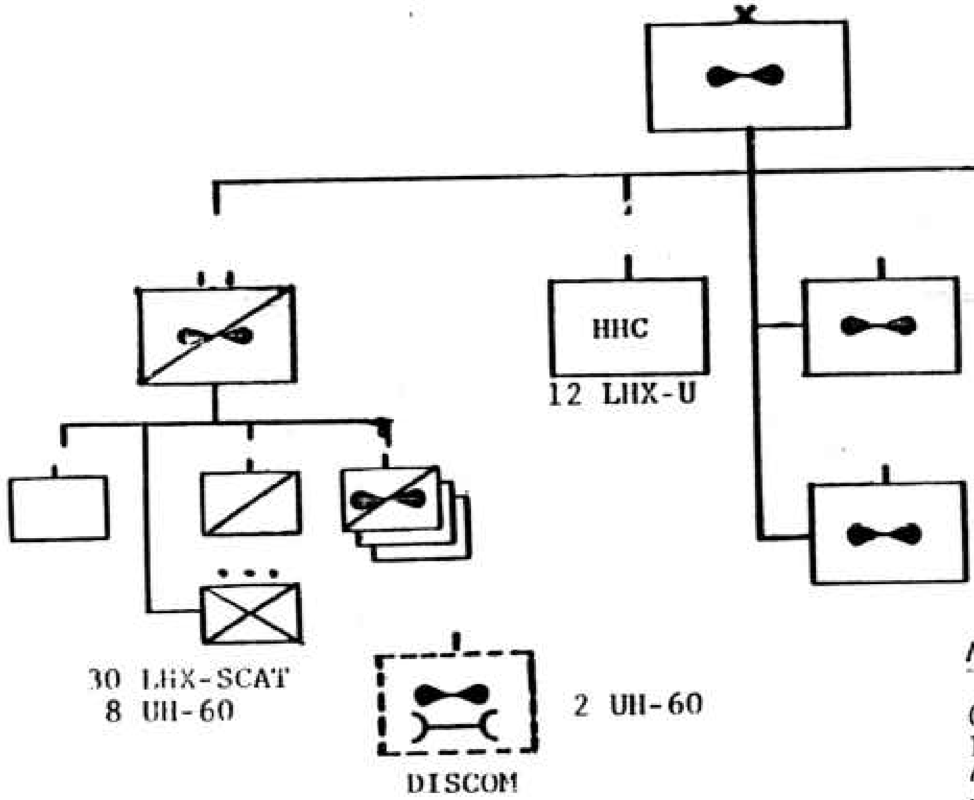
AIRBORNE DIVISION
COMBAT AVIATION BRIGADE



* LOCATED IN CLWI BN

UNCLASSIFIED

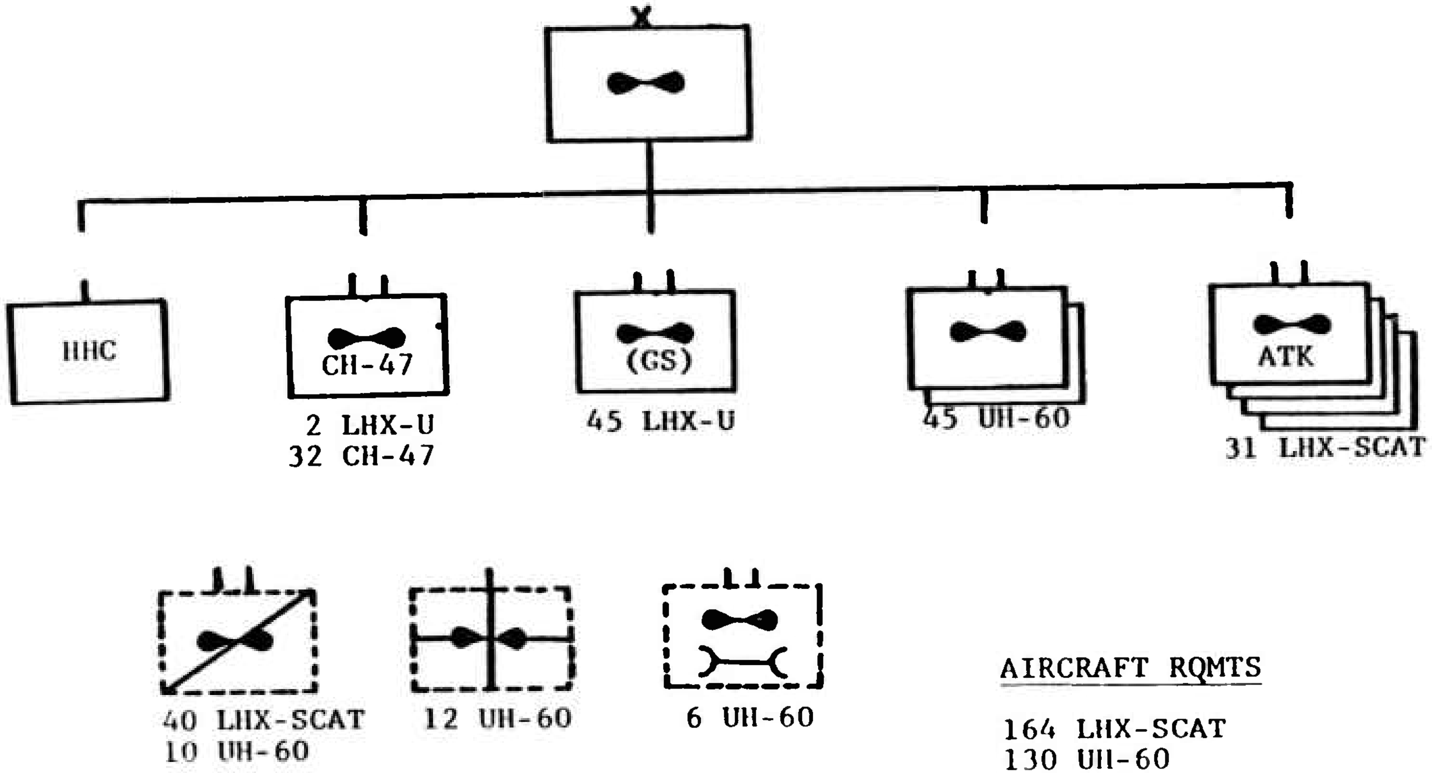
AIRCRAFT ROMTS

61 LHX-SCAT
12 LHX-U
43 UH-60
*3 EH-60

TOTAL DIVISIONAL ROMTS - 119 A/C

USAAVNC

AIR ASSAULT DIVISION
AVIATION BRIGADE



UNCLASSIFIED

AIRCRAFT RQMTS

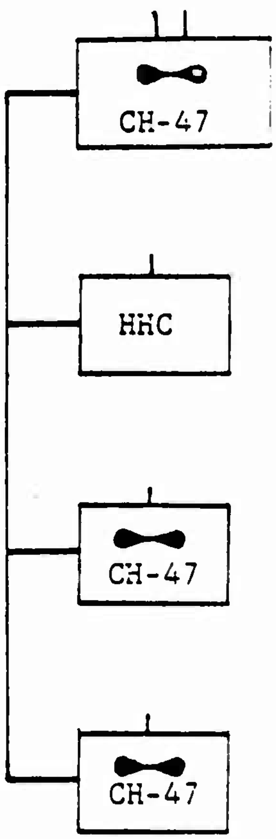
164 LHX-SCAT
130 UH-60
47 LHX-U
32 CH-47
3 EH-60

TOTAL DIVISIONAL RQMTS = 376

USAAVNC

AIR ASSAULT DIVISION

COMBAT AVIATION BATTALION (CH-47)



CURRENT	LHX RQMTS
2 UH-1 32 CH-47	2 LHX-U 32 CH-47
1 UH-1 16 CH-47	1 LHX -U 16 CH-47
1 UH-1 16 CH-47	1 LHX-U 16 CH-47

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US ARMY AVIATION CENTER

AIR ASSAULT DIVISION

COMMAND AVIATION BATTALION

	CURRENT	LHX RQMTS
GS	30 UH-1 15 OH	45 LHX-U
HHC		
UH	15 UH-1	15 LHX-U
UH	15 UH-1	15 LHX-U
OH	15 OH	15 LHX-U

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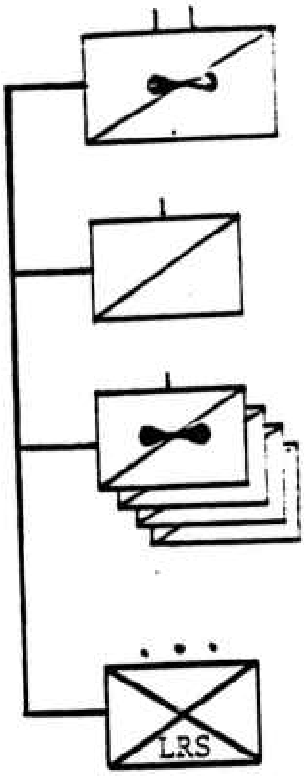
US ARMY AVIATION CENTER

AIR ASSAULT DIVISION

AIR RECONNAISSANCE SQUADRON



CURRENT	LHX RQMTS
24 SCT 16 AH-1 10 UH-60	40 LHX-SCAT
10 UH-60	10 UH-60
6 SCT 4 AH-1	10 LHX-SCAT

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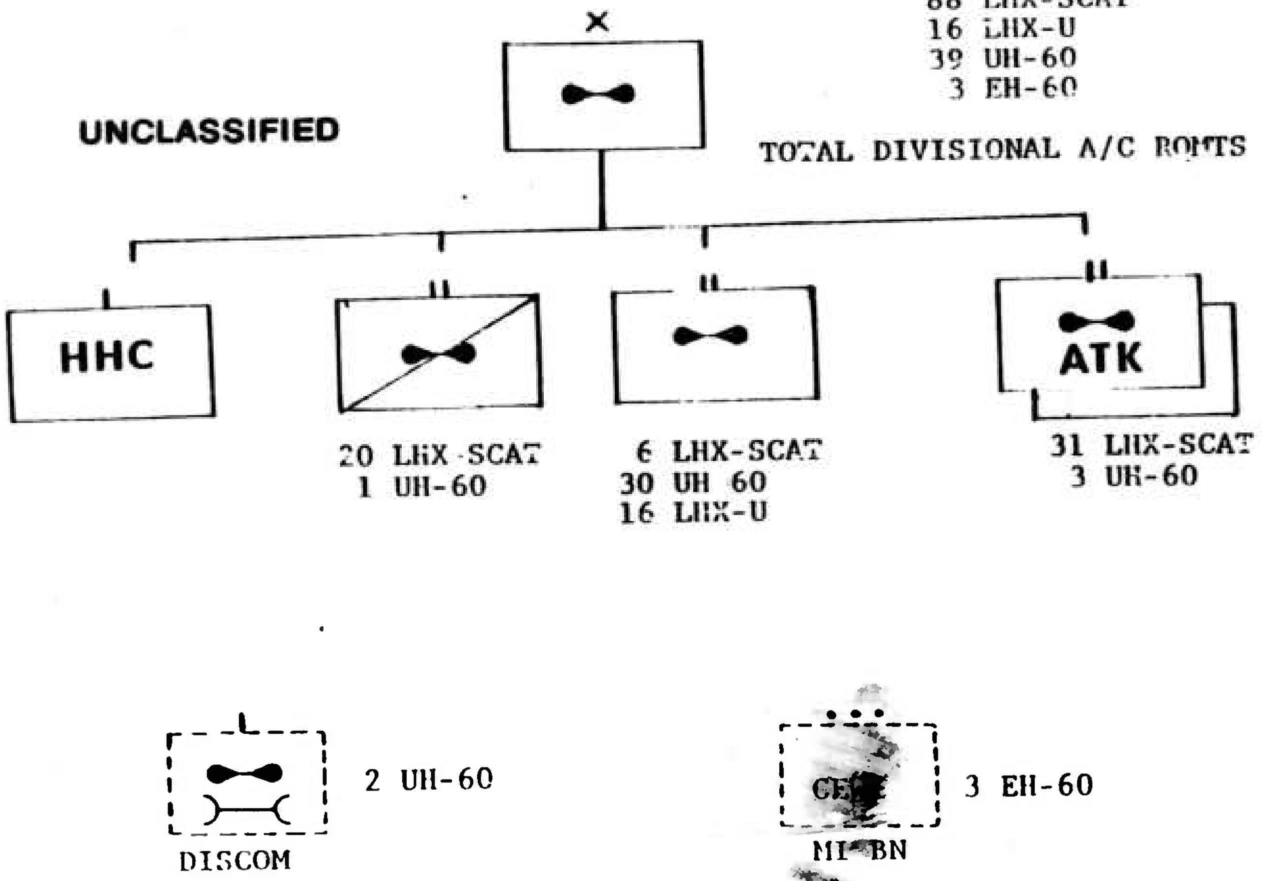
9TH MOTORIZED DIVISION

UNCLASSIFIED

AIRCRAFT RQMTS

88 LHX-SCAT
16 LHX-U
39 UH-60
3 EH-60

TOTAL DIVISIONAL A/C RQMTS = 146



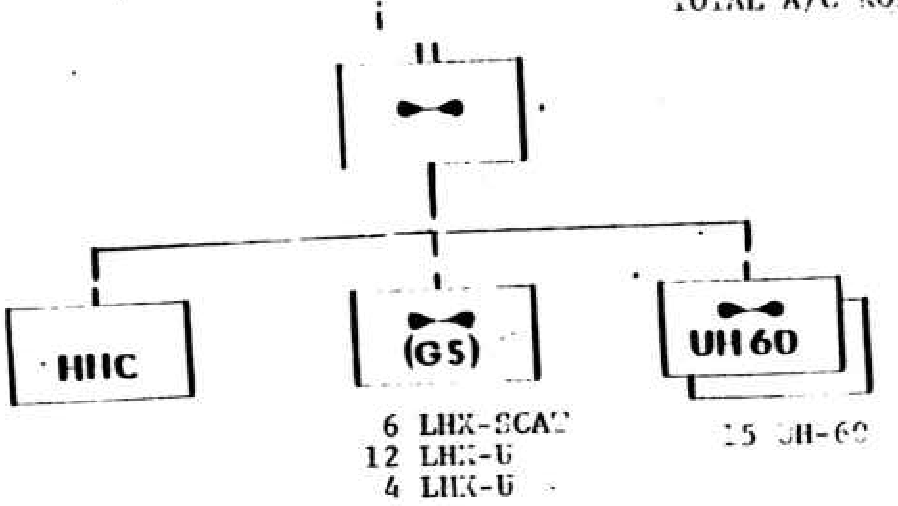
USAAVNC

9th MOTORIZED DIVISION CAB (GS)

AIRCRAFT RQMTS

30 UH-60
16 LHX-U
6 LHX-SCAT

TOTAL A/C RQMT = 52 A/C



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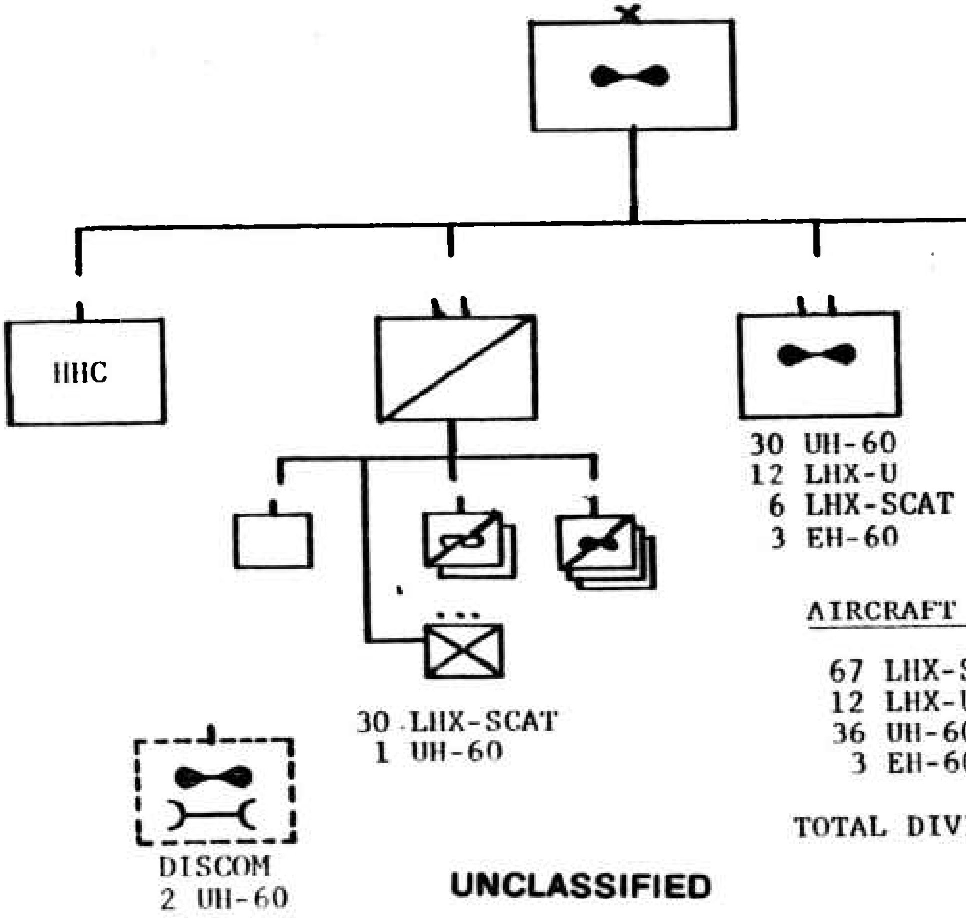
USAAVNC

2nd INFANTRY DIVISION
COMBAT AVIATION BRIGADE



AIRCRAFT RQMTS

67 LHX-SCAT
12 LHX-U
36 UH-60
3 EH-60

TOTAL DIVISIONAL RQMTS = 118 A/C

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USAAVNC

USAAVNC

CORPS

- LHX-U WILL GO TO THE COMMAND AVIATION BATTATION (GS) FOR COMMAND, CONTROL, LIAISON, AND STAFF TRANSPORT.

LHX - SCAT WILL EVENTUALLY PHASE OUT THE OH58D IN THE FAAO ROLE.

- LHX-U IN THE COMBAT AVIATION BATTALION (CH47) HAS 4 COMPANIES REQUIRING ONE LHX-4 FOR EACH COMPANY.
u

- LHX-SCOUT IN EACH OF THE ATTACK BN'S TO COMPLIMENT THE AH64 BY PHASING OUT THE OH58C/OH58D IN SCOUT ROLE.

- RCAS - LHX-SCAT WILL REPLACE BOTH AH1S AND OH58C IN THE SCOUT/PROTECTION ROLE.

* NOTE THE RCAS WILL STILL HAVE A COMPANY OF UH60 FOR LOGISTICAL RESUPPLY AND TROOP TRANSPORT.

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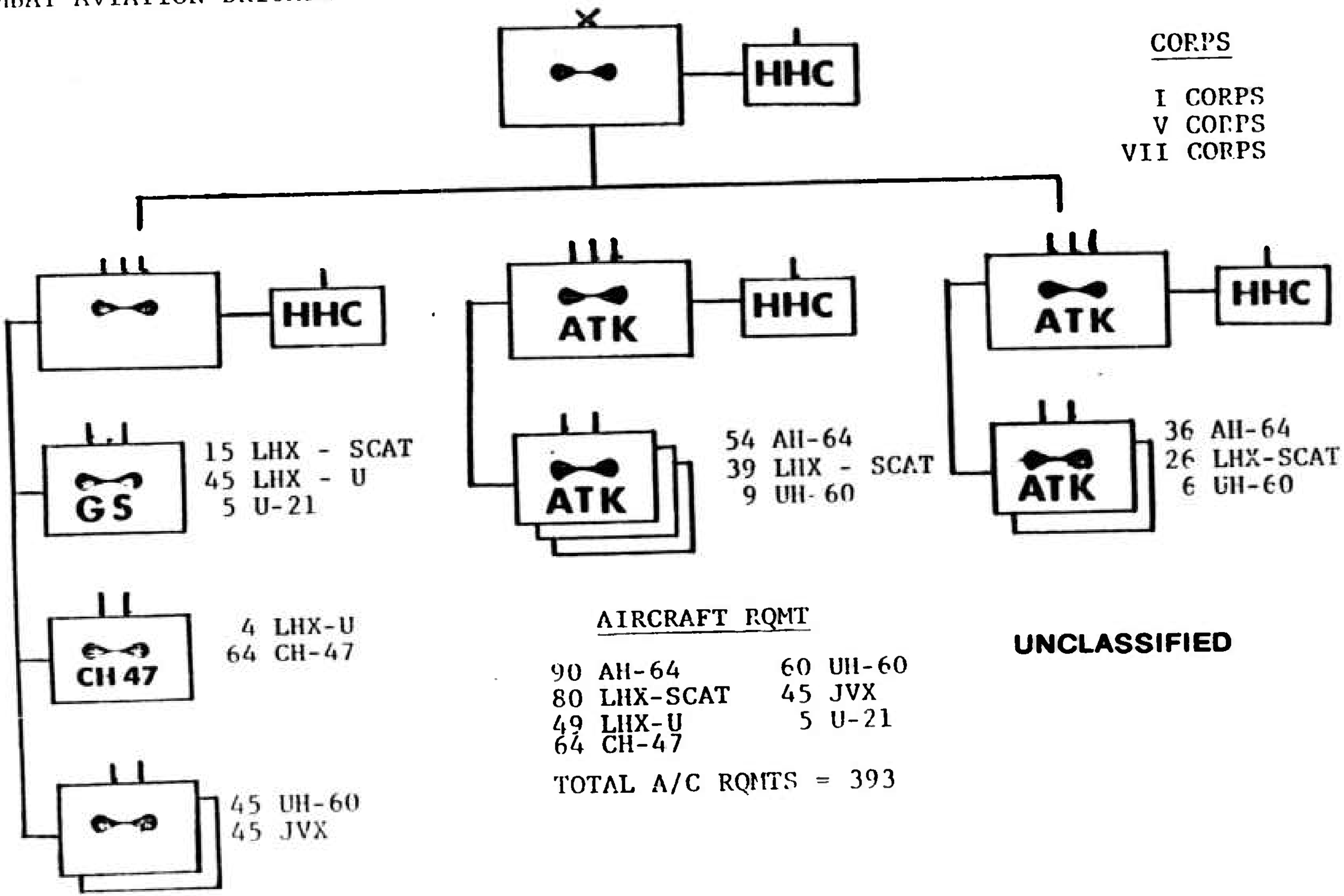
CORPS

STANDARD CORPS STRUCTURE

COMBAT AVIATION BRIGADE



CORPS

I CORPS
V CORPS
VII CORPS

AIRCRAFT RQMT

90 AH-64	60 UH-60
80 LHX-SCAT	45 JVX
49 LHX-U	5 U-21
64 CH-47	

TOTAL A/C RQMTS = 393

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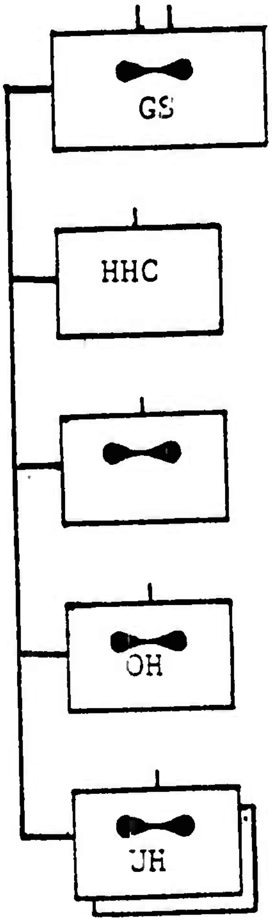
CORPS COMBAT AVIATION BRIGADE

COMMAND AVIATION BATTALION (CORPS)



COMMAND AVIATION BATTALION (GS)

CURRENT	LHX RQMT
30 UH-1 15 OH 15 SCT 5 U-21	45 LHX-U 15 LHX-SCAT 5 U-21
5 U-21	5 U-21
15 SCT	15 LHX-SCAT
15 OH	15 LHX-U
15 UH	15 LHX-U

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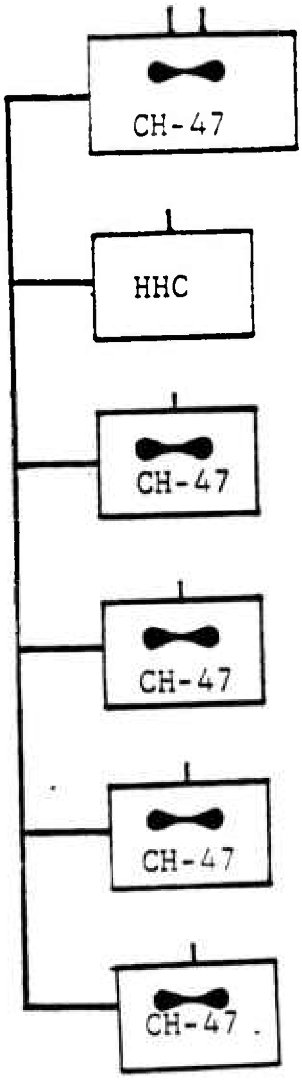
CORPS COMBAT AVIATION BATTALION (CH-47)

COMBAT AVIATION BATTALION CH-47



CURRENT	LHX RQMT
4 UH-1 64 CH-47	4 LHX-U 64 CH-47
1 UH-1 16 CH-47	1 LHX-U 16 CH-47
1 UH-1 16 CH-47	1 LHX-U 16 CH-47
1 UH-1 16 CH-47	1 LHX-U 16 CH-47
1 UH-1 16 CH-47	1 LHX-U 16 CH-47

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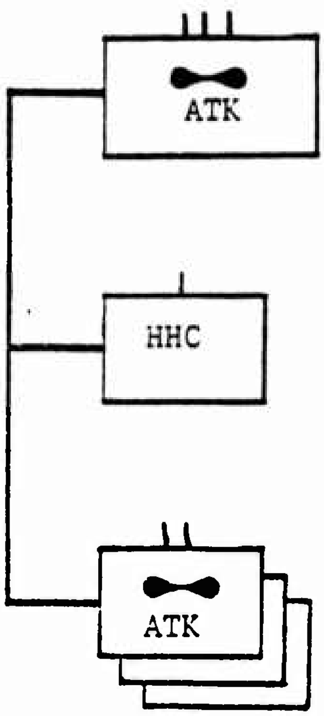
CORPS ATTACK HELICOPTER REGIMENT



— — ATTACK HELICOPTER REGIMENT

CURRENT	LHX - RQMT
39 SCT 63 AH-1 (54 AH-64) 9 UH-60	39 LHX-SCAT 54 AH-64 9 UH-60
13 SCT 21 AH-1 (18 AH-64) 3 UH-60	13 LHX-SCAT 18 AH-64 3 UH-60

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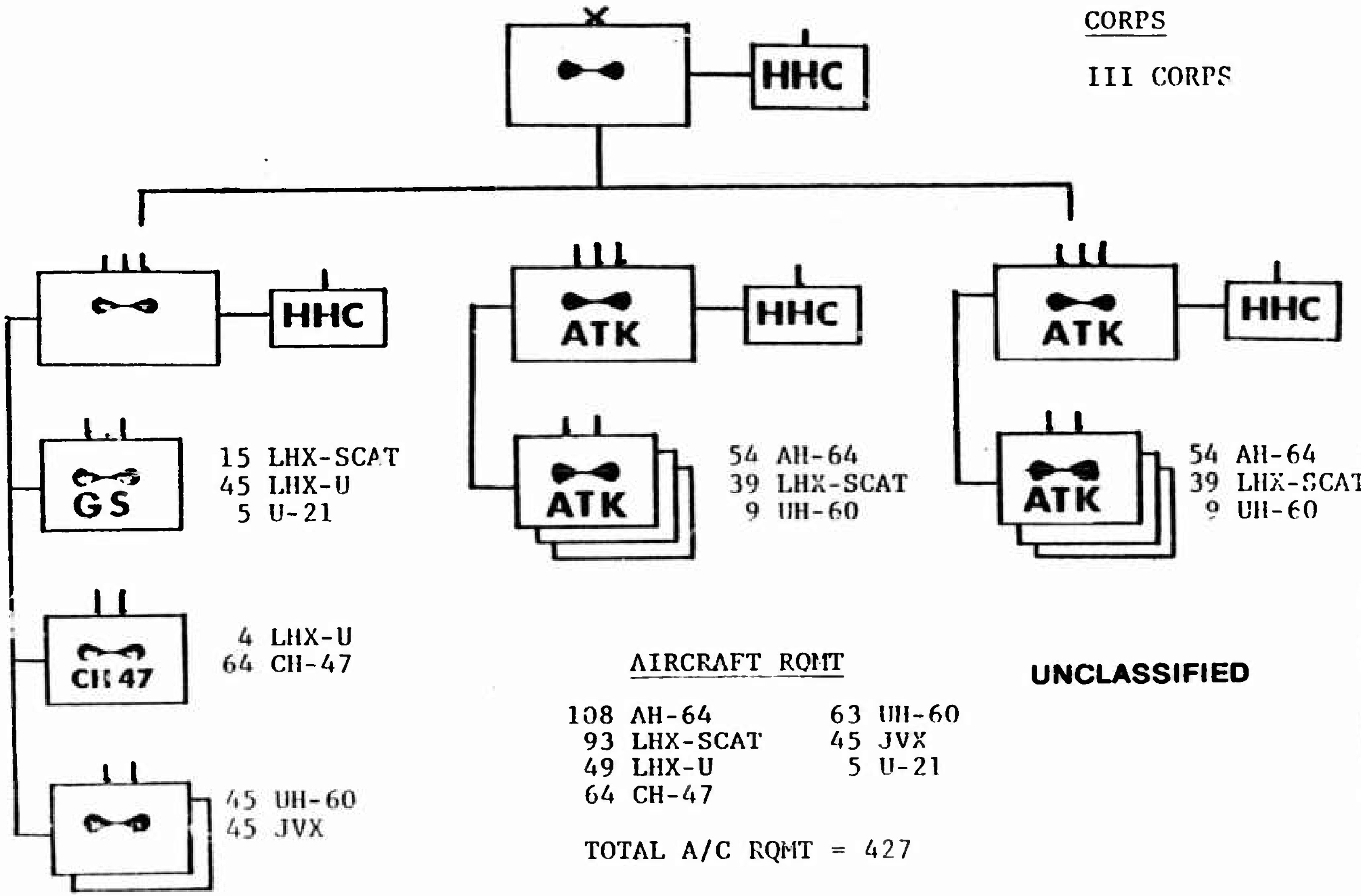
CORPS

HEAVY CORPS STRUCTURE

COMBAT AVIATION BRIGADE

CORPS

III CORPS



AIRCRAFT RQMT

108 AH-64	63 UH-60
93 LHX-SCAT	45 JVX
49 LHX-U	5 U-21
64 CH-47	

TOTAL A/C RQMT = 427

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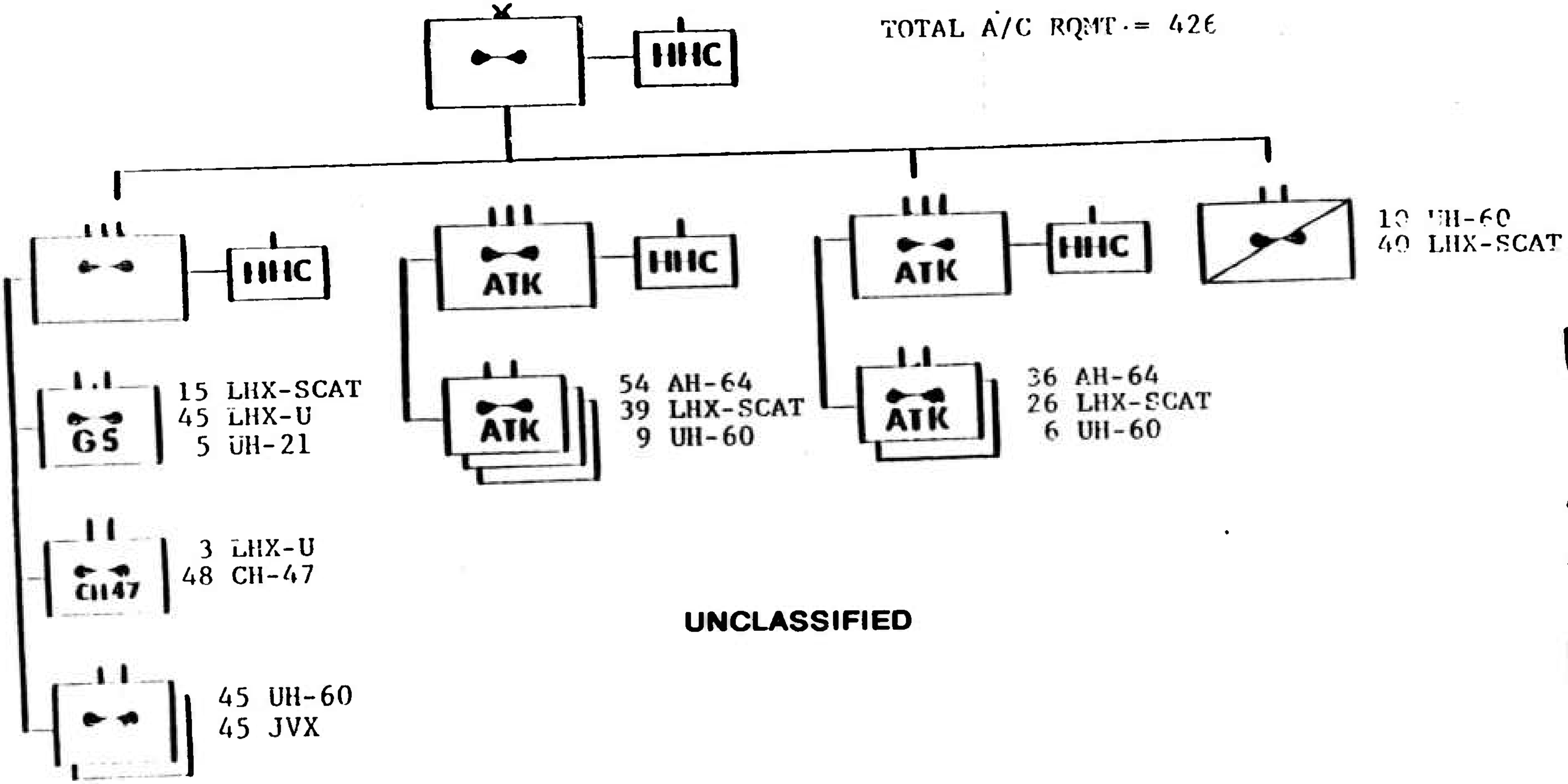
XVIII CORPS

CONTINGENCY CORPS AVIATION BRIGADE

AIRCRAFT RQMTS

5 UH-21	70 UH-60
90 AH-64	45 JVX
120 LHX-SCAT	48 CH-47
48 LHX-U	

TOTAL A/C RQMT = 426



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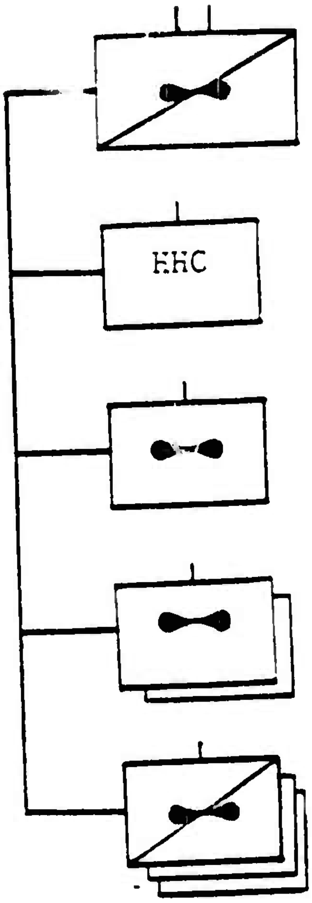
RCAS

REGIMENTAL COMBAT AVIATION SQUADRON



CURRENT	LHX RQMTS
27 SCT 26 AH-1 18 UH-60 3 EH-60	53 LHX-SCAT 18 UH-60 3 EH-60
1 SCT 3 EH-60 3 UH-60	1 LHX-SCAT 3 EH-60 3 UH-60
15 UH-60	15 UH-60
4 SCT 7 AH-1	11 LHX-SCAT
6 SCT 4 AH-1	10 LHX-SCAT

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ECHELONS ABOVE CORPS

- EAC - LHX-U WILL BE LOCATED IN THEATER AVIATION COMPANY FOR COMMAND, CONTROL, LIAISON AND TRANSPORT.

  LHX-U WILL RESOURCE THE PERSHING COMPANY.

  LHX-U WILL RESOURCE THE MHC AND HLC WITH ONE A/C PER COMPANY.

- 17TH GROUP WILL BE RESOURCED WITH LHX-SCAT TO PHASE OUT THE OH58C IN THE SCOUT ROLE TO COMPLEMENT THE HVY ATK HEL - INITIALLY RESOURCED WITH AHIS.

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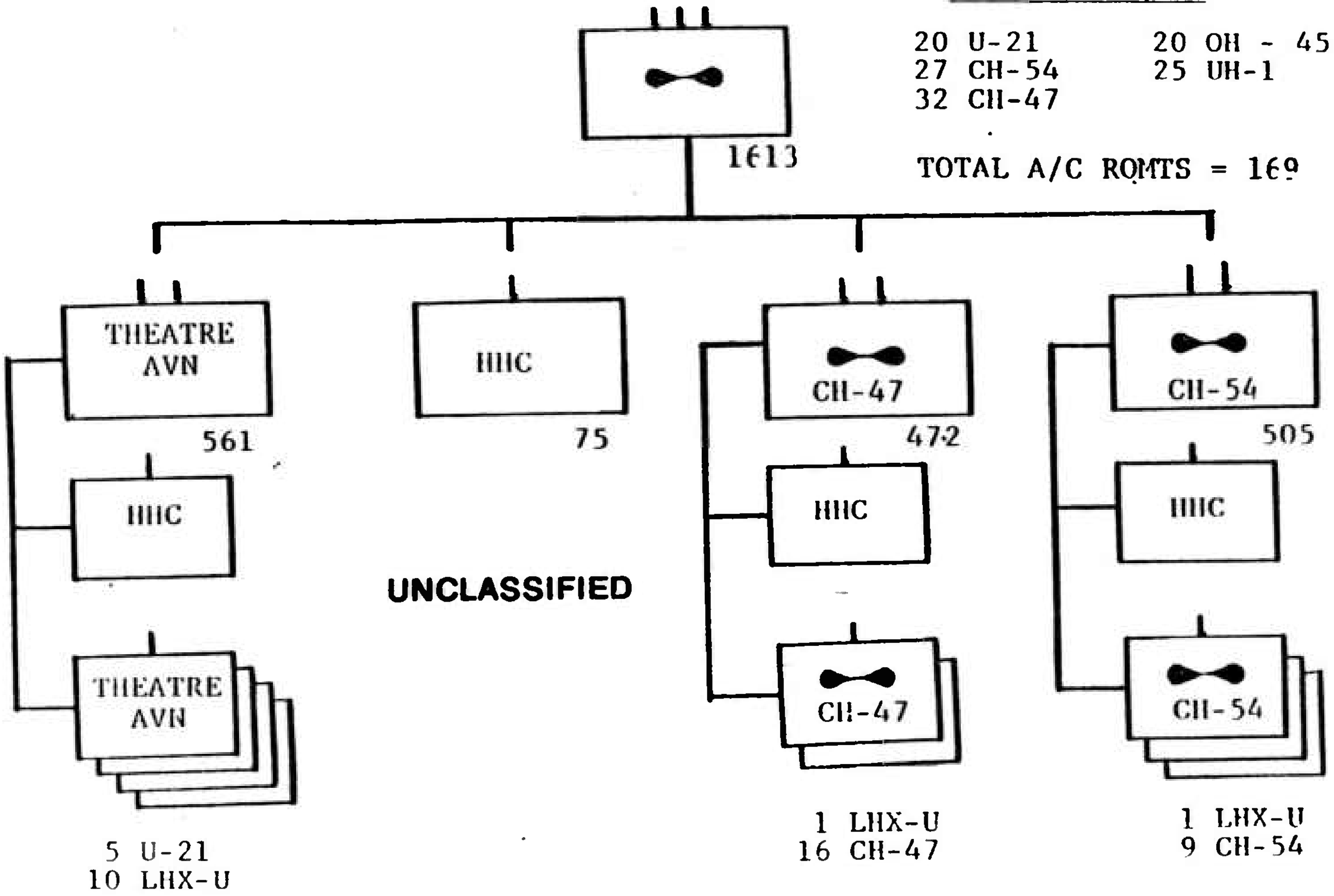
EAC: NATO

AIRCRAFT RQMTS

20 U-21
27 CH-54
32 CH-47
20 OH - 45 LHX-U
25 UH-1

TOTAL A/C RQMTS = 169



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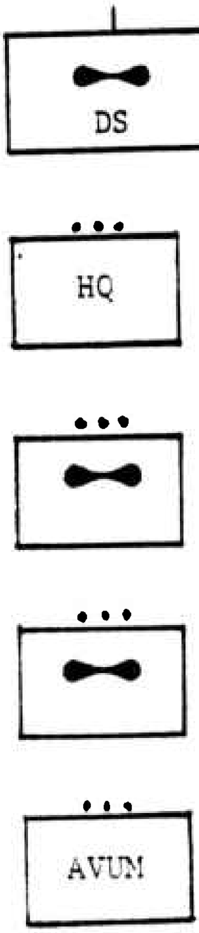
NOTE: COMMAND AVIATION COMPANY (GS) PERSHING LISTED SEPARATE

EAC: NATO

PERSHING BRIGADE AVIATION SUPPORT

COMMAND AVIATION COMPANY (DS)



CURRENT	LHX - RQMTS
12 UH-1	12 LHX-U
01277J500	
6 UH-1	6 LHX-U
6 UH-1	6 LHX-U

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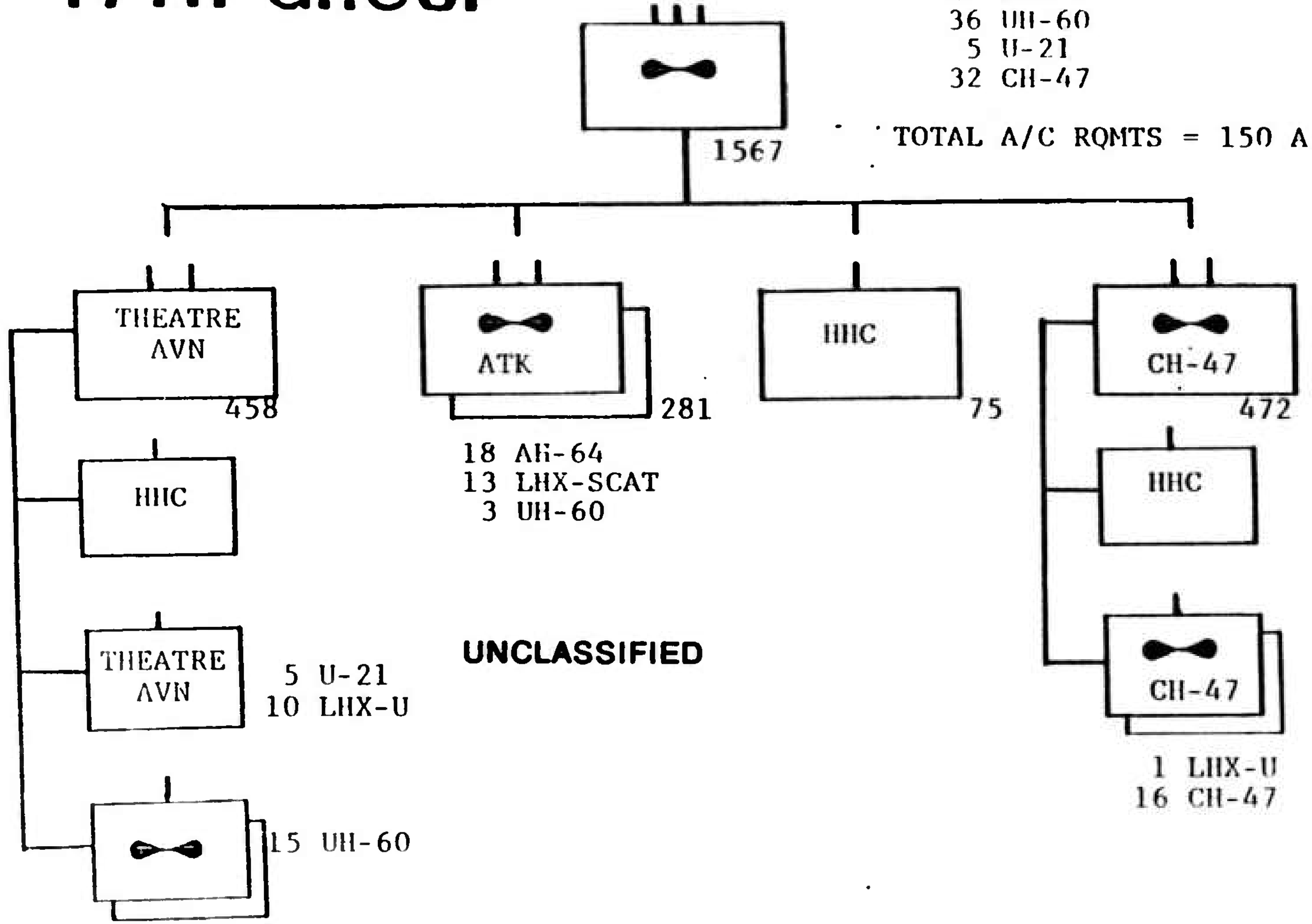
EAC: NEA

17TH GROUP

AIRCRAFT RQMTS

36 AH-64
26 LHX-SCAT
12 LHX-U
36 UH-60
5 U-21
32 CH-47

TOTAL A/C RQMTS = 150 A/C



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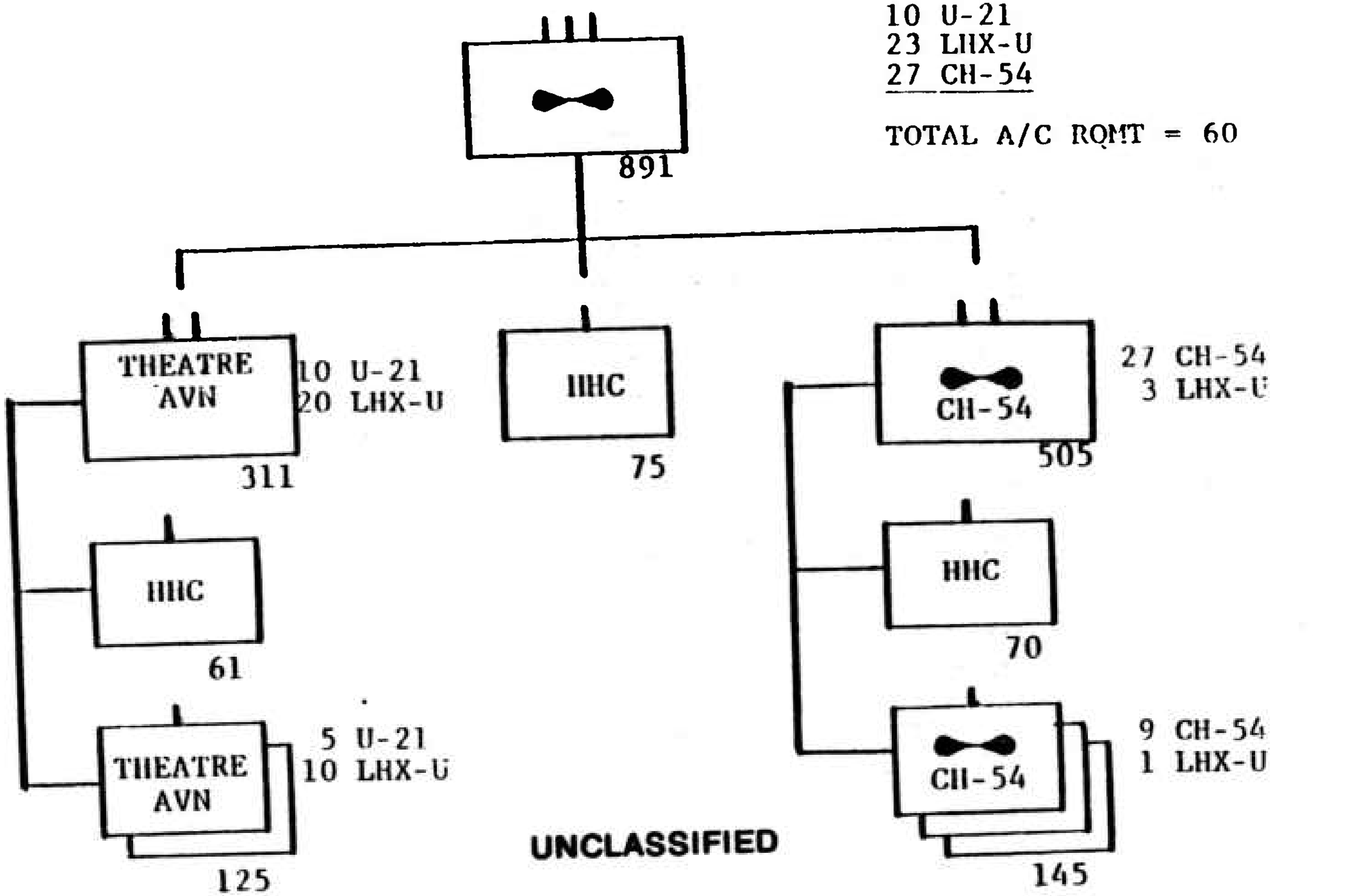
EAC: SWA



AIRCRAFT RQMTS

10 U-21
23 LHX-U
27 CH-54

TOTAL A/C RQMT = 60

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USAAVNC

SPECIAL OPERATIONS COMMAND (SOCOM) AND OTHERS

- THE SOAB - SPECIAL OPERATION AVIATION BATTALION WILL HAVE THE SCAT FOR THE LIGHT ATTACK ROLE FOR AERIAL ESCORT OF STRIKE MISSION, TO DESTROY ENEMY FORCES. THE LHX-U WILL BE UTILIZED FOR LIGHT UTILITY/ AIR ASSAULT STRIKE MISSIONS AND COMMAND, CONTROL, LIAISON AND STAFF TRANSPORT.

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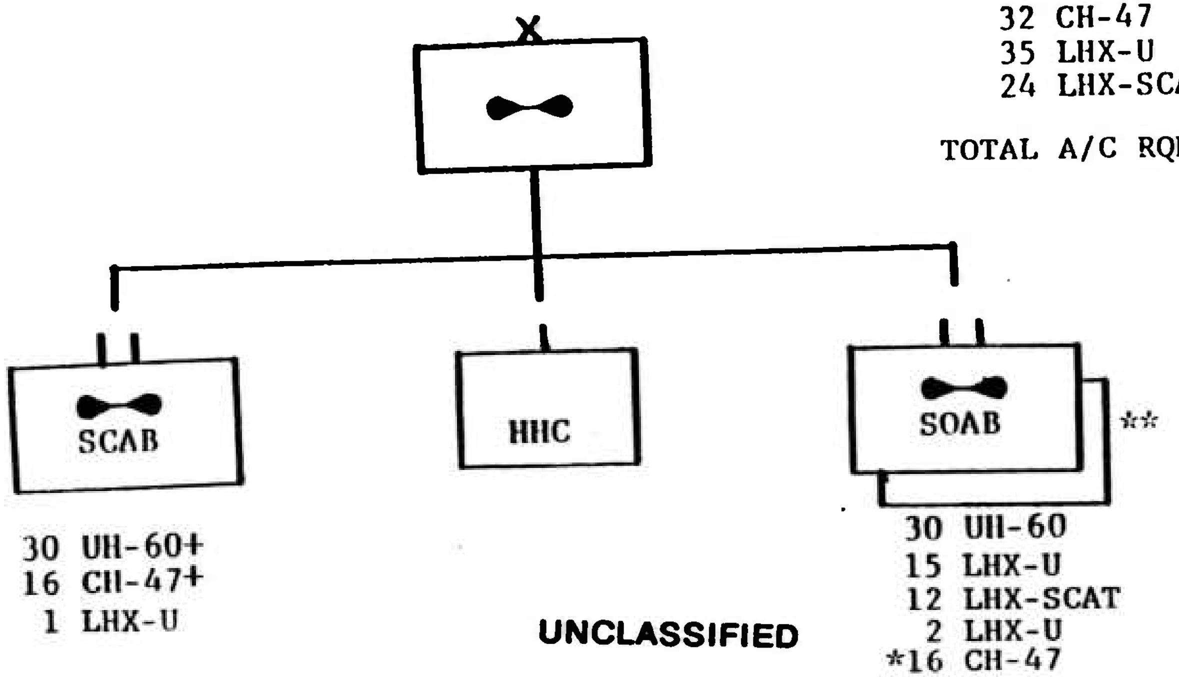
SOAF

SPECIAL OPERATIONS AVIATION BRIGADE

AIRCRAFT RQMTS

60 UH-60
30 UH-60+
16 CH-47+
32 CH-47
35 LHX-U
24 LHX-SCAT

TOTAL A/C RQMT = 197



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* 1 COMPANY (16 SHIP) RC DUAL MISSION

** RC SOAB MAY NOT INITIALLY BE RESOURCED WITH UH-60

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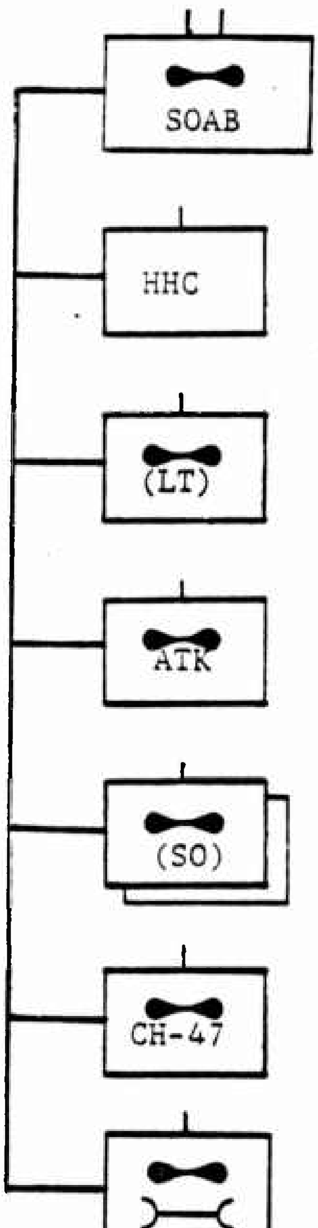
SOAF

SPECIAL OPERATION AVIATION BATTALION



Unit	CURRENT	LHX RQMTS
HHC	2 EH-6	2 LHX-U
(LT)	15 MH-6	15 LHX-U
ATK	12 AH-6	12 LHX-SCAT
(SO)	15 UH-60	15 UH-60
CH-47	16 CH-47 1 UH-1	16 CH-47 1 LHX-U

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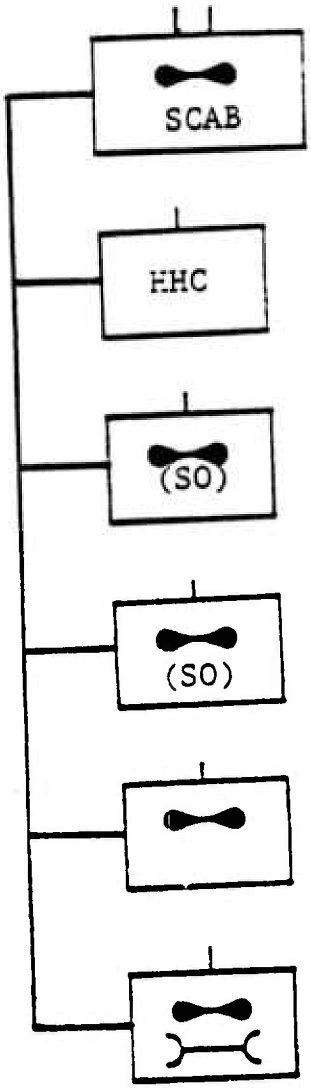
SOAF

SPECIAL COMBAT AVIATION BATTALION



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CURRENT	LHX RQMTS
15 UH-60(+)	15 UH-60(+)
15 UH-60(+)	15 UH-60(+)
16 CH-47(+) 1 UH-1	16 CH-47(+) 1 LHX-U

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- SEP BDE - 18 SEP BDE, 6 SIG BDE, 6 MP GRP, 25 ENG.

- THESE ELEMENTS HAVE A RQMT OF 275 LHX-U - IT IS RECOGNIZED THAT THESE RQMTS ARE SUPPOSED TO BE PHASED OUT AS THEY GO TO THE NEW AOE STRUCTURES BUT THIS WAS NOT ADDRESSED DURING THE FPR AND THESE WERE STILL PROGRAMMED IN THE STRUCTURE. IF AOE IS FINALLY IMPLEMENTED, THE MAJORITY OF THESE WILL BE ELIMINATED AND ONLY THE LT SEP BDE WILL HAVE A/C. THE INF SEP BDE AOE DESIGN STILL INCORPORATES 6 LHX-U FOR C^3 AND LIAISON (APPROVED BY GEN RICHARDSON 21 NOV 84).

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SEPARATE UNITS

	CURRENT	LHX RQMTS
AR/ MX / LT INF BDE	6 OH 2 UH	5 LHX-U
INF BDE	8 OH 3 UH	5 LHX-U
SIGN UNITS	7 OH 5 UH 3 U-21	5 LHX-U 3 U-21
MP GP	5 OH	5 LHX-U
ENG GP	3 OH 4 UH	5 LHX-U

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APPENDIX T

RELIABILITY, AVAILABILITY, AND MAINTAINABILITY/LOGISTICS (RAM/LOG) ANALYSIS (U)

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APPENDIX T

RELIABILITY, AVAILABILITY, AND MAINTAINABILITY/LOGISTICS (RAM/LOG) ANALYSIS (U)

T-1. (U) PURPOSE.

a. (U) The overall goal of any reliability, availability, and maintainability (RAM) program is to increase the effectiveness of a system with little or no increase in its support costs. With the doctrine of Army 21, this goal becomes a necessity due to the fluidity of the battlefield environment, the increase in the threat's capabilities, and the vulnerability of our forward support capabilities. In order to answer the Army's needs, the light helicopter family (LHX) must be highly reliable and easily maintainable with an optimized support concept that allows the system to be consistently available to the combat commander.

b. (U) The purpose of the RAM/Logistics (LOG) trade-off analysis (TOA) report is to identify and quantify where possible those minimum values of RAM and supportability goals that must be achieved if the user is to accomplish his mission. This analysis will involve both qualitative and quantitative parameters since the synergistic effect of all the subsystems on this aircraft do not lend themselves to quantitative results in every case.

c. (U) The quantitative results have been presented as user minimum needs or minimum acceptable values (MAV). Similar to the RAM parameters that appear in a requirement document, these values are meant to establish the floor or base case that the user must have to accomplish his mission. They are not the value the user wants but in order to preclude "gold plating from the outset", it is necessary to establish this base case. As the acquisition cycle proceeds and we produce the best technical approach (BTA), the cost and benefits of designing a system that exceeds the MAV parameters will be shown and the decision makers will be able to see the costs involved and the pay back in terms of mission accomplishment.

d. (U) Paragraph T-2, Background, of this report discusses the following topics:

(1) (U) The role of the TOD and how that RAM data was used.

(2) (U) Selection of reliability parameters that are both satisfactory to the user and can be used contractually.

(3) (U) Determining a scenario or mission need about which the analysis could be based.

(4) (U) Developing a flying-hour program that can support the mission scenario and will be used in the analysis.

(5) (U) Determining a baseline case for manpower requirements that will support the mission needs.

(6) (U) Logistic support concepts that will be used to support the LHX in the field.

(7) (U) Partial mission capabilities (PMC); how they were determined and how they will be used in the analysis.

(8) (U) Mandatory programs that must be included in the LHX program if the gains in R&M that were promised ever hope to be realized.

(a) (U) Functional partitioning.

(b) (U) Testability versus the false removal rate.

(c) (U) Software reliability.

(9) (U) An overall view of the reliability impact on the one-man cockpit design.

T-2. (U) BACKGROUND. The TOA is the follow-on document to the trade-off determination (TOD) in the normal acquisition cycle. Where the RAM/LOG TOD concentrated on hardware components and the reliabilities that could be expected to be achieved from these devices, the TOA concentrated upon the user's need to accomplish those missions for which the LHX was being designed. To this end, no attempt was made to question the results of the TOD report but rather this document was used as a stepping-off point for the TOA. There were some key issues raised in the TOD that need clarification and further analysis and these points will be covered in the TOA. The TOD results were based upon system maturity and an unconstrained design in terms of weight and cost. These values are still valid, but they must be considered in light of the overall cost and weight constraints of the present LHX program.

a. (U) <u>Reliability Parameters</u>.

(1) (U) The selection of reliability parameters is key to the overall values that will result from the analysis. It is important that these parameters answer the user's need and can be used to draft a system specification. During recent years, the way in which mission reliability has been looked at has changed significantly. In terms of a user parameter, mission reliability equates to the ability to perform a mission. In the past, this has been equated to mission abort rate which included failures that caused the pilot to return to the airfield. Although this parameter can be relatively high (100 hours), it does not answer the user's real need.

(2) (U) The term mission must be adequately defined in order to determine what mission reliability means. In the past, individual sorties or missions have been used to define reliabilities. This allowed systems to fail after they were needed during the sortie and not have these failures

chargeable against the aircraft. Thus, the term mission abort was used to define reliabilities. This approach, although easy to use in analysis and design, is unacceptable to the user in defining his need.

(3) (U) The mission of any combat asset is to destroy or support the destruction of the enemy. Although aircraft do this by flying individual sorties or missions, the overall mission does not cease when the aircraft returns to the airfield and shuts down. Normally, the combat environment is fluid enough that one does not know if the situation will call for an immediate relaunch of all the mission-ready air assets as soon as they are rearmed and refueled. For this reason, mission reliability must be viewed as the entire mission capability of the aircraft system. It also must include the entire combat day rather than considering only small increments of time.

b. (U) Sustainability.

(1) (U) The first reliability term selected is one that addresses the required maintenance burden. The term selected is essential maintenance action (EMA). This term is made up of all nondeferrable maintenance and includes red X, circle red X, and any loss of a mission essential function (MEF). The cataloging of this reliability parameter produces the total maintenance burden necessary to keep the aircraft in a fully mission capable (FMC) status.

(2) (U) In terms of combat capability, the mean time between EMA (MTBEMA) gives the user an indication of how often maintenance must be accomplished. This parameter is also directly related to the operational availability (A_0) or the system readiness objective (SRO). Since any EMA will cause a downing condition, maintenance performed under this parameter constitutes true downtime or nonavailable time.

c. (U) Mission Reliability.

(1) (U) Mission reliability for the LHX is examined under the parameter mission-affecting failure (MAF). This is not an abort rate but rather a parameter that accounts for any loss of any mission capability for the entire aircraft system. The reason this parameter was selected is that it will directly relate to the aircraft's ability to relaunch any mission after a rearming and refueling period.

(2) (U) The parameter MAF is a subset of EMA that takes into account when the failure was discovered and allows for functional redundancy. Where the EMA parameter includes all time, the MAF parameter only looks at mission time. For purposes of this analysis, mission time begins with preflight and ends with complete system shut down at the end of the flight. Functional redundancy failures would not be included in MAFs. These are failures of redundant systems that occurred during mission time that did not cause the pilot to lose any mission capabilities.

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d. (U) Mission Scenario.

(1) (U) In order to effectively state the user's need in a TOA, it is necessary to develop a scenario against which the LHX can be expected to be utilized in a combat operation. The 48 individual mission profiles (MP) that appear in this TOA represent specific mission needs but they do not tie together or address the day-to-day flying requirements of the LHX.

(2) (U) A baseline scenario must be established in order to effectively utilize the LHX as a combat asset. For both the Attack Helicopter Battalion (AHB) and the Aerial Reconnaissance Squadron (ARS), a baseline was developed that afforded minimum coverage over the 24-hour combat day. The assumption was made that this minimum rate could be sustained for an indefinite period but it would require maintenance stand-down periods if the rate was increased. The following represents the scenario and resultant flying-hour program.

e. (U) Planning Factors for Flying Hours.

(1) (U) The LHX is to be designated as an all-weather, day/night aircraft. This will be the first time the US Army has had this kind of capability in its aircraft fleet. For this reason, it is necessary to evaluate our old flying-hour programs to determine if they are adequate to effectively utilize this new asset. Rather than start with individual aircraft flying-hour programs, as documented in AR 95-33 and FM 101-20, the decision was made to examine the operational needs and subsequently produce the flying-hour program that would support that requirement.

(2) (U) The first unit examined in this analysis was the attack battalion. The reasons for this decision were the fact that this was a pure LHX unit and that the current doctrine allows a rather clear definition of the employment of this unit.

(3) (U) In order to support this operational analysis, a number of assumptions had to be made. These assumptions all support current doctrine and unit organization.

(a) (U) 3/5 mix. In support of current doctrine, all attack teams were comprised of eight aircraft. Three of these aircraft were in the scout role and five were in the attack role. No cross mixing was allowed between company-sized units so all eight aircraft had to come from the same company. No distinctions were made between scout and attack aircraft other than their role on the battlefield, thus all aircraft in the company were considered to be identically outfitted.

(b) (U) 24-hour operations. A great deal of time, effort, and money has gone into Army materiel systems since the Vietnam era in order to give the soldier and his commander the ability to conduct combat operations on a 24-hour basis. Although this equipment allows us to fight at night and in limited visibility conditions, no requirements have addressed the increased utilization rates that this all-weather, day/night capability will place upon the fighting units.

(4) (U) In this analysis, a 24-hour fighting capability was defined as aircraft combat flight time, not stand by time, at the airfield. Thus, in order to sustain this capability, company teams (eight aircraft) would be rotated on station to achieve the 24-hour fighting capability (shown in figure T-1). With this in mind, it became obvious that the battalion was the smallest unit that could sustain 24-hour operations since crew rest would be involved if the rate had to be sustained.

(5) (U) The minimum operational requirement placed upon the battalion by this 24-hour fighting capability was 192 blade hours. This number resulted from the cost of keeping around-the-clock presence of at least one team (eight aircraft) or 8 aircraft x 24 hours = 192 aircraft hours.

(6) (U) With the assumptions defined, it is now possible to define the flying-hour rate per aircraft that would be required to sustain this minimum requirement. Because this analysis is based upon unit mission requirements, the flying-hour rate will be directly dependent upon the organizational size of the unit. This is evident from the figure T-2.

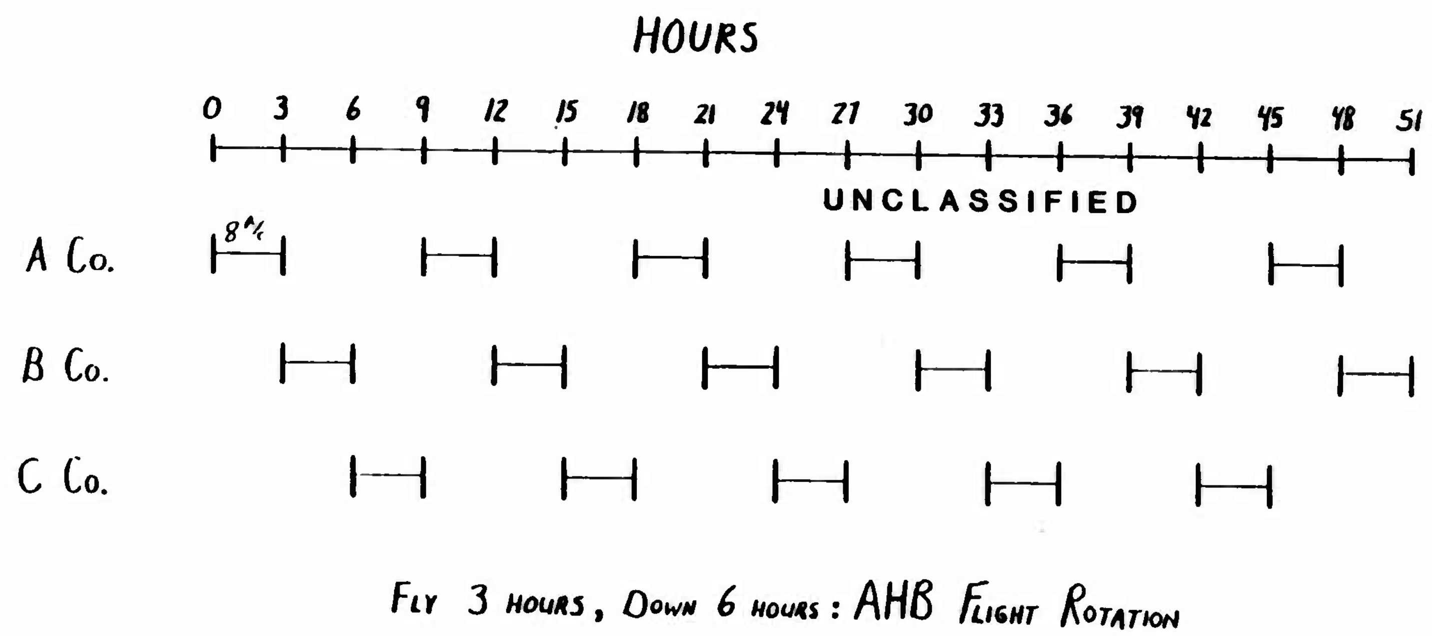

Figure T-1. (U) AHB 24-hour rotation.

		Flying-Hour Rates		
		/Day	/Month	/Year
Number of Aircraft in Company	8	8.0	240	2,880
	9	7.1	213	2,556
	10	6.4	192	2,304
	11	5.8	174	2,088
	12	5.3	159	1,908

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Figure T-2. (U) Sustained 192 blade hours/day.

(7) (U) Figure T-2 points out two significant things. Under today's TOEs which staff the attack companies at 11 aircraft, the flying-hour program in FM 101-20 is less than half of that needed to maintain 5.8 hours per aircraft per day. The second point is one of evolution of our TOEs. As we have put more capable aircraft in our units, we have reduced the numbers of aircraft required in the units (example, AH-64 staffing is less than AH-1 units). This reduction in numbers of aircraft necessitates increases in individual flying-hour rates to achieve the same mission requirements. From figure T-2, if LHX staffing is reduced from 11 to 10 aircraft, the flying-hour program must increase over 10 percent to sustain the minimum requirement.

(8) (U) The above analysis only holds for a combat asset like an attack battalion or cavalry squadron which must be on station (maintain contact with the enemy) as part of its mission. In this analysis, an increase in individual aircraft capability does produce a more effective fighting machine but the aircraft cannot afford to fly less since any decrease means time where contact is lost with the enemy. For utility or cargo aircraft where the mission is to transport troops or supplies, an increase in aircraft capability can directly reduce the flying-hour program. It is for this reason that the attack battalion and cavalry squadron were chosen as the basis for this analysis.

(9) (U) In light of figure T-1 and the present attack company organization, the flying-hour rate of 6 hours per aircraft per day was chosen for planning purposes in the LHX RAM analysis. This number allows for some increase over the minimum combat needs which would include administrative flights but more significantly it supports the analysis done in the Army Aviation Mission Area Analysis (AAMAA), the Army Aviation Personnel Requirements for Sustained Operations (AAPRSO) study, and the Maximum Daily/Helicopter Flying-Hour (MAX FLY) study.

(10) (U) A similar analysis has been done for the two air cavalry troops in the aerial reconnaissance squadron (ARS). By current doctrine, these units are assigned 12-hour responsibilities. They fight utilizing two 2-ship teams with an air battle captain (ABC) rotating on station with one 2-ship team while the main group goes back to rearm and refuel. Figure T-3 is a schematic of this type unit.

(11) (U) The flying-hour requirement that falls out for this unit is 114 blade hours per day for the squadron. Although significantly less than that required by the AHB, the squadron only has two air cavalry troops to meet this requirement. Figure T-4 is a breakdown of the flying-hour program based upon unit size similar to figure T-2 for the AHB. Under current staffing of 10 aircraft per troop, the individual aircraft requirement is:

Flight hours per aircraft per day = 5.7 hours.

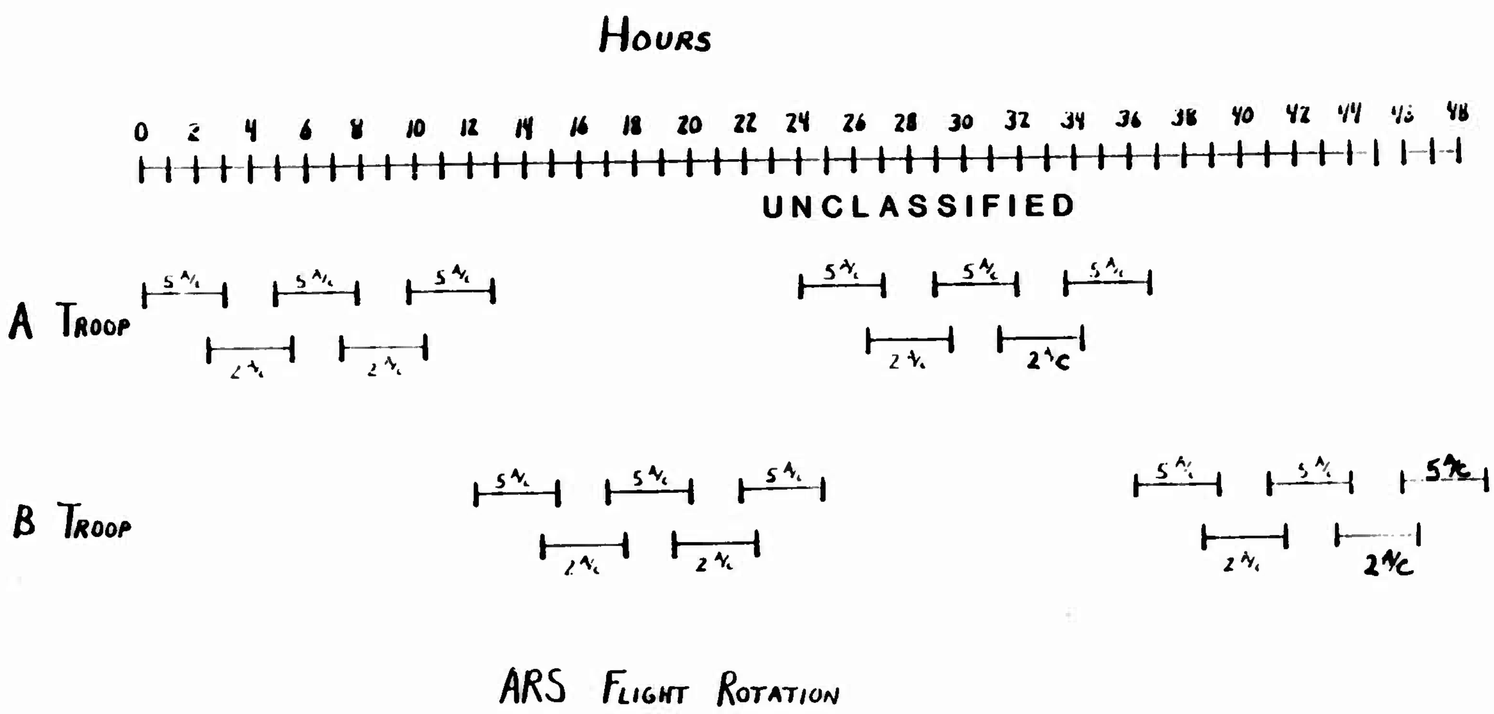

Figure T-3. (U) ARS flight rotation schematic.

	Flying-Hour Rates		
	/Day	/Month	/Year
Number of Aircraft in Company 7	8.14	244.3	2,931
8	7.13	213.8	2,565
9	6.33	190.0	2,280
10	5.7	171.0	2,052
11	5.18	155.5	1,865
12	4.75	142.5	1,710

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Figure T-4. (U) Sustained operations for cavalry.

f. (U) Manpower Requirements.

(1) (U) In order to determine the maximum maintenance burden that the LHX can sustain, an analysis of the manpower available at both aviation intermediate maintenance (AVIM) and aviation unit maintenance (AVUM) was performed. The assumptions of the analysis are as follows:

(a) (U) The manpower available to work on the total aircraft system includes all individuals in the grade of E-6 and below carrying a maintenance military occupational specialty (MOS). Those individuals that are responsible for maintaining more than one type aircraft (i.e., 35K) had their LHX-specific maintenance time prorated.

(b) (U) The productivity and direct time manpower authorization criteria (MACRIT) factors used came from AR 570-2.

(c) (U) The TOEs used in the analysis were:

1. (U) 01-185J400 for the AHB.

2. (U) 01-412X500 for the TAMC.

(d) (U) The aircraft in the AHB TOE are:

1. (U) 34 LHX-SCAT.

2. (U) 3 UH-60.

(e) (U) The aircraft and units supported by the TAMC are:

1 AHB	34 A/C (all LHX)
	3 A/C (non-LHX)
1 ARS	20 A/C (all LHX)
	4 A/C (non-LHX)
1 HHQ	6 A/C (all LHX)
1 TAMC	2 A/C (non-LHX)
2 CAC	30 A/C (non-LHX)
Totals	39 (non-LHX)
	60 LHX

(f) (U) The breakout of maintenance personnel from the AVUM and AVIM are found in figures T-6 and T-7 and are summarized in figure T-5 below:

	LHX (only)	All Aircraft	Non-LHX
AVUM (AHB)	86	19	7
AVIM (TAMC)	38	46	23

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Figure T-5. (U) Maintenance personnel.

(2) (U) Given the above assumptions, the following calculations were used to determne the maximum maintenance burden that could be sustained for the LHX in the AHB.

From AR 570-2:

2,500 man-hours per year = 6.8493 man-hours per day (productive)

AHB

	Auth	Non-LHX	LHX	Both
E-6				
66J30	1		1	
66T3F	1	1		
66V3F	1		1	
66Y3F	2		2	
67V30	3		3	
67Y30	7		7	
	15	1	14	0
E-5				
35K20	2			2
66V2F	1		1	
67T2F	1	1		
67T20	1	1		
67V2F	12		12	
67V20	3		3	
67Y20	8		8	
68B20	1			1
68D20	1			1
68G20	1			1
68J20	2		2	
68M20	1		1	
	36	2	27	7
E-4				
35K10	2			2
67T1F	1	1		
67T10	1	1		
67V10	5		5	
67Y10	10		10	
68B10	1			1
68D10	1			1
68F10	1			1
68G10	2			2
68J10	2		2	
68M10	3		3	
	27	6	10	11

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Figure T-6. (U) Maintenance personnel in AHB. (concluded on next page)

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	Auth	Non-LHX	LHX	Both
E-3				
35K10	5			5
67T10	2	2		
67V10	8		8	
67Y10	11		11	
68J10	3		3	
68M10	3		3	
	32	2	25	5

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Figure T-6. (U) (concluded)

TAMC

	Auth	Non-LHX	LHX	Both
E-6				
35P3F	1			1
66J3F	2		2	
66N3F	2	2		
66V3F	1		1	
66Y3F	1		1	
67N3F	1	1	7	
67V3F	1		1	
67Y3F	1		1	
68B30	2			2
68D30	1			1
68F30	1			1
68G30	1			1
	15	3	6	6
E-5				
35K20	1			1
35L20	2			2
35M20	2			2
35R20	1			1
66N2F	2	2		
66V2F	1		1	
66Y2F	1		1	
67N2F	1	1		
67N20	4	4		
67V20	2		2	
67Y20	2		2	
68B20	1			1
68D20	1			1
68F20	2			2
68G20	1			1
68H20	1			1
68J20	2		2	
68M20	2		2	
	29	7	10	12

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Figure T-7. (U) Maintenance personnel in TAMC. (concluded on next page)

	Auth	Non-LHX	LHX	Both
E-4				
35L10	2			2
35M10	1			1
67N1F	1	1		
67N10	5	5		
67V10	3		3	
67Y10	3		3	
68B10	3			3
68D10	1			1
68F10	2			2
68G10	1			1
68H10	1			1
68J10	2		2	
68M10	2		2	
	27	6	10	11
E-3				
35K10	1			1
35L10	4			4
35M10	2			2
35R10	2			2
67N10	7	7		
67Y10	4		4	
67Y10	5		5	
68B10	2			2
68D10	2			2
68F10	1			1
68G10	2			2
68H10	1			1
68J10	1		1	
68M10	2		2	
	36	7	12	17

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Figure T-7. (U) (concluded)

To convert this number to direct maintenance time, the direct/indirect maintenance factor of 1.4 resulted in:

6.8493 man-hours per day = 4.8923 maintenance man-hours per day (direct)

This number represents the actual direct maintenance hours that can be expected from an individual in a CAT I TOE unit on a daily basis. Using this factor and the maintenance personnel in the AHB, the following analysis resulted:

The portion of the maintenance manpower strength dedicated to the LHX:

Portion of LHX aircraft in the AHB = 34/37

From figure T-5, the total LHX manpower in the AHB becomes:

86 + 19 (34/37) = 86 + 17.46 = 103.46 AVUM personnel

These people can produce the following direct daily maintenance time:

(103.46) (4.8923) = 506.15 maintenance man-hours per day

Using the flying program previously developed results in the maximum daily maintenance burden at the AVUM level.

506.15/192 = 2.636 maintenance man-hours per flight hour

This is the maximum maintenance burden that AVUM can withstand and still support the stated flying-hour program.

(3) (U) It was also necessary to do a similar analysis for the TAMC to find that portion of AVIM that could be counted upon to support the LHX in the AHB. This was done using a similar approach.

The portion of LHX aircraft in the TAMC is 60/99. Using this number and the total LHX maintenance personnel in the TAMC and AHB resulted in the following manpower level:

38+(60/99) (46) = 65.87 LHX maintenance personnel

Since the TAMC had other LHX units to support, the portion of the LHX personnel for the AHB was:

34/60(65.87) = 37.33 personnel dedicated to AHB

37.33(4.8923) = 182.63 maintenance man-hours per day (direct)

182.63/192 = .9512 maintenance man-hours per flight hour at AVIM

This number becomes the maximum burden that AVIM manpower can withstand and still support the stated flying-hour program. Combining this with AVUM yields a total maintenance ratio:

MR = 3.587 maintenance man-hours per flight hour

(4) (U) By definition, the above maintenance ratio becomes the maximum maintenance burden for the LHX. It must be pointed out that it includes both on and off system maintenance. Although very little off system is done at the AVUM level, there presently remains a need to perform component repair at the AVIM level. The need to do off-system maintenance is counter to the 2-level maintenance effort discussed later but it does give an indication of what levels the maintenance ratio must achieve prior to realizing any manpower savings.

(5) (U) If the LHX becomes more manpower-intensive than this value, one of two things result. Either the force structure will have to be increased to support the additional manpower needs or the units will not be able to provide aviation support throughout the combat day. Neither of these alternatives are tolerable, thus the need to design for maintainability becomes a major driver in the LHX program.

g. (U) Logistic Support Concepts.

(1) (U) Due to the sophistication of the mission equipment package (MEP) and the new technologies that the LHX hopes to capture in the design, it is necessary to look beyond our current logistic concepts to see how we can more efficiently support this new system in the field. Initially, the LHX program hoped to capture any and all advances in support concepts. For this reason, the term "innovative support concepts" was initially used as the goal for the program. As the LHX evolved, however, a program developed by the Air Force, "2-level maintenance," came into vogue and was soon attached to the LHX as a "must have" program.

(2) (U) Two-level maintenance, as envisioned by the USAF, is a system of maintenance that does away with the intermediate level of component repair and sends components that require maintenance back to a depot-type facility. This system eliminates the need to carry sophisticated test and repair gear along with trained operators around the forward battlefield. As the USAF put this program together in "Fighter Avionics Supportability Demonstration" by MAJ Doc Doherty, USAF, it was based upon cost and reliability of the individual boxes or LRUs. If the cost was low enough, less than $10/removal free operating hour and the reliability was high enough, at least 2,000 hours mean time between removal, then the 2-level program is a viable option.

(3) (U) The 2-level maintenance concept is not new to the Army, it is just that we have never labeled it as such. Currently, the UH-1 has components such as the transmission that fall under 2-level maintenance. There is no intermediate maintenance performed on Huey transmissions. If there is a problem with a UH-1 transmission, it is removed and replaced with a good one.

Meanwhile, the faulty transmission is returned to a depot facility for repair. This constitutes a 2-level maintenance program and it is that type of maintenance that is the "goal" of the LHX program.

(4) (U) The Black Hawk maintenance philosophy was one of "fix forward." The fallout of this approach was that many components were designed such that they also fell into the 2-level definition of maintenance. So while the term 2-level is new, it certainly is not a new maintenance philosophy.

(5) (U) It is the opinion of the user, the Aviation Center, and the Aviation Logistics School, that the goal of 2-level maintenance is a good one but as pointed out by MAJ Doherty in his paper, it does not work for all components. As we try to make the LHX an efficient, effective fighting machine, its logistic support concept should be the most cost-effective one in terms of combat capabilities. It should not be one that tries to design a system around a 2-level maintenance system just to prove that we can do it. If the LRU reliabilities are high enough and the diagnostics allow rapid identification of faulty components, then a 2-level system of maintenance will be a natural fallout of the design.

(6) (U) The USAF has recently found that 2-level maintenance is not the savior they hoped for. In a recent conference on aviation maintenance in March 1985, the USAF equivalent to our DCS for logistics, stated that in many cases they have found that the 2-level approach actually reduced their readiness rates. This occurred where they failed to look at the time and tools to accomplish component repair at the intermediate level and just transferred the task to a depot. The fallout of the USAF's recent analysis is that they now feel that cost-effective in terms of readiness is the proper parameter to evaluate the location of maintenance tasks and 2-level maintenance is an over simplification. They have come full circle and now talk "innovative support" in terms of doing what is necessary to increase readiness rates and reduce O&S costs.

h. (U) Partially Mission Capable (PMC).

(1) (U) The LHX is the first airframe that has allowed PMC to be designed into the architecture of the aircraft system. A great deal of the MEP for this airframe will be software that will have functional redundancies built into the programing. This will allow some degradation of the combat capabilities of the aircraft without having a total loss of any of the mission capabilities. These degradations might include more time to process data or the inability to utilize the full range capabilities of a weapon system or target acquisition system. Although these losses equate to a non-FMC aircraft, they still let the pilot perform all his missions although he is in a degraded mode. In terms of crew capabilities, the PMC condition will necessitate a higher workload for the pilot and some overall degradation of the combat effectiveness of the LHX system.

(2) (U) The problem with the analysis of a PMC criteria is the lack of a yardstick to quantify this parameter. In the past, components on an aircraft have either worked or failed to work. We have never had the opportunity or the means to address PMC in the acquisition cycle.

(3) (U) As a first cut at defining PMC, a series of matrices was developed that looked at the mission, MEF, and the hardware that are required to perform a specific MEF. Copies of these matrices appear in figures T-8 and T-9. For each mission, the essential equipment was designated with a check mark in the appropriate box. Although this matrix will undoubtably change before the LHX goes to test, it does allow one to access each mission and what losses constitute a failure for that mission. Conversely, for the loss of any piece of hardware, it is possible to determine which mission can still be performed by the aircraft.

(4) (U) The matrices do not produce a PMC requirement but they do allow the assessment of the overall aircraft mission capabilities during the testing of the airframe and systems. Copies of these matrices accompany the failure definition/scoring criteria (FD/SC) which appear in annex A of this report. The result of scoring these matrices will be individual mission reliabilities. To produce a requirement for individual mission reliabilities would be counterproductive since it would presuppose that we could accurately predict the frequency and need for each of the stated missions. It was for this reason that the parameter MAF was selected earlier as it rolls all the mission capabilities into one parameter. The matrix approach will, however, give the decision maker a very useful tool in evaluating the LHX during testing.

i. (U) <u>R&M Programs for the LHX</u>. There are a number of programs and strategies that must be included in LHX design in order to capture the technologies that will give the Army a highly reliable, combat-ready asset. These programs were initially documented in the TOD report but it is necessary to again specify the programs and reaffirm their necessity to the LHX. There have been significant changes in the LHX program since the system attributes document (SAB) was published. These changes have included cuts in the crew size and reductions in the MEP that is the life blood of this system. In order to preclude these cuts from degrading the overall combat readiness, it is necessary to separate these key R&M programs that should be drivers for the overall program. These key issues, which will be discussed individually, include functional partitioning, testability, software reliability, and software management.

(1) (U) Functional partitioning.

(a) (U) Functional partitioning is an approach to avionics and software design that separates the individual functions within a component and isolates them to modules. This is not the most cost-effective approach from a design standpoint, but from testability and repair, it offers many advantages. First modules would be individually cheaper than the total component they represent. The lower cost of stockage will permit PLL stockage which will allow field units to replace modules precluding the necessity to send the entire component back for repair. Because the individual modules are smaller and perform limited functions, their individual reliabilities would be significantly higher than the parent component. This high reliability coupled with the lower cost drives the modules toward either throw-away (one level) or

UH SCAT MATRIX WITH ALLOWABLE DEGRADATION.
X Indicates the Minimum Essential Equipment the Aviation Center feels is necessary for a commander to launch a ship for the mission indicated

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MISSION PROFILE # / MEF	#22 CAAO	#20 AMP/ASLT	#26 OFF AIR	#19 SNEAD	#17 DEEP STK	#13 ANTI P/M	#12 ANTI AR	#14 SUP STK	#45 HPC SVY	#23 AIR/AIR	#16 SECURITY	#18 RACO
INTERNAL HOIST												
TROOP INSERTION												
INTERNAL CARGO												
WEAPONS SYSTEM.		X	X	X	X	X	X	X	X	X	X	X
TARGET ACQUISITION	X	X	X	X	X	X	X	X		X	X	X
ASE	X	X	X	X	X	X	X	X	X	X	X	X
NAVIGATION	X	X	X	X	X	X	X	X	X	X	X	X
COMMUNICATE	X	X	X	X	X	X	X	X	X	X	X	X
FLY ADEQUATELY	X	X	X	X	X	X	X	X	X	X	X	X
MISSION EQUIP. PKG												
COMMO. UHF/AM												
SINGCARS 40W FM	X	X	X	X	X	X	X	X	X	X	X	X
HF/SSB	X		X	X	X	X	X	X		X	X	
UHF AM(HQ)	X	X	X	X	X	X	X	X	X	X	X	X
INTERCOM	X	X	X	X	X	X	X	X	X	X	X	X
WIDE BAND SECURE	X	X	X	X	X	X	X	X	X	X	X	X
NARROW BAND SECURE	X		X	X	X	X	X	X		X	X	
I.D. SECURE IFF	X	X	X	X	X	X	X	X	X	X	X	X
PJH CAPABILITIES	X	X	X	X		X	X		X	X		X
DIG.MAP W/TER.CORR	X	X	X	X	X	X	X	X	X	X	X	X
VELOCITY SENSOR	X	X	X	X	X	X	X	X	X	X	X	X
GPS	X	X	X	X	X	X	X	X	X	X	X	X
RADAR ALTIMETER	X	X	X	X	X	X	X	X	X	X	X	X
INERTIAL REF. SYS.		X	X	X	X	X	X	X		X		X
3 D AIR DATA SENS.		X	X	X	X	X	X	X		X		X
RADAR WARN. RCVR.	X	X	X	X	X	X	X	X	X	X	X	X

Figure T-8. (U) MEF versus mission MATRIX SCAT. (concluded on next page)

LASER WARNING RCVR	x	x	x	x	x	x	x	x	x	x	x	
RADAR JAMMER			x	x	x	x	x	x		x		
INFRARED JAMMER	x	x	x	x	x	x	x	x	x	x	x	x
OPTICAL SENSOR	x	x	x	x	x	x	x	x	x	x	x	x
OPTICAL JAMMER				x	x			x		x		
TGT.ACQ. EOTADS IR	x	x	x	x	x	x	x	x		x	x	x
EOTADS DAY T.V.	x	x	x	x	x	x	x	x		x	x	x
MILL. WAVE RADAR	x	x	x	x	x	x	x	x	x	x	x	x
DISPLAYS(H.M.D.	x	x	x	x	x	x	x	x	x	x	x	x
NVPS	x	x	x	x	x	x	x	x	x	x	x	x
PANEL DISPLAY	x	x	x	x	x	x	x	x	x	x		x
VOICE CONTROLS	x	x	x	x	x	x	x	x	x	x	x	
KEYBOARD	x	x	x	x	x	x	x	x	x	x	x	x
FDLS				x	x		x	x	x	x		x
DATA LOAD/VERIFY	x	x	x	x	x	x	x	x	x	x	x	x
FLT. CNTL. SYS.	x	x	x	x	x	x	x	x	x	x	x	x

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Figure T-8. (U) (concluded)

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LHX-U MEF MATRIX WITH ALLOWABLE DEGRADATION.

X Indicates the Minimum Essential Equipment the Aviation Center feels is necessary for a commander to launch a ship for the mission indicated

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MISSION PROFILE # / MEF	#44 CAR	#27 CMD RLY	#42 COURIER	#2 C3 LIASN	#35 SOF INFIL	#34 TEAM INS	#46 MSL.SPT	#10 INSP.FOR	#43 RESUPPLY	#36 AMPP/AGT
INTERNAL HOIST	x				x	x	x	x		
TROOP INSERTION	x		x	x	x	x	x	x		x
INTERNAL CARGO			x		x	x	x	x	x	x
EXTERNAL CARGO								x	x	x
ASE	x	x	x	x	x	x	x	x		x
NAVIGATION	x	x	x	x	x	x	x	x	x	x
COMMUNICATE	x	x	x	x	x	x	x	x	x	x
FLY ADEQUATELY	x	x	x	x	x	x	x	x	x	x
MISSION EQUIP. PKG										
COMMO. UHF/AM										
SINGCARS 40W FM	x	x	x	x	x	x	x	x	x	x
HF/SSB					x	x		x		
UHF AM(HQ)	x	x	x	x	x	x	x	x	x	x
INTERCOM	x	x	x	x	x	x	x	x		x
WIDE BAND SECURE	x	x	x	x	x	x	x	x		x
NARROW BAND SECURE	x	x		x	x	x		x		
I.D. SECURE IFF	x	x	x	x	x	x	x	x	x	x
DJH CAPABILITIES										x
DIG.MAP W/TER.CORR	x				x	x	x	x		x
VELOCITY SENSOR	x	x	x		x	x	x	x		x
GPS	x	x	x	x	x	x	x	x	x	x

Figure T-9. (U) MEF and mission MATRIX utility. (concluded on next page)

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RADAR ALTIMETER	x	x	x		x	x	x	x		x
INERTIAL REF. SYS.										
3-D AIR DATA SENS.										
RADAR WARN. RCVR.	x				x	x	x	x		x
LASER WARNING RCVR	x				x		x	x		x
RADAR JAMMER					x			x		x
INFRARED JAMMER					x			x		x
OPTICAL SENSOR					x			x		x
OPTICAL JAMMER					x			x		
TGT. ACQ. EOTADS IR										
EOTADS DAY T.V.										
MILL. WAVE RADAR	x				x			x		
DISPLAYS(H.M.D.					x			x		
NVPS	x	x	x	x	x	x	x	x	x	x
PANEL DISPLAY	x	x	x	x	x	x	x	x	x	x
VOICE CONTROLS					x			x		x
KEYBOARD	x	x	x	x	x	x	x	x	x	x
FDLS					x					
DATA LOAD/VERIFY	x	x	x	x	x	x	x	x	x	x
FLT. CNTL. SYS.	x	x	x	x	x	x	x	x	x	x

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Figure T-9. (U) (concluded)

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2-level maintenance. An added benefit is that many modules, if properly partitioned, could be used to support more than one component. Thus, the same processing module might be interchangeable in UHF, VHF, and FM radios. This would significantly cut down on the number of separate lines in PLL while still serving the same number of avionic components.

(b) (U) The key to capitalizing on this new approach in avionics is to demand it in the design. As stated earlier, this is not a cheap option from a cost/design standpoint but the long-term benefits make it mandatory. Without this program incorporated into the entire MEP, the overall weight will increase, the cost of spares will increase, the life cycle cost will go up, and from a maintainability standpoint, the aircraft will require more maintenance.

(2) (U) Testability/Diagnostics.

(a) (U) Along with functional partitioning, another essential program within the LHX design is a requirement for improved testability and diagnostics. Although this program is thought to be a maintainability-driven need, it is really a reliability program. Currently, across the Army, Navy, and Air Force our false removal rates are running about 40 percent. This means that 4 of every 10 components removed from an aircraft are checked and found okay on the test stand. We can ill afford this failure rate if any improvements are to be gained in the areas of mission reliability and combat readiness.

(b) (U) The goal of the diagnostic program should be less than 5-percent false removals. These gains are possible through onboard BIT that is part of the software in the MEP. The pilot will be cued not only that he has lost an MEF but the fault will be isolated down to the module level. This fault location will be verified by maintenance personnel either through the maintenance data recorder or some means of fault verification prior to any component removal. By achieving a goal of not more than 5 percent false removal, the LHX will have made a two-fold gain. First, the maintenance manpower required for the false removals, test verfication, and return to the supply system will be saved. And second, there is a significant reliability improvement that can be achieved without a design change to any component.

(c) (U) As in any other R&M program, the testability and diagnostics issue is not cheap. Like the old saying, however, testability amounts to "pay me now or pay me more later." Without sufficient money and effort in this program, any reliability improvement in component design takes a 40-percent cut when it gets degraded by the false removal rate. Also, any efforts to streamline the logistic support get bogged down with false removals in the pipeline that increases the requirement for spares and increase the turnaround time for component repair.

(3) (U) Software reliability.

(a) (U) Software, both onboard and external, is the key that sets the LHX apart from current aircraft. Many of the current pilot duties will be reduced through effective use of computer programing (software). Maintenance tests, specifically diagnostics, are expected to be significantly reduced through fault isolation down to module level. These advances, which are all part of the ARTI effort, have their basis in software and the management of information within the airframe.

(b) (U) Classicly, reliabilities have always been thought of as those numbers inherent with hardware components. This approach is no longer valid with the amount of information that must be processed onboard the LHX. A faulty software program can have catastrophic results within the airframe as the loss of major pieces of hardware. For this reason, it is imperative that the programing for the aircraft is managed in such a way that the software does not have any loose ends in it.

(c) (U) The writing and management of software is not an endeavor that the major airframers are prepared to deal with. They are hardware men who build and fly airframes. It will be necessary for each of the primes to either hire a cell of software managers or team with a contractor who is already in the business. Considering that approximately 57 percent of the cost of the LHX will be tied up in the MEP, it almost appears that the airframers are no longer the primes but rather just another subcontractor. How the software is managed by each of the primes will be a major discriminator. Any change in design or hardware will require a software rewrite. This rewrite can be a bookkeeping drill if the software is properly documented or it can result in a monumental effort. Whatever the means, the key is that without software that can be counted on to perform its job, the hardware in the aircraft is useless.

j. (U) Reliability Impact on One-Man Cockpit.

(1) (U) One of the goals of the LHX program has been the design of a one-man cockpit. From a technological standpoint, the capabilities are all out there to allow a single man to functionally perform a combat mission. This approach, however, seems to ignore some of the realities of life when it comes to dealing in a combat environment. There is nothing clean and neat in combat that allows one to break a mission down into blocks of time that can be readily accomplished by high-tech software and hardware.

(2) (U) The major drawback of the one-man design is the fact that we are violating good RAM design practices. We are building a $6 million aircraft with a single point failure mode. There are redundancies built into all the mission equipment but the pilot still stands out as a nonredundant component that is 7.62mm vulnerable.

(3) (U) The LHX is the major aircraft to be employed with the light division. If our doctrine is valid, these divisions will be employed in areas that are "lightly" defended, no heavy armor like Grenada or the Falklands. In these type conflicts, pilots can be expected to encounter a great deal of small arms up to and including 12.7mm. We are designing the LHX to counter the missile, radar, and IR threats but little can be done about the enemy with an unaided 7.62mm or 12.7mm weapon. If history is any indication, then our

experiences in Grenada might set the stage for the type of action our light divisions might expect. If this is true, then we should expect to be hit by a great deal of small arms fire. The LHX, which is even more ballistically tolerant than the Black Hawk, should be able to survive the small arms with little or no problem. That, unfortunately, holds only for the aircraft; it does not include the pilot. Of the five Black Hawks that took large amounts of small arms fire in Grenada, three of those aircraft had either the pilot or copilot wounded. It does no good to have a survivable aircraft when the pilot cannot fly the ship safely home. Not only do we lose the aircraft but we also lose a pilot that might have been able to return to combat after his wounds were tended to.

(4) (U) To summarize, technology may be able to give us the capabilities to fly a one-man aircraft but in a combat environment men and material are precious items, all together too precious to send to combat with a single point failure mode.

T-3. (U) ASSUMPTIONS. This RAM/Logistics TOA includes several assumptions which were necessary in order to develop the operational analysis for the LHX. Since these assumptions are an integral part of the foundation of this analysis, they deserve as much attention as the results of this analysis. If current doctrine is changed or one of these assumptions are found unrealistic, then the analysis results must change to reflect the new input.

a. (U) Eight Aircraft Per Attack Team. In support of current doctrine, all attack teams in the AHB were comprised of eight aircraft. Three of these aircraft were in the scout role and five were in the attack role. Also, by current doctrine, the ARS consisted of flights alternating between five aircraft and two aircraft. In the flights of five aircraft, there were two teams of two aircraft, each consisting of one attack and one scout helicopter. These four aircraft work with the air battle captain in the fifth helicopter. The flights of two aircraft consisted of one helicopter in the attack role and the other in the scout role. No cross mixing was allowed between company-sized units so all aircraft had to come from the same company or troop. No distinctions were made between scout and attack aircraft other than their role on the battlefield, thus all aircraft in the company or troop were considered to be identically outfitted. A more detailed discussion of these assumptions for the AHB and ARS is given in chapters T-5 and T-6.

b. (U) Twenty-four-Hour Fighting Capability. All scenarios and flying-hour programs were developed based upon fighting 24 hours per day. This fighting capability did not include standby time or maintenance downtime but only included actual flight time. This is a rather stringent requirement based upon old planning factors for combat; however, if Army aviation is to afford 24-hour coverage within the division, then a minimum program exists which is 192 blade hours per day for the AHB and 114 blade hours per day for the ARS.

c. (U) Constant Maintenance Manpower. The third major assumption in this analysis dealt with the LHX maintenance manpower. Because there were so many other variables in the analysis, it was felt that manpower should be held constant in order to establish a baseline. Projected LHX TOEs were used to determine the total manpower support available for the LHX. This value was held constant despite the proposed increases in the flying-hour programs. The result was that the maintenance ratio that fell out of the analysis was the maximum value that could be afforded without any increase in personnel strength. Likewise, any lower value would equate to a reduction in the number of personnel necessary to support the LHX.

T-4. (U) LIMITATIONS. There are three major limitations associated with this RAM/Logistics TOA. These limitations impact very significantly on the results of this analysis, but their use was unavoidable.

a. (U) The first major limitation is the fact that in analyzing aircraft maintenance downtime, a realistic value for administrative and logistics downtime (ALDT) is required but is very difficult to obtain. This analysis is limited to ALDT values which are best guesses and the values cannot be enforced by contracts. The ALDT value is a big driver of the RAM parameters so the inaccuracy of this value must be noted.

b. (U) The flying-hour program established for this analysis also presents limitations. As stated in the assumptions, the AHB combat flight time is based on 192 blade hours for one combat day. During periods of wartime surge conditions, this minimum value of 192 blade hours would not reflect the actual AHB blade-hour requirements. This is because more than one team of eight aircraft would be needed in the air at the same time from a given battalion. The implications of this limitation are that the RAM values established are based only on the constant flying-hour programs for the AHB and ARS, not considering combat surge conditions.

c. (U) Current doctrine imposed a third major limitation upon this analysis by requiring specific numbers of aircraft in the AHB and ARS teams. If flexibility existed in this area, the trade-offs for more or less aircraft per team could be examined in depth. When compared with the eight-aircraft team (three scout; five attack) for the AHB, a six-aircraft team (two scout; four attack) from the same size company offers less stringent RAM requirements for the unit but also less combat effectiveness or stowed kills. The same basic issue holds true for the ARS. These trade-offs were not investigated for this analysis due to the need to remain consistent with current aviation doctrine.

T-5. (U) METHODOLOGY.

a. (U) Mission Analysis.

(1) (U) In order to remain consistent in developing the light helicopter family (LHX) reliability, availability, and maintainability (RAM) parameters, the attack helicopter battalion (AHB) was used as the basis for the mission analysis. A similar analysis for the reconnaissance squadron is included. Within the constraints of the flying-hour program and the manpower analysis developed earlier, the next logical step in developing the LHX RAM trade-offs is the development of a reliability parameter in terms of a mission success rate and sustainability in combat.

(2) (U) The LHX in this AHB analysis will be flown in the 3/5 mix associated with the attack helicopter doctrine. Each of the eight LHX aircraft will be of similar configuration and all come from one company to keep unit integrity. The unit size was varied from 11 to 10 aircraft for analysis, and a mission duration of 3 hours was used as a nominal mission length.

(3) (U) To develop the mission reliability parameters for the LHX, it is necessary to look beyond the single-ship approach and consider the attack team. This is done to examine the aircraft in its standard operational environment and to effectively utilize the adverse weather, day/night capability of this new system. Also, the time required to relaunch an attack team must be considered since the Army will utilize the aircraft for multiple daily missions as pointed out previously in the flying-hour program and in the recent Maximum Daily Helicopter Flying Hour (MAX FLY) and AARAPSO studies.

(4) (U) Knowing that we have daily multiple mission requirements, it is possible to construct a rather simple scenario to produce a time line of a mission day for the AHB and define the terms that will be used in the analysis. Figure T-10 illustrates consecutive missions during the normal combat day and the available maintenance time. Figure T-11 is the same type graph, but it gives each company a 6-hour responsibility made up of two 3-hour blocks. This is presented as a more realistic scenario since it takes into account crew rest and has larger blocks of maintenance time available to the unit. Unfortunately, this scenario is a RAM driver since it necessitates a relaunch during each 6-hour block to cover the second 3-hour mission.

(5) (U) From figure T-10, the available maintenance time is 6 hours between missions and 15 hours between subsequent missions (the time from the end of one mission to the start of the second mission). The significance of this larger maintenance period is that it indicates the amount of time available to fix any aircraft that is not utilized for any one mission. The similar numbers for the 6-hour scenario, figure T-11, are 12 hours and 30 hours.

(6) (U) Given the two scenarios, one can now determine the parameters that effect the turnaround or repair time for downed aircraft during the nonflying periods. There are really only two significant factors that effect the turnaround time of an aircraft and these are mean time to repair (MTTR) and administrative and logistics downtime (ALDT). MTTR includes the clock time to perform all direct maintenance and ALDT includes any delay time for parts or administration. Considered together, MTTR and ALDT constitute all the "nonavailable" time for an aircraft system and are associated with not mission capable maintenance (NMCM) and not mission capable supply (NMCS), respectively.

(7) (U) These terms must be determined before any sustainability analysis can be performed. From coordination with the materiel developer, it was determined that a value of:

MTTR = 1.0 hours

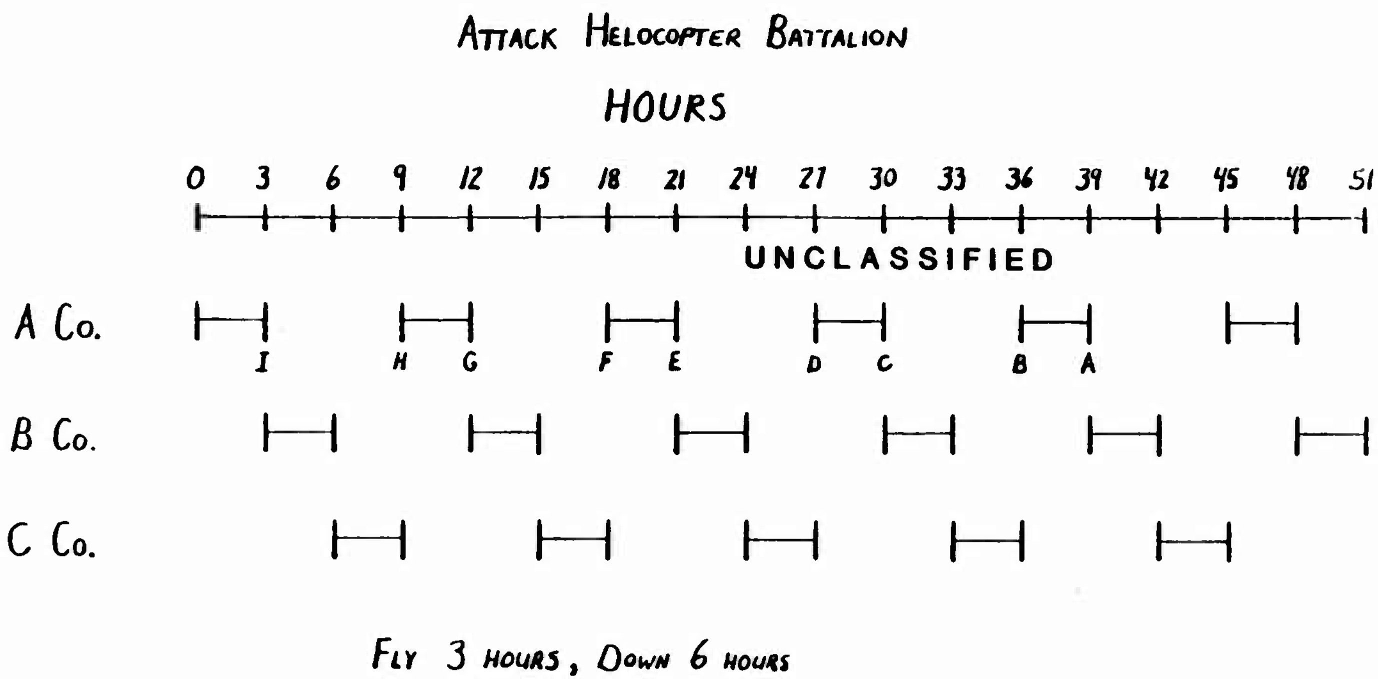

Figure T-10. (U) Fly 3 hours, down 6 hours.

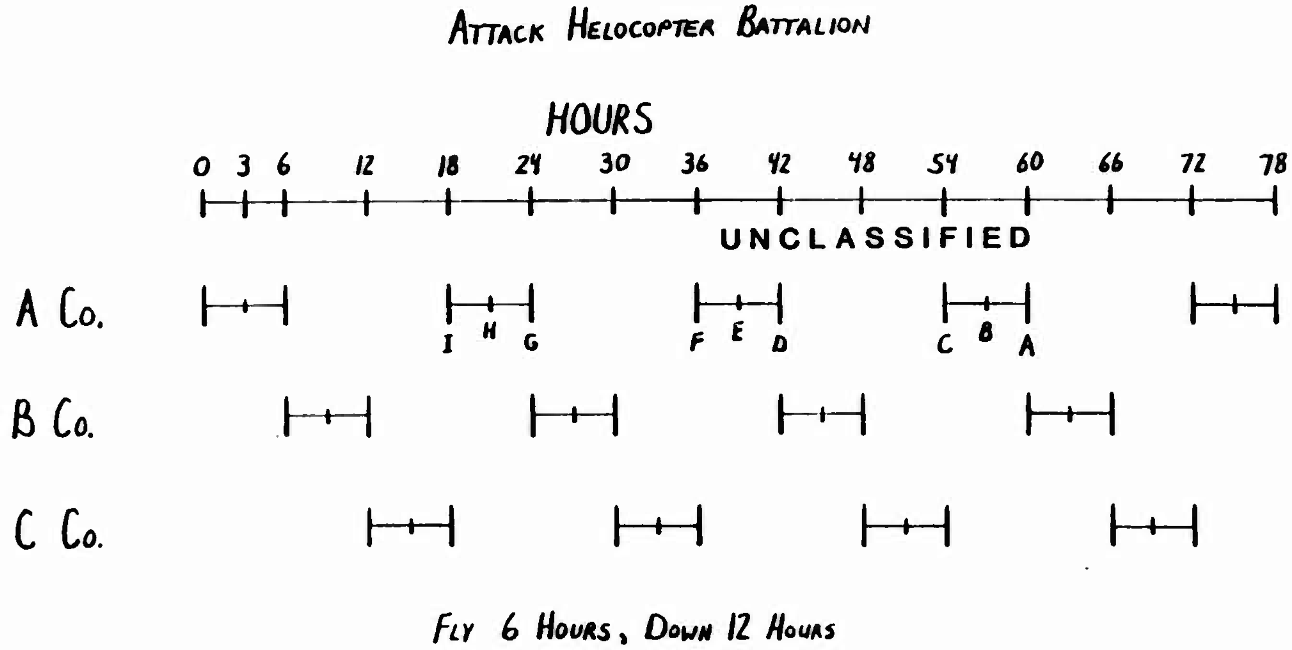

Figure T-11. (U) Fly 6 hours, down 12 hours.

as shown in the trade-off determination (TOD) report is an achievable, low risk number and was thus used to develop the trade-off analysis. The value for ALDT was developed by the US Army Aviation Systems Command (AVSCOM) and appears in annex T-II. The value used was:

ALDT = 5.0 hours.

b. (U) Probability of Repair.

(1) (U) Given the previous values for MTTR and ALDT, a probability function was developed to determine the probability of repair given that a failure has occurred. This was done by making the following assumptions:

(a) (U) Both ALDT and MTTR follow the exponential probability function.

(b) (U) Combined probability distributions can be calculated using the convolution theorem.

(c) (U) The resultant equation is:

P = (Z2 * EXP(-Z3/Z2) * (-1 + (Z1/Z2) * EXP (-Z3/Z1 + Z3/Z2))
+ (Z2 - Z1))/(Z2 - Z1)

where

Z1 = MTTR

Z2 = ALDT

Z3 = Maintenance time since maintenance was initiated

P = Probability of repair

It is now possible to construct a time line of this probability function that could be used to predict the percentage or probability of repair for any given failure. This curve appears on figure T-12.

(2) (U) With repair times and a scenario defined, it is now necessary to correctly define the reliability parameters that must be used to define the maintenance burden and the mission success rate.

(3) (U) The first parameter selected is essential maintenance actions (EMA). This term includes any maintenance action that causes an aircraft to be in a partial mission capable (PMC) or not mission capable (NMC) condition, and it includes any loss of a mission essential function (MEF) as defined in the failure definition (FD)/scoring criteria (SC) Annex T-I of this report. It is any maintenance action that must be performed prior to launch of the aircraft. Any incident that causes an aircraft to be PMC for any mission is considered an EMA even though the aircraft can still launch and perform some of its assigned missions. The reason this parameter was selected is that it captures the maintenance burden that is required to keep the aircraft in a fully maintenance capable (FMC) condition.

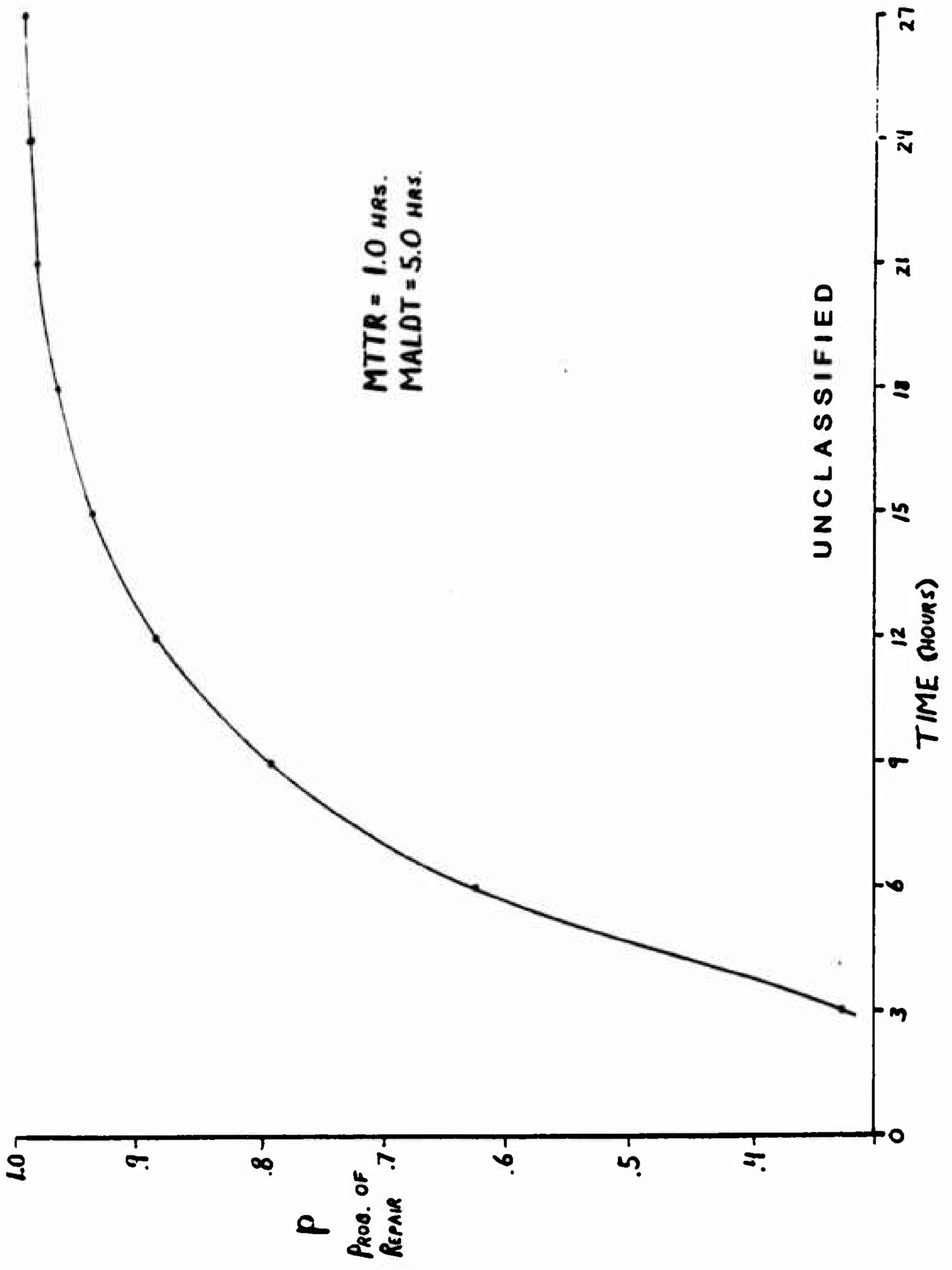

Figure T-12. (U) Probability of repair for any given failure.

(4) (U) The second parameter selected is mission-affecting failure (MAF). Like EMA, this term is an operational term but it is a subset of EMA since it is not as restrictive. First, an incident is considered a MAF only if it is discovered during mission time, thus a PMC or NMC incident discovered during scheduled maintenance is only an EMA and not a MAF. Secondly, the loss redundant path during mission time that does not effect the capabilities of the aircraft is not an MAF, but it is still an EMA if it must be corrected prior to relaunch. In this manner, the maintenance cost or burden to correct the redundant path is captured, but the mission success rate is enhanced due to redundancies.

T-6. (U) ANALYSIS/RESULTS.

a. (U) Sustainability Analysis for LHX Attack Helicopter Battalion (AHB).

(1) (U) With all the parameters defined, it is now possible to return to the scenarios and determine the minimum requirements necessary to sustain com-bat operations. In reviewing the two scenarios, it is evident that only one, the 6-hour mission block, is practical since the 3-hour mission block does not allow sufficient crew rest to sustain the scenario beyond 12 hours. However, since the 3-hour block would be the less stringent from the standpoint of a RAM driver, it is initially used to define the sustainability parameter (EMA).

(2) (U) Under proposed LHX tables of organization and equipment (TOE), the AHB will have 11 scout-attack (SCAT) aircraft per company. This means that at any given time when a mission could be launched, the company can have no more than three aircraft down for parts or maintenance caused by an EMA.

(3) (U) Selecting a random mission launch, point B, in figure T-10, it is possible to calculate the number of aircraft that would be unrepaired (i.e., not FMC) at that point in the time line. For each of the previous mission launches within a company, there is a specific period of maintenance time available for aircraft which fail, causing an EMA. This maintenance time is used with figure T-12 to determine the probability of nonrepair for aircraft which fail during each of these previous launches. Figure T-13 depicts the various times and probabilities of repair and nonrepair associated with the 3-hour mission block scenario.

(4) (U) By multiplying the probability of nonrepair for each of the previous missions, with the number of failures per mission, the expected number of unrepaired aircraft can be determined. This expected number of unrepaired aircraft for each of the previous missions can be summed together to obtain the total number of aircraft unrepaired at point B on the time line. The number of failures per mission in this scenario is:

$$\text{number of failures/mission} = \frac{\text{(8 aircraft) (3 flight-hours)}}{\text{mean time between failures (MTBF)}}$$

Start of Mission (B)

Point	Maintenance Time from Point (hours)	Probability of Repair	Probability of Nonrepair
C	6	.6243	.3753
E	15	.9378	.0622
G	24	.9897	.0103
I	33	.9983	.0017

Immediate Relaunch of Mission (A)

Point	Maintenance Time from Point (hours)	Probability of Repair	Probability of Nonrepair
A	0	0.0	1.0
C	9	.7934	.2066
E	18	.9658	.0342
G	27	.9944	.0056
I	36	.9991	.0009

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Figure T-13. (U) Three-hour mission blocks for AHB.

(5) (U) Since the maximum number of unrepaired (not FMC) aircraft in this scenario, must be three the following equation can be developed and solved for MTBF:

$$(.3753)\frac{(8)(3)}{\text{MTBF}} + (.0622)\frac{(8)(3)}{\text{MTBF}} + (.0103)\frac{(8)(3)}{\text{MTBF}} + (.0017)\frac{(8)(3)}{\text{MTBF}} = 3 \text{ aircraft}$$

MTBF = 3.6 hours.

(6) (U) Since this analysis considers all maintenance actions, the reliability or sustainability parameter is the mean time between essential maintenance actions (MTBEMA), thus:

MTBF = MTBEMA = 3.6 hours.

(7) (U) A similar analysis done for the 6-hour mission blocks is shown in figure T-14. For this analysis, it is not the first launch at C (figure T-11) that is critical, but it is the second launch at B that is the RAM driver. As seen (figure T-14), point B yields a:

MTBEMA = 8.7 hours.

Start of Mission (C)

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Point	Maintenance Time from Mission (hours)	Probability of Repair	Probability of Nonrepair
D	12	.8866	.1134
E	15	.9377	.0623
G	30	.9969	.0031
H	33	.9983	.0017

$$(.1134)\frac{(8)(3)}{\text{MTBF}} + (.0623)\frac{(8)(3)}{\text{MTBF}} + (.0031)\frac{(8)(3)}{\text{MTBF}} + (.0017)\frac{(8)(3)}{\text{MTBF}} = 3$$

MTBF = 1.4 hours

Start of Mission (B)

B	0	0.0	1.0
D	15	.9378	.0622
E	18	.9659	.0341
G	33	.9983	.0017
H	36	.9991	.0009

$$(1.0)\frac{(8)(3)}{\text{MTBF}} + (.0622)\frac{(8)(3)}{\text{MTBF}} + (.0341)\frac{(8)(3)}{\text{MTBF}} + (.0017)\frac{(8)(3)}{\text{MTBF}} +$$

$$(.0009)\frac{(8)(3)}{\text{MTBF}} = 3$$

MTBF = 8.7 hours

Immediate Relaunch of Mission (A)

A	0	0.0	1.0
B	3	.3264	.6736
D	18	.9658	.0342
E	21	.9813	.0187
G	36	.9991	.0009

$$(1.0)\frac{(8)(3)}{\text{MTBF}} + (.6736)\frac{(8)(3)}{\text{MTBF}} + (.0342)\frac{(8)(3)}{\text{MTBF}} + (.0009)\frac{(8)(3)}{\text{MTBF}}$$

MTBF = 13.3 hours

Figure T-14. (U) Six-hour mission blocks for AHB.

(8) (U) In order to show the trade offs associated with the number of aircraft allotted in the AHB units by the LHX TOE, the previous analysis was performed using a unit strength of 10 SCAT aircraft. The analysis is exactly the same as the previous analysis, until paragraph 6a(5). With 10 aircraft, the maximum number of unrepaired aircraft (not FMC) is two. The results of this 10-aircraft unit analysis were:

MTBEMA = 5.4 hours (3-hour mission blocks)

MTBEMA = 13.8 hours (6-hour mission blocks)

(9) (U) The previously developed values for the reliability parameter MTBEMA can now be compared to determine part of the trade offs involved with changing the number of aircraft in the LHX AHB units. For both the 3-hour and 6-hour mission block scenerios the 10 aircraft unit required a 50 percent higher MTBEMA. This demonstrates that there is a very significant increase in required aircraft reliability, associated with decreasing by a single aircraft the number of aircraft allotted to each company in the AHB.

(10) (U) Figure T-15 summarizes the sustainability trade-offs for the LHX unit size.

Number A/C per company	MTBEMA	
	3-hour scenario	6-hour scenario
11	3.6	8.7
10	5.4	13.8

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Figure T-15. (U) AHB unit size.

b. (U) Sustainability Analysis for LHX Aerial Reconnaissance Squadron (ARS).

(1) (U) The LHX ARS consists of 2 troops of 10 helicopters each, plus other equipment. Depicted in figure T-16 is the normal mission utilization of the ARS in a flank-securing role. "A" troop has the responsibility for the first 12-hour daylight mission with "B" troop being considered as a 12-hour night troop. These 12-hour flight periods would continue until the mission is cancelled. The 12-hour mission block for "A" troop will consist of five 2.4-hour segments of reconnaissance, which is equal to 12 hours. The actual flight time for each segment is considered to be 3 hours. This allows 0.3 hours to fly to the area of reconnaissance, perform a reconnaissance of 2.4 hours, and 0.3 hours to return to rearm and refuel.

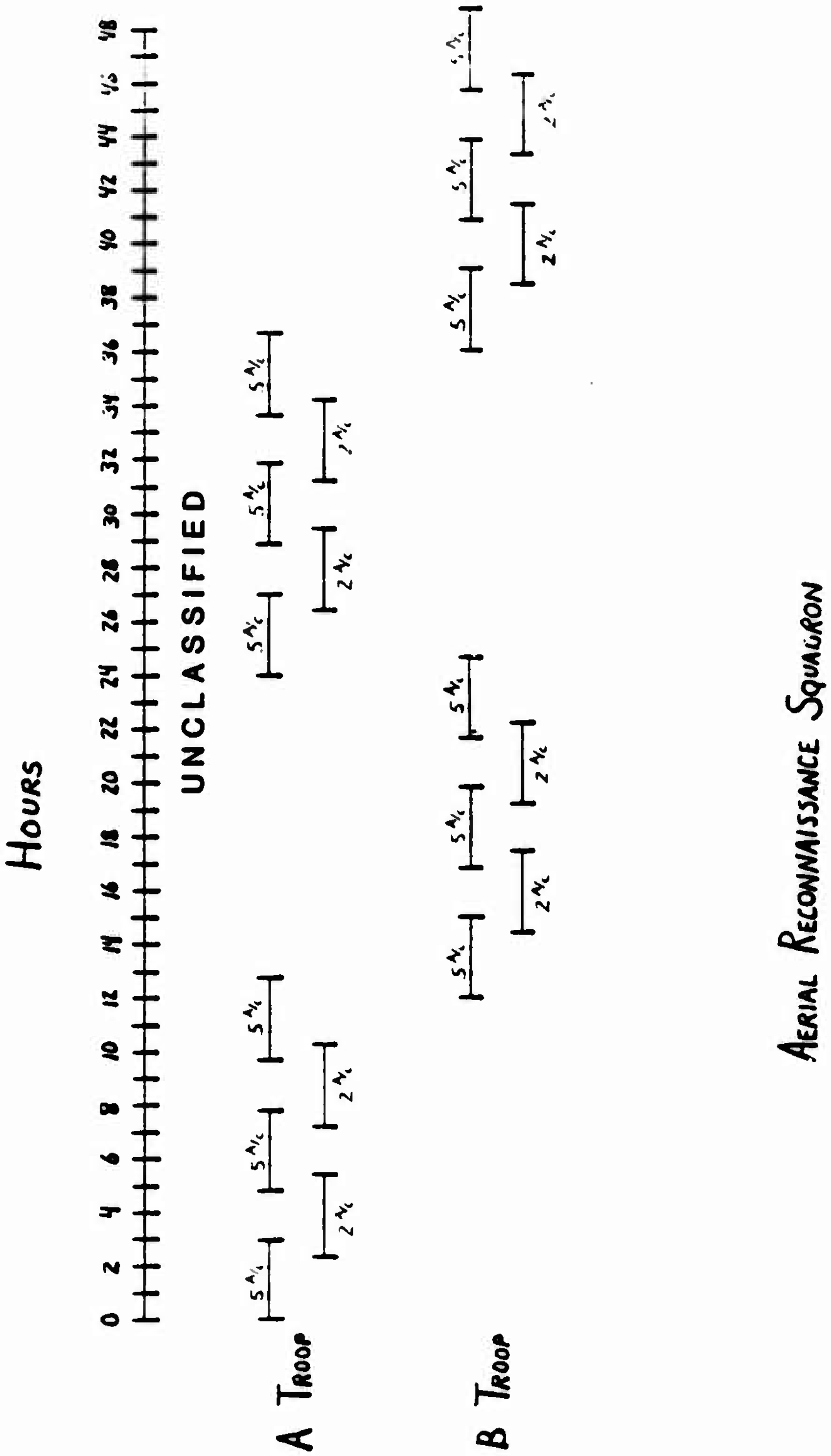

Figure T-16. (U) Aerial reconnaissance squadron.

(2) (U) The "A" troop first flight will consist of five LHX helicopters operating as two teams. One operating as a scout and one as an attack helicopter for team one; the same is true for team 2. The fifth helicopter is used by the air battle captain.

(3) (U) The second flight will consist of one helicopter in the scout role and one in the attack role for a total of two helicopters. After this flight, the troop will alternate between a five-helicopter mission and a two-helicopter mission to complete their combat day.

(4) (U) An analysis similar to the AHB was accomplished for the ARS. From figure T-17, it is obvious that at point H the troop can have no more than three NMC aircraft to launch the final team for their 12-hour mission block. Figure T-18 provides the percent of nonrepair that will produce a sustainability parameter of:

MTBEMA = 4.5 hours Mission F

MTBEMA = 6.9 hours Mission H

This value for MTBEMA increases drastically with each mission and does not consider any PMC aircraft.

c. (U) Mission Reliability Analysis for AHB.

(1) (U) Up to this point, nothing has been said of mission success rate or the MAF. This parameter will be defined by requiring an attack team to relaunch upon return from a mission.

(2) (U) The ability to relaunch would equate to a unit (11 aircraft company) being able to field at least eight operational aircraft from those returning from the mission in progress and those left behind in the hangar. As a first cut at this problem, the assumption was made that all aircraft that did not launch were ready, thus the team success would be at least five of eight aircraft returning fully operational. The definition of a successful mission is any aircraft that returns with all MEF operational and needing no more than a period of rearm and refuel prior to launch. With this criteria, the three company aircraft that were left behind when the team originally launched could be utilized to fill up the attack team and allow an immediate relaunch.

(3) (U) Figure T-19 is a graph of individual aircraft success and the resulting team success at the end of the mission. This figure was derived using the binomial theorem universally accepted for recording a probability given the minimum number of successes and individual probabilities.

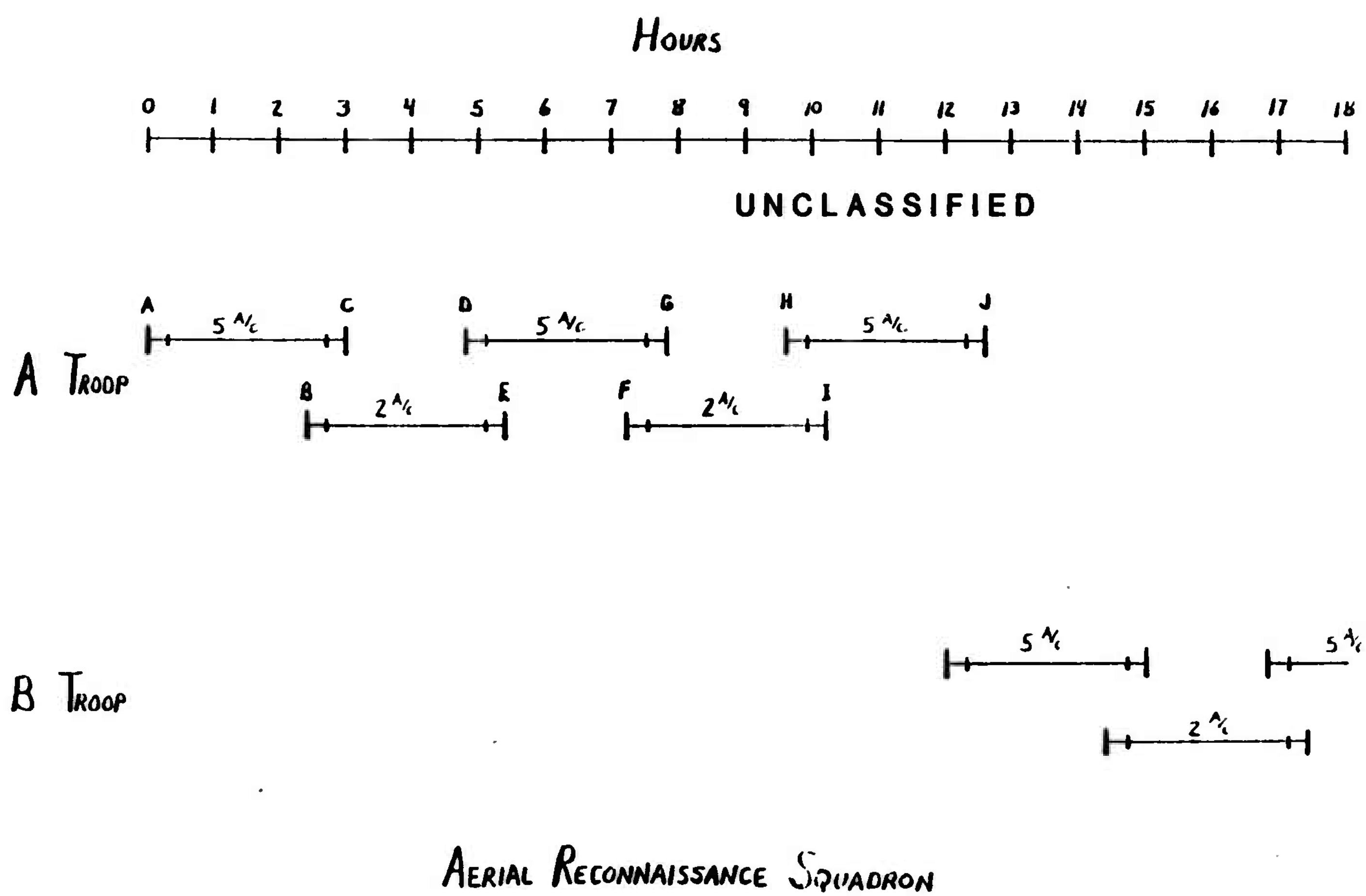

Figure T-17. (U) Aerial reconnaissance squadron.

Start of Mission (F)

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Point	Maintenance Time from Point (Hours)	Probability of Repair	Probability of Nonrepair	Flight Hours (MD X No. A/C)
E	1.8	.1692	.8308	6
C	4.2	.4641	.5359	15
Previous missions	19.2	.9731	.0268	15

$$\frac{6\ FH}{MTBF}(.8308) + \frac{15\ FH}{MTBF}(.5359) + \frac{15\ FH}{MTBF}(.0268) = 3\ A/C\ Not\ FMC$$

MTBF = 4.47 hours

Start of Mission (H)

Point	Maintenance Time from Point (Hours)	Probability of Repair	Probability of Nonrepair	Flight Hours (MD X No. A/C)
G	1.8	.1692	.8308	15
E	4.2	.4641	.5359	6
C	6.6	.6641	.3335	15

$$\frac{15\ FH}{MTBF}(.8308) + \frac{6\ FH}{MTBF}(.5359) + \frac{15\ FH}{MTBF}(.3335) = 3\ A/C\ Not\ FMC$$

MTBF = 6.89 hours

Start of Mission (J)

Point	Maintenance Time from Point (Hours)	Probability of Repair	Probability of Nonrepair	Flight Hours (MD X No. A/C)
J	0	0	1.0	15
I	2.4	.2492	.7508	6
G	4.8	.5234	.4766	15
E	7.2	.7040	.2960	6
C	9.6	.8168	.1832	15

$$\frac{15\ FH}{MTBF}(1.0) + \frac{6\ FH}{MTBF}(.751) + \frac{15\ FH}{MTBF}(.477) + \frac{6\ FH}{MTBF}(.296) + \frac{15\ FH}{MTBF}(.183) =$$

3 A/C Not FMC

MTBF = 10.39 hours

Figure T-18. (U) Analysis for ARS.

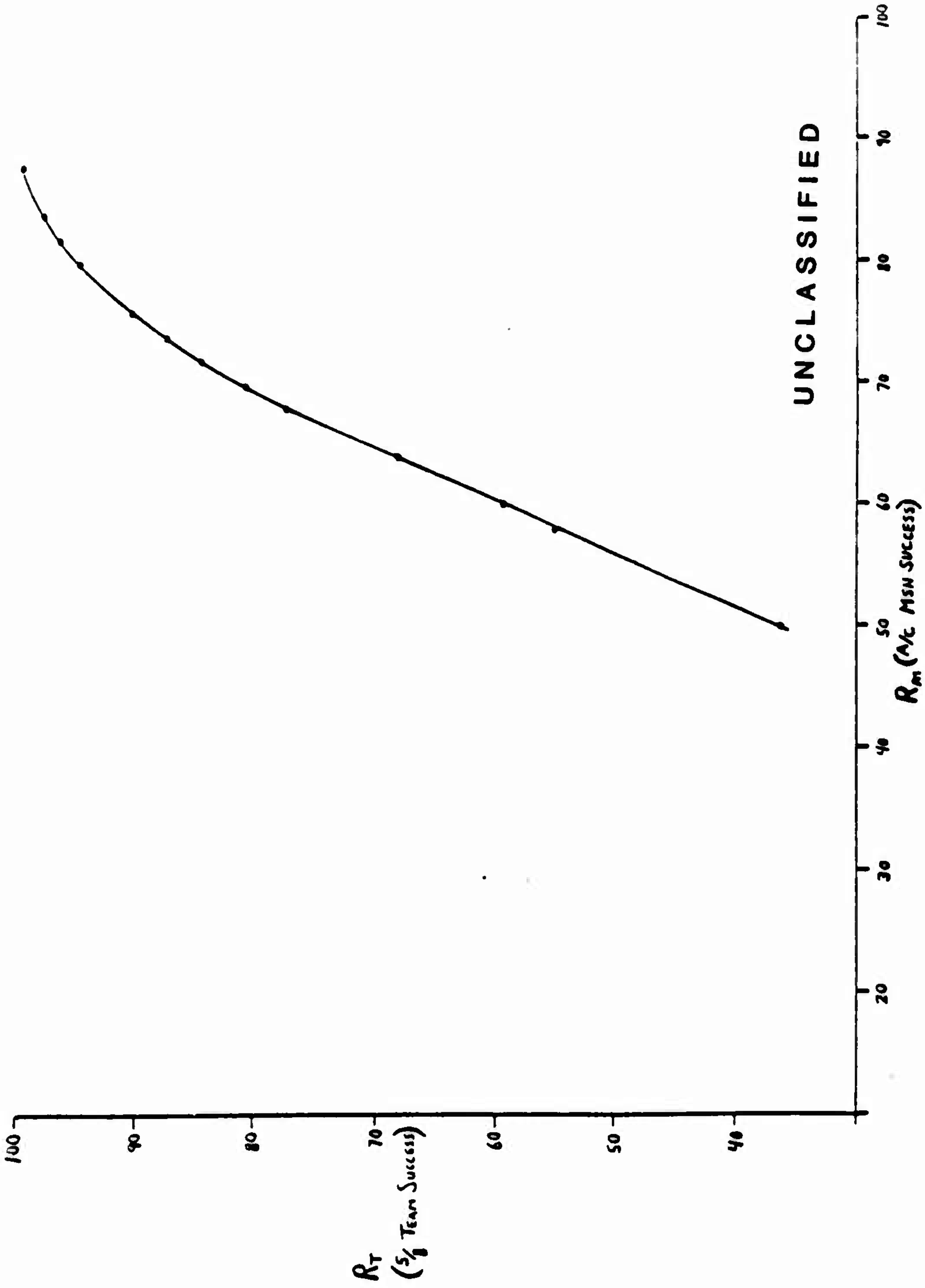

Figure T-19. (U) Individual aircraft success versus team success (11 aircraft per unit).

$$P(X) = \sum_{X = S}^{N} \binom{N}{X} R^X (1-R)^{N-X}$$

Where--

X = Number of systems successfully completing mission.

S = Minimum number of systems required (five).

P = Probability of success for team.

N = Total number of systems operating as a unit (eight).

R = Probability of one system successfully completing mission.

$$\binom{N}{X} = \frac{N!}{X!\ (N-X)!}$$

(4) (U) By itself, this graph is of little value but when plotted along with mean time between mission-affecting failure (MTBMAF) in figure T-20, it gives the reader the ability to see the trade-off between aircraft mission reliability and the probability that the commander would be able to relaunch an attack team. The break point in this figure occurs at an individual reliability of about .70 and a team relaunch capability of 80. What this means to the commander is that any time he launches an 8-ship attack team, he has a probability of .8 or an 80 percent chance that five of the eight aircraft that return require no maintenance and can, subsequently, be relaunched immediately if his three remaining aircraft are operational.

(5) (U) The above analysis produces a mission reliability of:

MTBMAF = 8.4 hours.

(6) (U) In order to show the trade offs for mission reliability with the 10 and 11 aircraft AHB units, the previous analysis was repeated for a 10 aircraft attack helicopter company. In this case only 2 aircraft can be NMC for the company to have a relaunch capability. This generated a need for at least six of eight aircraft returning from missions fully operational. Figures T-21 and T-22 are the results of the 10 aircraft unit analysis. For the 10 aircraft unit to maintain the same .80 probability of team success as the 11 aircraft unit, the individual aircraft mission reliabilities must equal .80 probability. This produces a mission reliability parameter of:

MTBMAF = 13.4 hours

(7) (U) This 60 percent increase in MTBMAF for the 10 aircraft company again shows the substantial reliability demands associated with decreasing size of the attack helicopter company from 11 to 10. Figure T-23 depicts the reliability parameters for both companies.

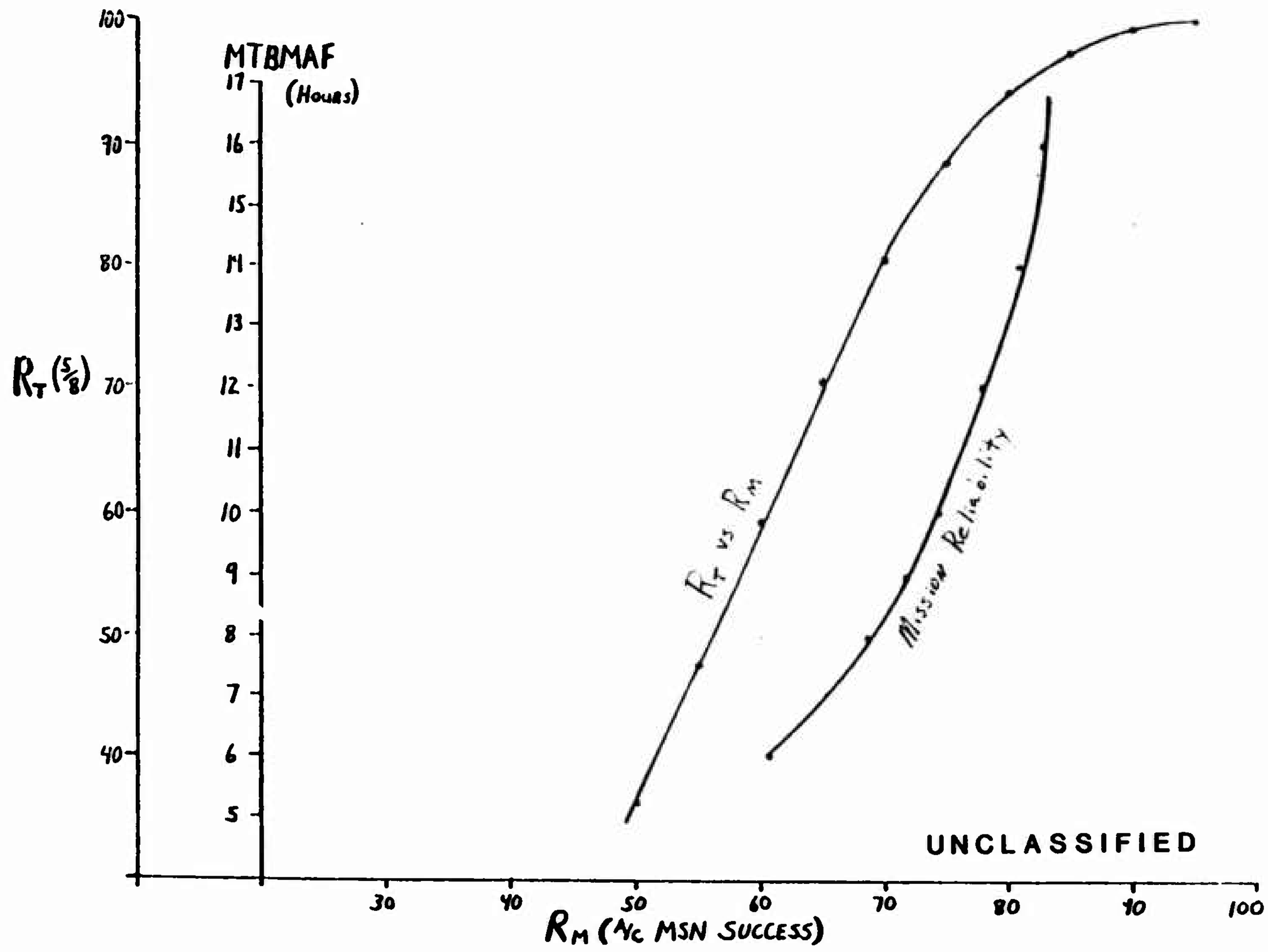

Figure T-20. (U) Overlay to figure T-19 showing mission reliability (11 aircraft per unit).

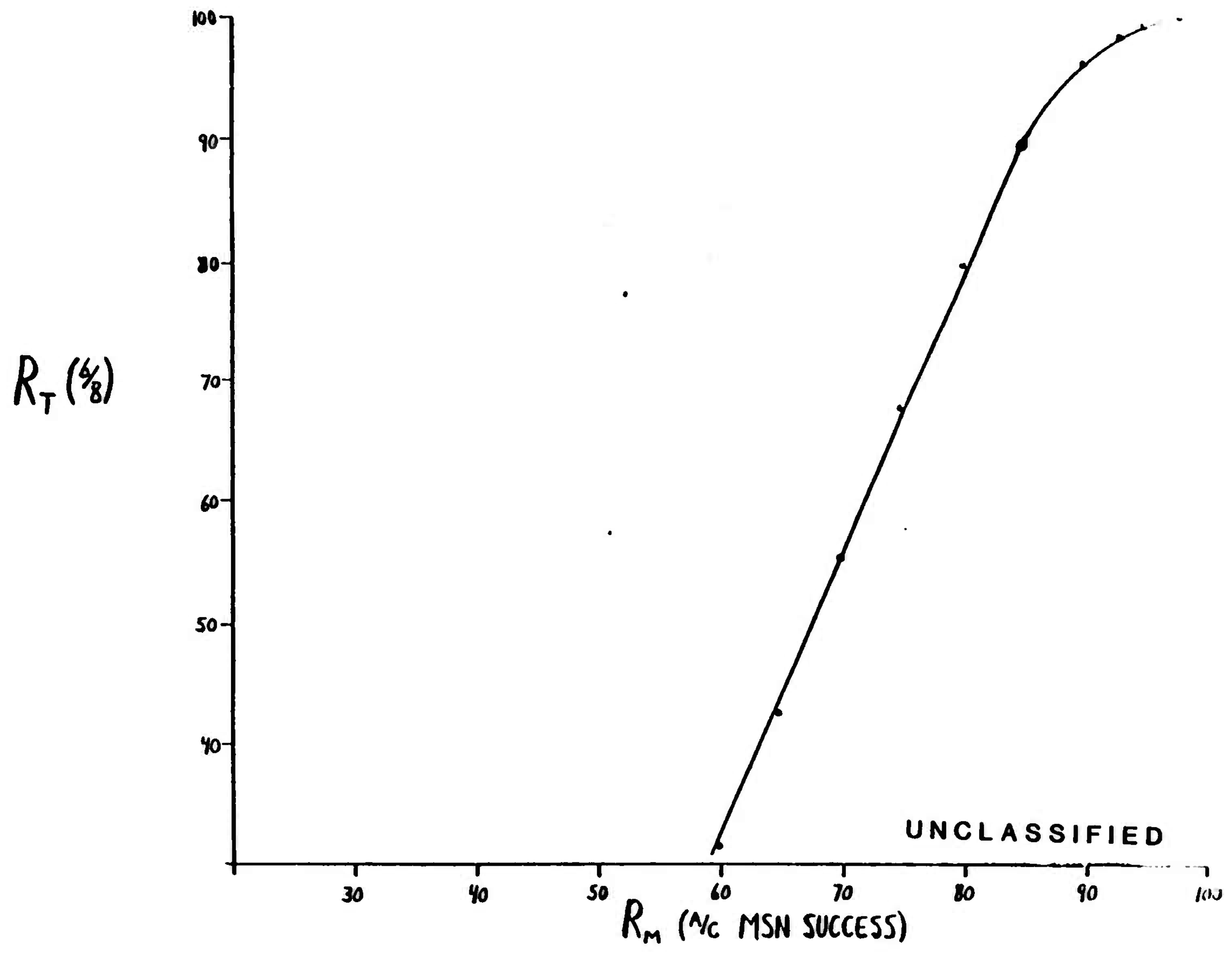

Figure T-21. (U) Individual aircraft success versus team success (10 aircraft per unit).

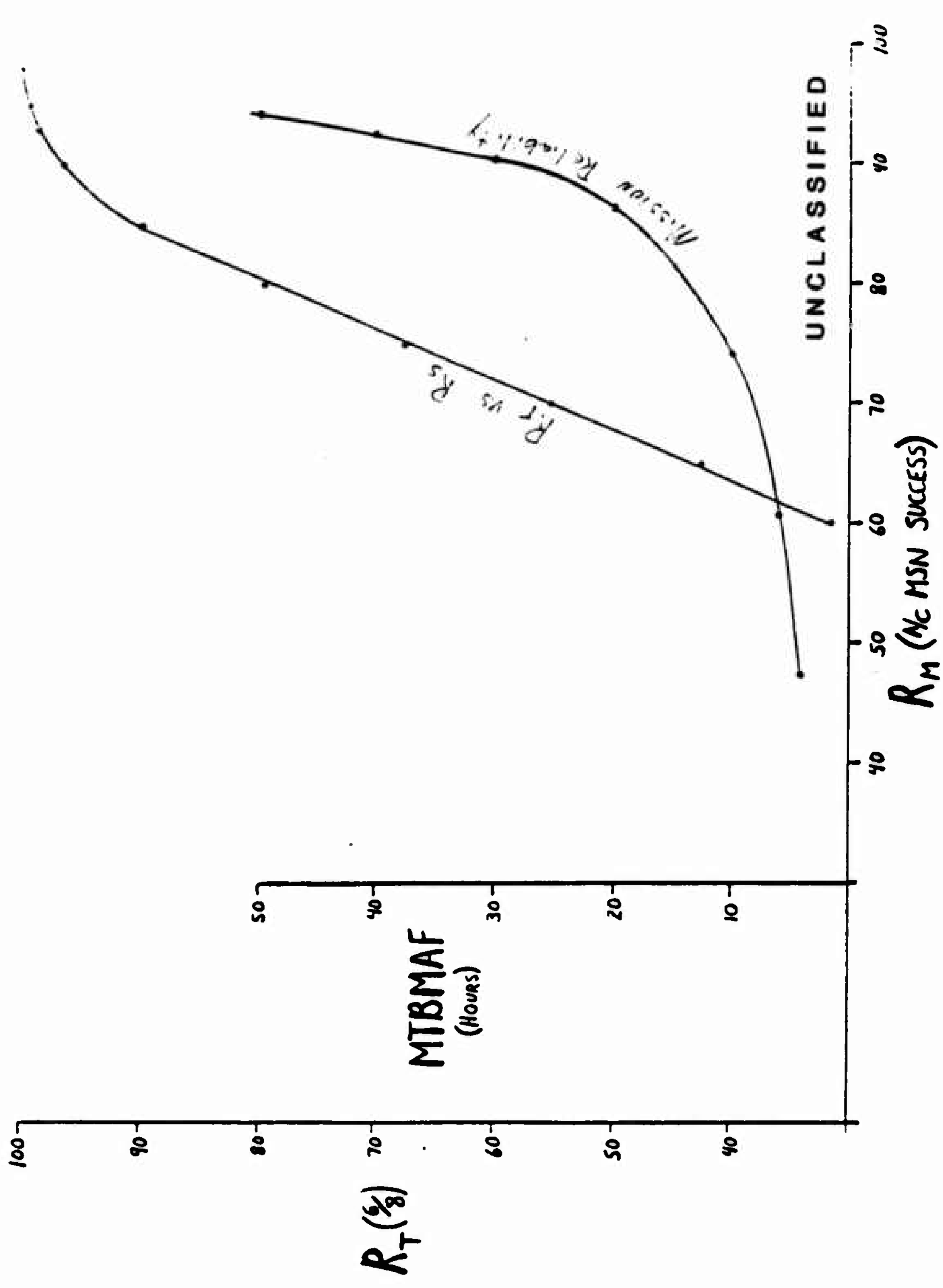

Figure T-22. (U) Overlay to figure T-21 showing mission reliability (10 aircraft per unit).

	11 Aircraft Company	10 Aircraft Company
MTBEMA (3-hour msn)	3.6 hours	5.4 hours
MTBEMA (6-hour msn)	8.72 hours	13.08 hours
MTBMAF	8.4 hours	13.4 hours

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Figure T-23. (U) Attack helicopter battalion.

1. (U) Mission Reliability Analysis for ARS.

(1) (U) For the mission of the ARS, the relaunch criteria would be some-what different from that used for the AHB. As seen in figure T-17, the key times for relaunch would be at points C, G, or J when the commander felt the need to keep the maximum number of aircraft on station. At points C and G during the mission day the troop would have three aircraft not flying. If these three aircraft were fully operational then the troop could relaunch if they were able to return with at least two successful aircraft. Although the criteria to return from a mission with at least two FMC aircraft is not difficult it is difficult to guarantee that the three aircraft that remained in the hanger were ready to go when the team returned. For these reasons the MAF parameter for the ARS was developed utilizing both a two and three ship success rate. Figures T-24 and T-25 depict these results. Utilizing the criteria of individual aircraft success of 70 percent, the team success for the cavalry team results in 84 percent for three of five and 97 percent for two of five.

(2) (U) Figure T-26 depicts the reliability parameters that result from the analysis for the ARS.

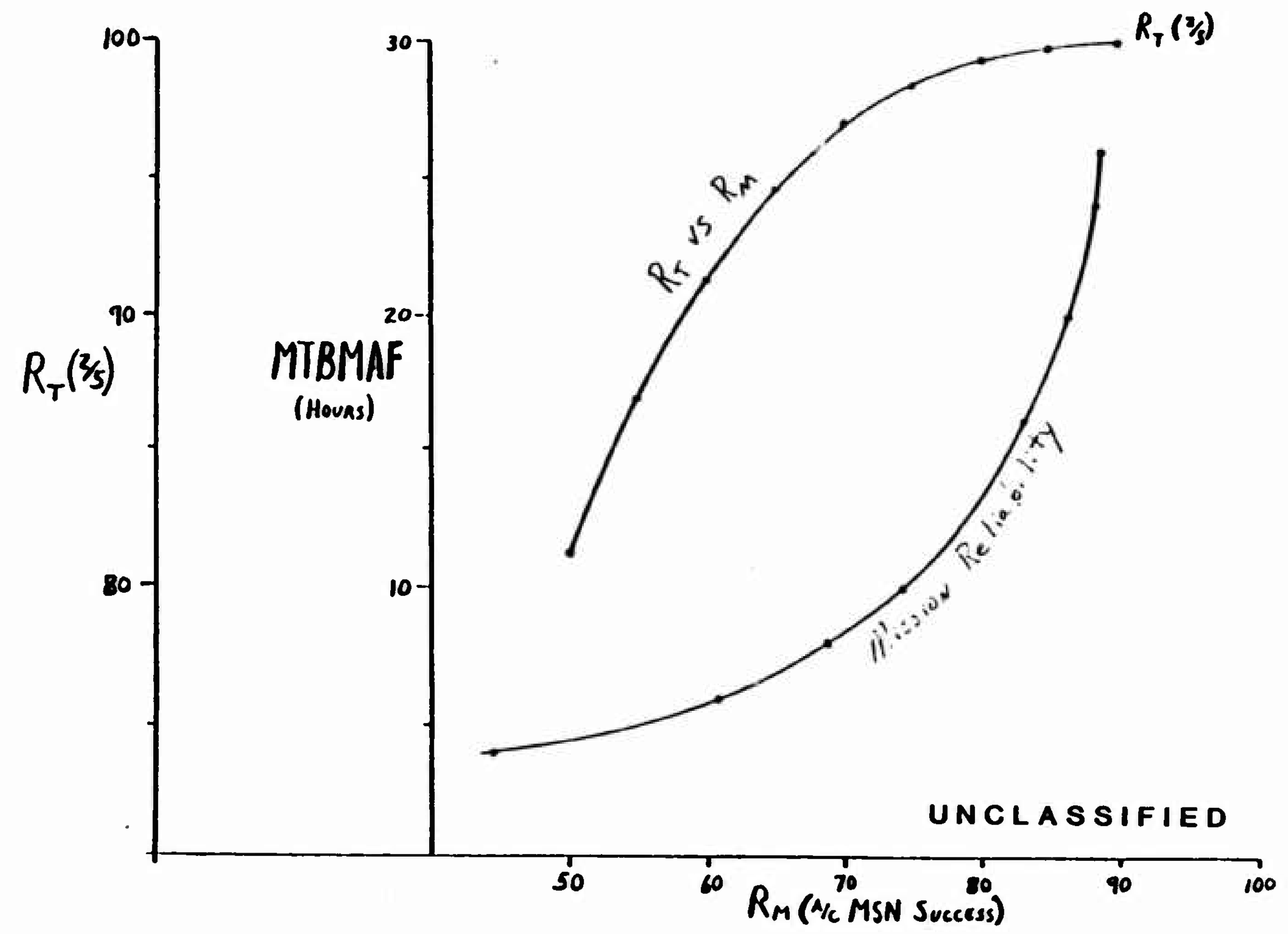

Figure T-24. (U) Overlay for ARS (2-ship success rate).

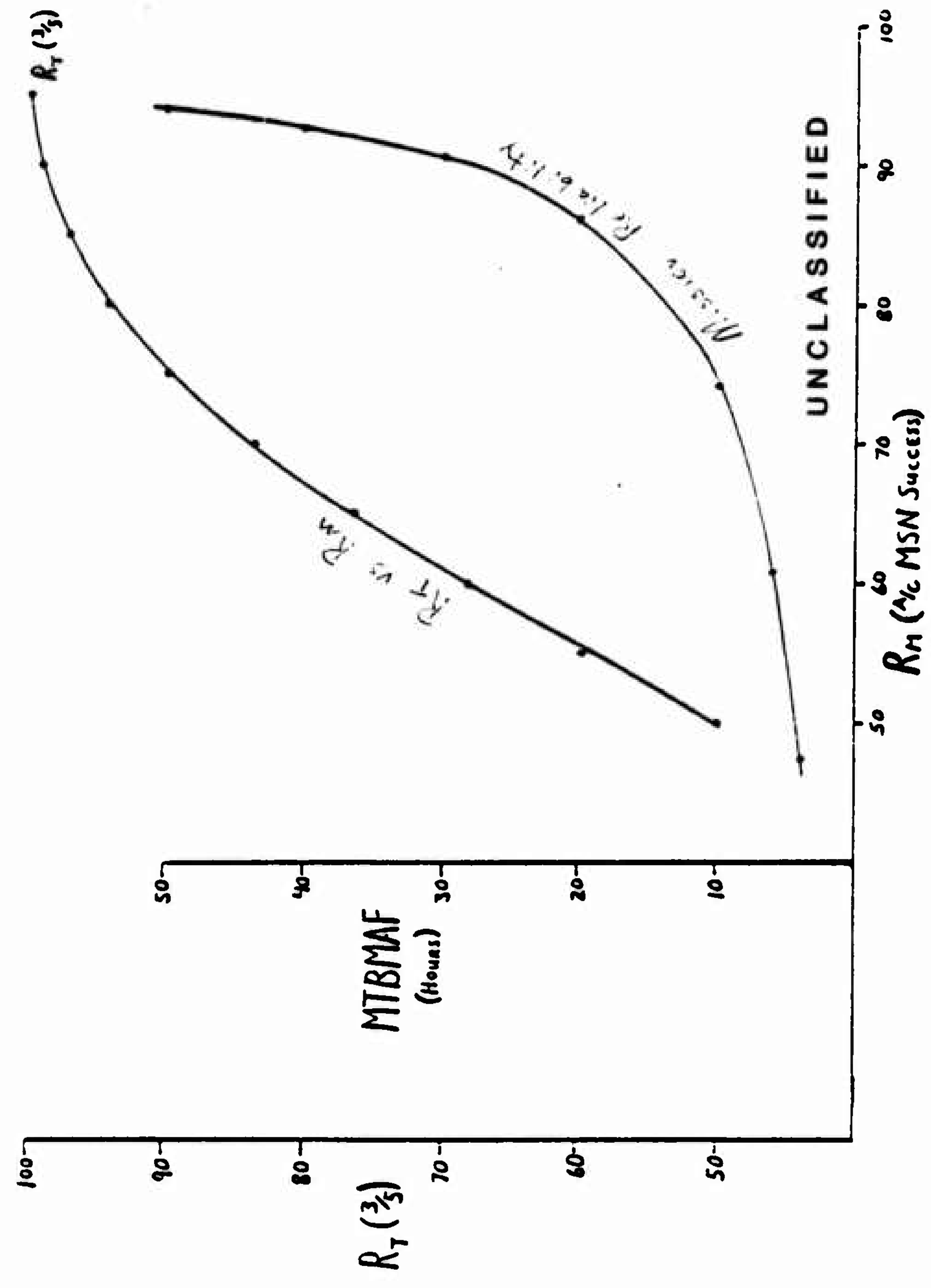

Figure T-25. (U) Overlay for ARS (3-ship success rate).

	10 Aircraft troop	11 Aircraft troop
MTBEMA (mission F)	4.5 hrs	3.4 hrs
MTBEMA (mission H)	7.1 hrs	5.3 hrs
MTBEMA (mission J)	10.4 hrs	7.8 hrs
MTBMAF	8.4 hrs	7.0 hrs

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Figure T-26. (U) Aerial reconnaissance squadron.

T-7. (U) FINDINCS.

a. (U) Based upon the analysis the major trades in the RAM area were done on the unit sizes. The reason for this was that a dollar figure could not be attached to individual RAM parameters since each one encompasses the entire airframe system design. As the design firms up and costs become more refined it will be incumbent upon the decision makers to look at the force structure issue. It was the goal of this analysis to lay the ground work for such a decision. Without the costs in terms of RAM clearly defined it is very easy to get caught up in the emotions of an argument and decide to cut force structure because of some promised increase in reliability or availability. This report has made an attempt to clearly define those parameters so if the Army wishes to reduce force structure in the aviation assets it knows what the bill is in terms of flying hours per aircraft per day and reliabilities for those aircraft.

b. (U) The recommendations of this report are made by looking at the results of the TOD report along with the present analysis. As mentioned previously in an unconstrained budget the RAM numbers have no real upper bound. The TOD report looked at fully mature systems that were achievable in terms of the LHX program. In that light the RAM parameters and unit sizes selected for the LHX appear in figure T-27.

	AHB	ARS
Company/troop size	11 aircraft	10 aircraft
Fly hours per day	5.8	5.7
MTTR	1.0	1.0
Maint ratio	3.6 MMH/FH	3.6 MMH/FH
MTBEMA	8.7 hrs	7.1 hrs
MTBMAF	8.4 hrs	8.4 hrs

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Figure T-27. (U) TOD selected RAM parameters and unit sizes.

ANNEX I TO APPENDIX T

FAILURE DEFINITIONS AND SCORING CRITERIA (FD/SC) (U)

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APPENDIX I TO APPENDIX T

FAILURE DEFINITIONS AND SCORING CRITERIA (FD/SC) (U)

T-I-1. (U) INTRODUCTION. This annex contains the failure definitions/scoring criteria (FD/SC) for establishing an agreed-upon data base. This data base will be used for making reliability and maintainability assessments for evaluation of the total system, to include contractor-furnished equipment (CFE), Government-furnished equipment (GFE), and subsystem interfacing (not to include training devices). All test incidents, including embedded computer software incidents, will be scored using the guidelines in paragraph T-I-4. Prior to any official scoring, the reliability, availability, and maintainability (RAM) working group may modify this FD/SC with appropriate rationale.

T-I-2. (U) MISSION-ESSENTIAL FUNCTIONS (MEF). The following MEFs will be evaluated against the missions that appear in the operational mode summary/mission profiles (OMS/MP).

a. (U) Start with installed power and fly adequately to permit satisfactory and expeditious accomplishment of all missions. Included in this definition are all of the airframe, powertrain, and dynamic components necessary to fly the aircraft.

b. (U) The communication systems must be capable of allowing the pilot (as a minimum) to perform all missions. This includes both air-to-air and air-to-ground communication as specified in the mission profiles.

c. (U) The navigation systems onboard must be capable of allowing the crew to perform all missions.

d. (U) The weapon systems must be capable of engaging ground and air targets as in the mission profiles.

e. (U) The target acquisition system must be capable of acquiring and designating air and ground targets as specified in the mission profiles.

f. (U) The aircraft survivability equipment (ASE) must function in a manner that will allow the crew to perform all missions.

T-I-3. (U) GENERALIZED FAILURE DEFINITION. A mission-affecting failure (MAF) is defined as any incident or malfunction which causes or could have caused the inability to perform one or more MEFs.

a. (U) MAFs are subdivided into two groups. One group includes all MAFs that occurred during flight time. The second group is a subset of the first and includes only those MAFs that resulted in a mission abort. Incidents that affect a mission or mission-essential function but occur outside of flight time are counted as essential maintenance actions (EMA).

b. (U) For the purpose of evaluating RAM parameters, flight time is defined in accordance with Army Regulation (AR) 95-1.

c. (U) The classification/chargeability guidelines and flow chart in paragraph d further delineate failure definition and accountability. Chapter 8 of the RAM Rationale Report Handbook (US Army Training and Doctrine Command/US Army Materiel Development and Readiness Command Pamphlet 70-11) contains RAM definitions and a more detailed description of parameters.

T-I-4. (U) DETERMINING FAILURE RATES. Major aircraft systems normally have more than one inherent mission. For that reason, it is necessary to look not only at the overall failure rate of the aircraft, which will include all systems, but also at the failure rates for each specific mission in light of the OMS/MP. This will be done by means of a matrix of MEFs and MSNs (figure T-I-1). Each MEF failure will, by definition, cause at least one MSN to record a failure. By scoring each MEF failure, the appropriate MSN failures will also be reflected and this data can be used to record both specific mission and overall mean time between mission-affecting failures (MTBMAF).

T-I-5. (U) CLASSIFICATION/CHARGEABILITY GUIDELINES AND FLOW CHART. The process of scoring test incidents is divided into two parts. The first part is the classification of the test incident based upon the failure definition. Classification is a categorization of the effect of the incident. The classification is made without regard to who or what caused the incident. The second part of the scoring process is the assignment of chargeability for all test incidents. The chargeability step assigns the primary cause for the occurrence of the incident to one of the operational elements. Figure T-I-2 contains the classification/chargeability flow chart. The following steps 1-13 describe the flow chart in detail. Paragraph T-I-6 is a listing of the codes used and the appropriate scoring conference decision (SCD) chargeability sequence.

a. (U) <u>Step 1 - No test.</u>

(1) (U) Question: No test?

(2) (U) Procedure: If the incident is a no test as described in the expansion below, score the incident as a no test, record the category of no test, and stop. Code all SCDs, MEFs, and MSNs as N. If the incident is not a no test, proceed to step 2.

(3) (U) Expansion:

(a) (U) Pretest checkout. This includes an initial flight test, acceptance inspection by test agency, weapon firing, and burn-in of components. The test plan must specify the number of flight hours, rounds and rockets fired, and hours for burn-in of components. All incidents detected after the initial inspection period will be scored on their own merit under succeeding steps. Any impending malfunction discovered in post-test inspection will be scored on it's own merit under succeeding steps.

LHX SCAT MATRIX WITH ALLOWABLE DEGRADATION.
X Indicates the Minimum Essential Equipment the Aviation Center feels is necessary for a commander to launch a ship for the mission indicated

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MISSION PROFILE # / MEF	#22 FAAO	#28 AMP/ASLT	#26 OFF AIR	#19 SNEAD	#17 DEEP STK	#13 ANTI P/M	#12 ANTI AR	#14 SOF STK	#45 NBC SVY	#25 AIR/AIR	#16 SECURITY	#18 RACH
INTERNAL HOIST												
TROOP INSERTION												
INTERNAL CARGO												
WEAPONS SYSTEM.		x	x	x	x	x	x	x	x	x	x	x
TARGET ACQUISITION	x	x	x	x	x	x	x	x		x	x	x
ASE	x	x	x	x	x	x	x	x	x	x	x	x
NAVIGATION	x	x	x	x	x	x	x	x	x	x	x	x
COMMUNICATE	x	x	x	x	x	x	x	x	x	x	x	x
FLY ADEQUATELY	x	x	x	x	x	x	x	x	x	x	x	x
MISSION EQUIP. PKG												
COMMO. UHF/AM												
SINGCARS 40W FM	x	x	x	x	x	x	x	x	x	x	x	x
HF/SSB	x		x	x	x	x	x	x		x	x	
UHF-AM(HQ)	x	x	x	x	x	x	x	x	x	x	x	x
INTERCOM	x	x	x	x	x	x	x	x	x	x	x	x
WIDE BAND SECURE	x	x	x	x	x	x	x	x	x	x	x	x
NARROW BAND SECURE	x		x	x	x	x	x	x		x	x	
I.D. SECURE IFF	x	x	x	x	x	x	x	x	x	x	x	x
PJH CAPABILITIES	x	x	x	x		x	x		x	x		x
DIG.MAP W/TER.CORR	x	x	x	x	x	x	x	x	x	x	x	x
VELOCITY SENSOR	x	x	x	x	x	x	x	x	x	x	x	x
GPS	x	x	x	x	x	x	x	x	x	x	x	x
RADAR ALTIMETER	x	x	x	x	x	x	x	x	x	x	x	x
INERTIAL REF. SYS.		x	x	x	x	x	x	x		x		x
3 D AIR DATA SENS.		x	x	x	x	x	x	x		x		x
RADAR WARN. RCVR.	x	x	x	x	x	x	x	x	x	x	x	x

Figure T-I-1. (U) MEF versus mission MATRIX SCAT. (continued on next page)

LASER WARNING RCVR	x	x	x	x	x	x	x	x	x	x	x	
RADAR JAMMER			x	x	x	x	x	x		x		
INFRARED JAMMER	x	x	x	x	x	x	x	x	x	x	x	x
OPTICAL SENSOR	x	x	x	x	x	x	x	x	x	x	x	x
OPTICAL JAMMER				x	x			x		x		
TGT.ACQ. EOTADS IR	x	x	x	x	x	x	x	x		x	x	x
EOTADS DAY T.V.	x	x	x	x	x	x	x	x		x	x	x
MILL. WAVE RADAR	x	x	x	x	x	x	x	x	x	x	x	x
DISPLAYS:H.M.D.	x	x	x	x	x	x	x	x	x	x	x	x
NVPS	x	x	x	x	x	x	x	x	x	x	x	x
PANEL DISPLAY	x	x	x	x	x	x	x	x	x	x		x
VOICE CONTROLS	x	x	x	x	x	x	x	x	x	x	x	
KEYBOARD	x	x	x	x	x	x	x	x	x	x	x	x
FDLS				x	x		x	x	x	x		x
DATA LOAD/VERIFY	x	x	x	x	x	x	x	x	x	x	x	x
FLT. CNTL. SYS.	x	x	x	x	x	x	x	x	x	x	x	x

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Figure T-I-1. (U) (continued)

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LHX-U MEE MATRIX WITH ALLOWABLE DEGRADATION.

X Indicates the Minimum Essential Equipment the Aviation Center feels is necessary for a commander to launch a ship for the mission indicated

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MISSION PROFILE # MEE	#44 SAR	#29 COMMO RLY	#42 COURIER	#2 C3 LIASN	#33 SOF	#34 INSTN TEAM	#46 INS MSL.SPT	#30 INSP.EQP	#43 RESUPPLY	#36 AMPP/AST
INTERNAL HOIST	X				X	X	X	X		
TROOP INSERTION	X		X	X	X	X	X	X		X
INTERNAL CARGO			X		X	X	X	X	X	X
EXTERNAL CARGO								X	X	X
ASE	X	X	X	X	X	X	X	X		X
NAVIGATION	X	X	X	X	X	X	X	X	X	X
COMMUNICATE	X	X	X	X	X	X	X	X	X	X
FLY ADEQUATELY	X	X	X	X	X	X	X	X	X	X
MISSION EQUIP. PKG										
COMMO. UHF/AM										
SINGCARS 40W FM	X	X	X	X	X	X	X	X	X	X
HF/SSB					X	X		X		
UHF AM(HQ)	X	X	X	X	X	X	X	X	X	X
INTERCOM	X	X	X	X	X	X	X	X		X
WIDE BAND SECURE	X	X	X	X	X	X	X	X		X
NARROW BAND SECURE	X	X		X	X	X		X		
I.D. SECURE IFF	X	X	X	X	X	X	X	X	X	X
PJH CAPABILITIES										X
DIG.MAP W/TER.CORR	X				X	X	X	X		X
VELOCITY SENSOR	X	X	X		X	X	X	X		X
GPS	X	X	X	X	X	X	X	X	X	X

Figure T-I-1. (U) (continued)

RADAR ALTIMETER	x	x	x		x	x	x	x		x	
INERTIAL REF. SYS.											
3 D AIR DATA SENS.											
RADAR WARN. RCVR.	x				x	x	x	x		x	
LASER WARNING RCVR	x				x		x	x		x	
RADAR JAMMER					x			x		x	
INFRARED JAMMER					x			x		x	
OPTICAL SENSOR					x			x		x	
OPTICAL JAMMER					x			x			
TGT.ACQ. EOTADS-IR											
EOTADS-DAY T.V.											
MILL. WAVE RADAR	x				x			x			
DISPLAYS:H.M.D.					x			x			
NVPS	x	x	x	x	x	x	x	x	x	x	
PANEL DISPLAY	x	x	x	x	x	x	x	x	x	x	
VOICE CONTROLS					x			x		x	
KEYBOARD	x	x	x	x	x	x	x	x	x	x	
FDLS					x						
DATA LOAD/VERIFY	x	x	x	x	x	x	x	x	x	x	
FLT. CNTL. SYS.	x	x	x	x	x	x	x	x	x	x	

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Figure T-I-1. (U) (concluded)

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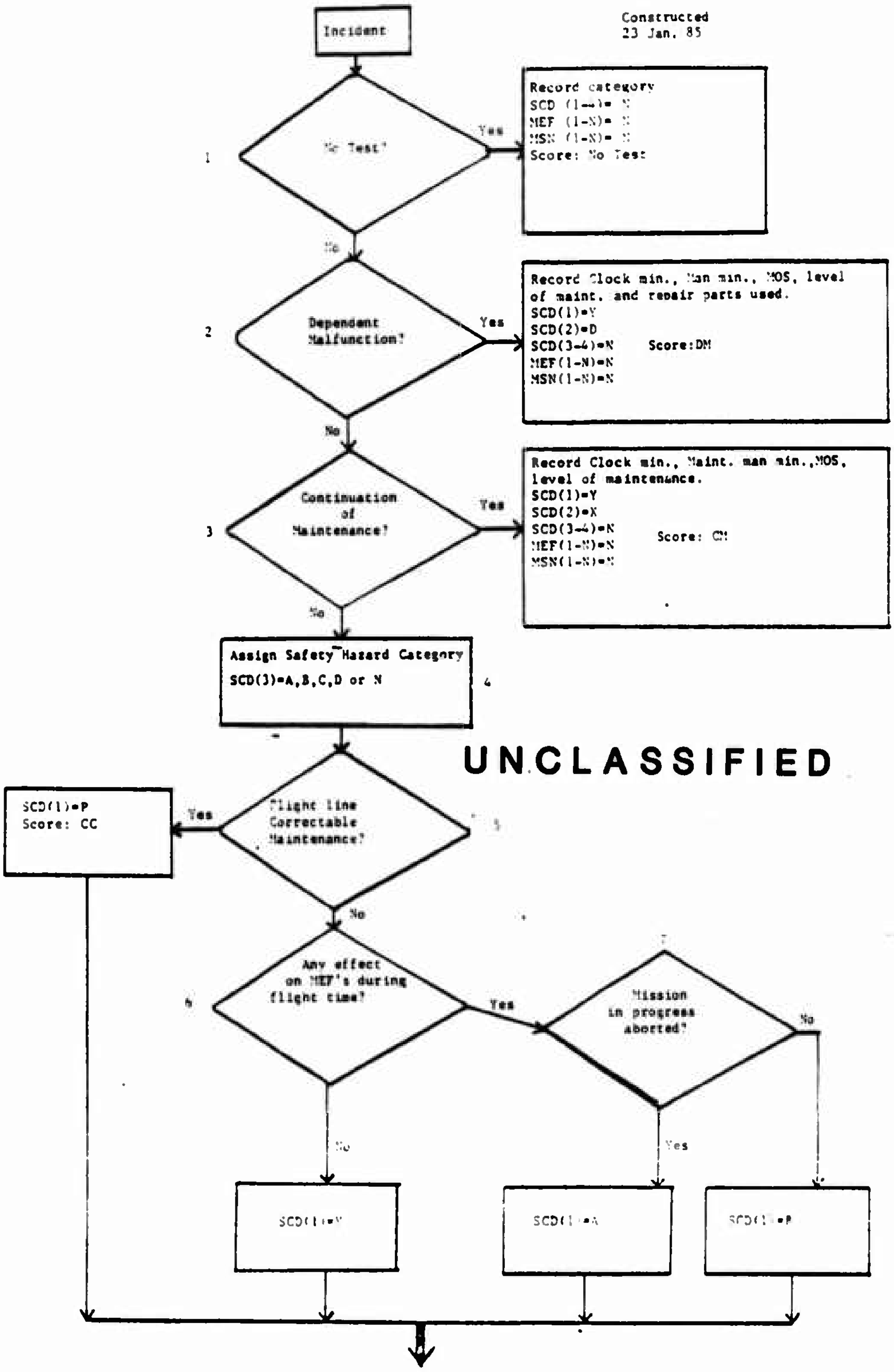

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Figure T-I-2. (U) FD/SC flowchart. (concluded on next page)

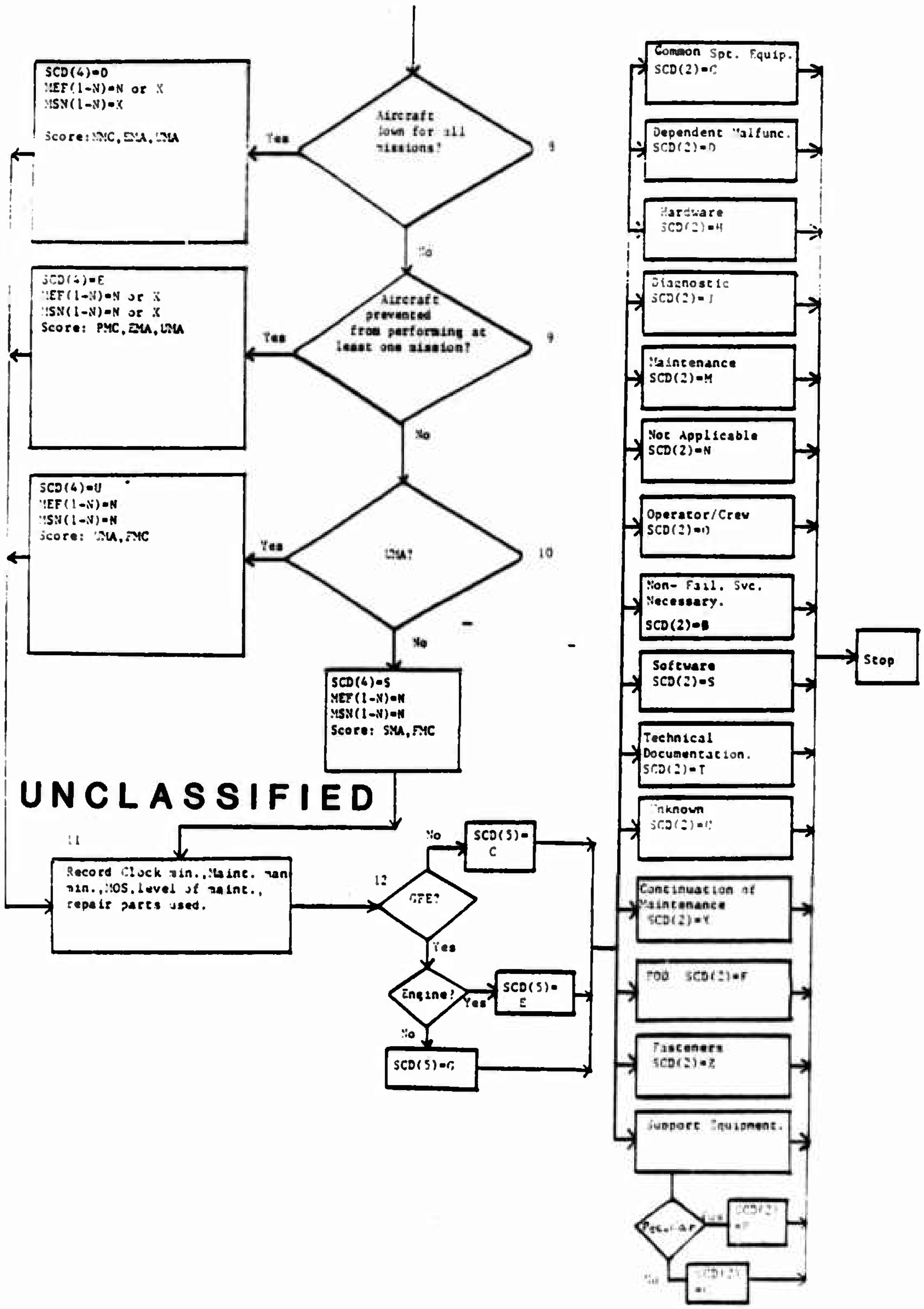

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Figure T-I-2. (U) (concluded)

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(b) (U) Equipment modification. This includes all maintenance actions involved in the installation of hardware kits or incorporation of redesigned components. If the replaced component was not functioning at the time of its replacement with the modification, the incident will be scored on its own merit. The maintenance time will be estimated based on the time to restore the system to its original condition. Subsequent malfunctions of the modification will be scored on their own merit.

(c) (U) Test peculiar. Malfunctions caused by nonsystem equipment or people not acting as crew or maintenance personnel are scored as no test. Engineering evaluations to analyze the cause of malfunctions, as well as any malfunctions and/or maintenance efforts caused by the engineering evaluation, are scored as a no test. This also includes maintenance evaluations conducted as a part of the test plan and malfunctions of the test-peculiar equipment or caused by the instrumentation. Incidents related to test-peculiar diagnostic equipment used in lieu of the diagnostic equipment which will be fielded are scored under their own merit under succeeding steps. Incidents caused by contractor or other personnel acting as crew or maintenance personnel will be scored under their own merit under succeeding steps.

(d) (U) Deliberate abuse. This incident includes all willful abuse (e.g., performance capability limit test) whether it was prescribed by the test plan or not. Crew or maintenance errors will be scored on their own merit under succeeding steps.

(e) (U) Non-RAM oriented. This step includes those events for which a test incident report might be initiated by the test activity, but which are not incidents used in RAM computations. Examples include suggested improvements, reports of test procedures, unusable or unacceptable replacements parts which were discovered prior to or during installation, inability to meet performance specifications where no malfunction has occurred, and suggested human factors improvements. Recommended changes to the system support package not related to a specific test incident are also covered by this step.

(f) (U) Accident. This step includes damage caused by natural phenomena and other influences which are beyond the control of the operational elements of the system. Accidents caused by hardware malfunction or other operational elements of the system are charged on their own merit under succeeding steps.

b. (U) Step 2. Dependent Malfunction.

(1) (U) Question: Was the incident a dependent malfunction?

(2) (U) Procedure: If yes, score as a dependent malfunction, flow to parent incident; record clock minutes, man-minutes, military occupational specialty (MOS,), level of maintenance, and repair parts used; and stop. Code SCD(1) = Y, SCD(2) = D, SCD(3) = N, and all MEFs and MSNs as N.

(3) (U) Expansion: A dependent malfunction is a malfunction that is directly caused by other concurrent malfunctions and would not have occurred

but for the presence of that concurrent malfunction or malfunctions. These dependent malfunctions are not charged as failures. One failure is charged against the primary, or causative, failure. The maintenance time recorded is the sum of the maintenance times necessary to correct the related dependent malfunctions.

c. (U) Step 3. Continuation of Maintenance.

(1) (U) Question: Was the incident a continuation of maintenance?

(2) (U) Procedure: If yes, score the event as a continuation of maintenance, flow to parent incident; record clock minutes, maintenance man-minutes, MOS, level of maintenance, and repair parts used; and stop. Code SCD(1) = Y, SCD(2) = X, SCD(3) = N, and all MEFs and MSNs as N.

(3) (U) Expansion: Continuation of maintenance covers incidents where maintenance was previously initiated but was interrupted or not completed. The interruption may be caused by the continued testing of the equipment in a degraded mode because of a lack of spare or repair parts at the test site. Also, the interruption may be caused by the inability of maintenance personnel on site to perform the required maintenance.

d. (U) Step 4. Safety Failure.

(1) (U) Procedure: Assign a safety hazard category I, II, III, IV, or N. Code SCD(3) = A, B, C, D, or N. Go on to step 4.

(2) (U) Expansion: The safety categories are extracted from Military Standard (MIL-STD) 882A, Requirements for Systems and Associated Subsystems and Equipment, 28 June 1977, which provides uniform requirements and criteria for establishing and implementing system safety programs. Under section V, the work hazard severity is defined as follows:

> Work hazard severity codes provide a qualitative measure of the worst potential consequences resulting from personnel error; environmental conditions; design inadequacies; procedural deficiencies; system, subsystem or component failure; or malfunction as follows:
>
> Category I - Catastrophic
>
> May cause death or system loss.
>
> Category II - Critical
>
> May cause severe injury, severe occupational illness, or major system damage.
>
> Category III - Marginal
>
> May cause minor injury, minor occupational illness, or minor system damage.

Category IV - Negligible

Will not result in injury, occupational illness, or system damage.

e. (U) Step 5. Flight Line-Correctable Maintenance Action.

(1) (U) Question: Was the incident a malfunction corrected by the crew and/or unit maintenance personnel prior to mission initiation, using only tools on hand, and which was performed within 15 minutes?

(2) (U) Procedure: If yes, score as a flight line-correctable maintenance action. Code SCD(1) = P, and proceed to step 7.

(3) (U) Expansion: This step covers those minor maintenance actions occurring during preflight which may interrupt the start of the mission, but which the crew and/or unit maintenance personnel can correct by "immediate action" and continue the mission. Action need not be maintenance, but may be simply rerunning the "beginning operations" procedures. In a test environment, there will usually be test-peculiar analysis and diagnostic time associated with the action. Delete test-peculiar time before scoring this incident. The time limit set is the maximum downtime of a MEF which would not result in a serious impact on the effectiveness of the system. Breaching a launch window by more than 15 minutes will, in all cases, disqualify an incident from this category.

f. (U) Step 6. Loss of MEFs and Mission Capability.

(1) (U) Question: Were there any losses of MEFs that occurred from the beginning of preflight to complete system shutdown?

(2) (U) Procedure: If the answer is yes, proceed to step 6. If no, score SCD(1) = Y and go on to step 7.

(3) (U) Expansion: Answer yes to this question if there was a MEF lost or degraded beyond utility and the incident occurred during flight time. Incidents found during post-flight that are deemed to have occurred during the operating time and would have affected any MEFs, including those not exercised for the particular mission at hand, are to be charged as MAFs, unless they can be corrected in 60 clock minutes or less. Incidents which cause the loss of a MEF or mission capability, but occur outside the flight time, are counted as EMAs. This question incorporates effects on any type of mission the aircraft may have had to perform (the meaning of the "could have caused" phrase in paragraph 2c). If an item is fully redundant, a malfunction is not scored as an MAF as long as one of the items is functioning. If a back-up system is not fully redundant, a failure of the primary item will be scored as a MAF regardless of the status of the back-up system at the time of the incident. Missions and MEFs are listed in paragraph f.

g. (U) Step 7. Mission Aborts.

(1) (U) Question: Was the mission in progress aborted due to the loss of this MEF?

(2) (U) Procedure: If yes, score as a MAF (abort) and code SCD(1) = A. If no, score as MAF (msn complete) and code SCD(1) = B. Go on to step 7.

(3) (U) Expansion: Step 6 established that there was a MAF that occurred during the mission. This step separates out those MAFs that resulted in an abort of the mission in progress. This could occur at any time from the beginning of preflight to complete system shutdown.

h. (U) Step 8. Not Mission-Capable (NMC) Event.

(1) (U) Question: Was the aircraft down for all missions?

(2) (U) Procedure: If yes, score as a NMC event and an EMA. Code SCD(4) = D, all MSN codes = X, and MEF(1) through MEF(4) = N or X, as appropriate.

(3) (U) Expansion: A NMC event is an incident which causes the aircraft to be incapable of initiating any of the aircraft's designated missions. These are incidents which convert the aircraft to an NMC status.

i. (U) Step 9. EMAs.

(1) (U) Question: Was the aircraft prevented from performing at least one mission?

(2) (U) Procedure: If the incident was an EMA, score the aircraft as partially mission capable (PMC) and the incident as an EMA. Code SCD(4) = E and MEFs and MSNs = N or X, as appropriate.

(3) (U) Expansion: EMAs include all MAFs, all losses of MEF or mission capability that occurred outside the operating time, all NMC events, plus any additional unscheduled maintenance actions (UMA) which required corrective action prior to starting the next mission. If an aircraft is placed in a partially mission capable (PMC) status as the result of an incident, an EMA is required. Repair of a redundant mission-essential component would be included in this.

j. (U) Step 10. UMA.

(1) (U) Question: Was the incident an UMA?

(2) (U) Procedure: If yes, score as an UMA and code SCD(4) = U and all MEFs and MSNs as N. If no, score the incident as a scheduled maintenance action and code SCD(4) = S and all MEFs and MSNs as N. In either case, the aircraft is fully mission capable (FMC) and is scored accordingly.

(3) (U) Expansion: UMAs include all incidents which require corrective maintenance and are not identified as scheduled maintenance as described below. Scheduled maintenance actions are programed services and/or replacements performed at intervals defined by either calendar time or usage (hours, rounds, etc.) as dictated by airworthiness releases. Any impending or actual failure found during a scheduled inspection will be scored on its own merit under the preceding steps. Scheduled maintenance also covers those programed replacements which are not usage-related but which are dictated by measured wear or deterioriation (on-condition maintenance). Replacement of an item or component prior to its reaching the durability requirement will be charged as an UMA and will be scored on its own merit under the preceding steps. Scheduled maintenance also includes daily crew chief inspections, scheduled lubes, services, spectral oil analysis program (SOAP), and periodic cleaning/washing. Unscheduled lubes, services, or SOAP will be scored on their own merit under the preceding steps.

k. (U) Step 11. For each incident, record clock minutes, maintenance man-minutes, MOS, level of maintenance, and repair parts used.

l. (U) Step 12. GFE.

(1) (U) This step identifies the materiel involved in the malfunction as GFE or CFE.

(2) (U) If the problem involved any piece of GFE other than the engine, score SCD(5) = G. If the problem involves the engine, score SCD(5) = E. The entire engine is considered GFE for the purpose of RAM scoring.

(3) (U) If the problem involves CFE, score SCD(5) = C.

m. (U) Step 13. Identification of Chargeable Elements.

(1) (U) This step identifies the operational element primarily responsible for the incident.

(2) (U) Procedure: Assign the test incident to one of the following categories:

(a) (U) Hardware. This includes incidents that are attributable to hardware design. Foreign object damage (FOD) specifically designed against should also be charged to hardware. Built-in test equipment is also included. Code SCD(2) = H.

(b) (U) Operator/crew. If incident was due to an error or FOD caused by the operator or crew personnel, code SCD(2) = O.

(c) (U) Maintenance personnel. If the incident was due to an error or FOD caused by maintenance personnel, code SCD(2) = M.

(d) (U) Software. This includes incidents that are attributable to characteristics of embedded computer software. Each occurrence of a recurring embedded software incident will be scored on its own merit. Code SCD(2) = S.

(e) (U) Diagnostic. Diagnostic cues are considered to be all automatic test equipment and test measurement and diagnostic equipment external to the aircraft system. Code SCD(2) = J.

(f) (U) Support equipment. This support equipment includes special and common tools, etc. Code SCD(2) = C, if common, and SCD(2) = P, if test-peculiar.

(g) (U) Technical documentation. This includes incidents that are attributable to misleading, incorrect, or missing information located in operator's manuals, maintenance manuals, etc. Code SCD(2) = T.

(h) (U) Unknown. This includes incidents where the operator notices a malfunction, but maintenance personnel cannot duplicate the malfunction. Code SCD(2) = U.

(i) (U) Not applicable. This block is used primarily for no test situations, a scheduled maintenance action, or any type of incident that is not a MAF.

(j) (U) Fasteners. This block is used if the problem involves fasteners, cowling latches, fire extinguisher clips, and other types of fasteners.

(k) (U) Nonfailure but service necessary. This block is used for services that are found necessary but are not performed as part of ordinary preventive maintenance tasks. These services are not system failures. System failures should be scored as such elsewhere in this flow chart.

T-I-6. (U) CODES. The following computer codes are used to facilitate the handling of large numbers of test incidents:

SCD(1) = Classification

A - (msn abort)

B - (msn complete)

P - Crew-correctable maintenance action

N - No test

Y - Other

SCD(2) = Type of Malfunction (Chargeability)

C - Common support equipment

D - Dependent malfunction

H - Hardware

J - Diagnostic

M - Maintenance

N - Not applicable

O - Operator/Crew

P - Peculiar support equipment

S - Software

T - Technical documentation

U - Unknown

X - Continuation of maintenance

F - FOD

Z - Fasteners

B - Nonfailure; service necessary

SCD(3) - Safety Classification (MIL-STD 882A)

A - Category I - Catastrophic

B - Category II - Critical

C - Category III - Marginal

D - Category IV - Negligible

N - Safety not affected

SCD(4) = Maintenance Classification

E - Essential maintenance action

D - Not mission capable

U - Unscheduled maintenance action

S - Scheduled maintenance action

N - Not applicable

MEF(i) = Mission-Essential Function Affected

Scored as:

X = Mission-essential function lost

N = Not affected

MEF(1) - The aircraft must fly adequately to permit satisfactory and expeditious accomplishment of all specified missions. Included in this definition are all of the airframe, powertrain, and dynamic components necessary to fly the aircraft.

MEF(2) - The communication systems must be capable of allowing the crew to perform all specified missions. This includes both air-to-air and air-to-ground communications as specified in the mission profiles.

MEF(3) - The navigation systems onboard must be capable of allowing the crew to perform all specified missions.

MEF(4) - The weapon systems must be capable of engaging ground and air targets as specified in the mission profiles.

MEF(5) - The target acquisition system must be capable of acquiring and designating air and ground targets as specified in the mission profiles.

MEF(6) - The ASE must function in a manner that will allow the crew to perform all specified missions.

MSN(i) = Mission Capabilities Affected

Scored as:

X = Mission capability lost

N = Not affected

MSN(1) - Attack.

MSN(2) - Special operation force strike.

MSN(3) - Reconnaissance and security.

MSN(4) - Rear area combat operations.

MSN(5) - Field artillery aerial observer.

NOTE: Matrices have been developed to aid the scorer in determining whether a mission capability or MEF was lost; the matrix shows a relationship between MEF and mission, and individual subsystems to MEF.

T-I-7. (U) SYSTEM DEFINITION. The system is considered to be one aircraft and crew and all support equipment. The scope of these failure definitions includes all components and subsystems of the system, any peculiar ancillary items, all peculiar support equipment required for operation of the system, any peculiar support equipment required for maintenance or storage, and all fittings, interface elements, and hardware required inside or outside the aircraft. Any critical dedicated nonpeculiar support item will be considered as part of the system on its own merit. The above definition does not necessarily incorporate the same hardware as the materiel developer's contractual specification.

T-I-8. (U) RAM TERM DEFINITIONS.

a. (U) Reliability.

(1) (U) Definition of reliability. MIL-STD 721C defines reliability as the probability that an item will perform its intended function for a specified interval under stated conditions. The specified intervals for this requirement are the operational mission durations as defined in the OMS/MP section of this annex.

(2) (U) Abort. The loss of a MEF from the beginning of preflight to complete system shutdown, if essential to completing the specific mission at hand, is considered to constitute a mission abort. Operating time is considered flight time, and flight time for this scoring criteria is defined in accordance with AR 95-1.

(3) (U) Reliability measures.

(a) (U) MTBMAF. MTBMAF is the total flight time of an item divided by the total number of losses of MEFs which occurred from the beginning of preflight to complete system shutdown. Losses of MEFs which occurred outside these parameters are counted as EMAs.

(b) (U) Mean time between essential maintenance actions (MTBEMA). MTBEMA is the total flight time of an item divided by the total number of EMAs incurred over the calendar time period in which the flight time of the item was accumulated. An EMA is a maintenance action which cannot be deferred and causes the loss of one or more MEFs.

(c) (U) Mean time between unscheduled maintenance actions (MTBUMA). MTBUMA is the total flight time of an item divided by the total number of UMAs incurred over the calendar time period in which the operating time of the item was accumulated. Simultaneous UMAs which are required to correct unrelated failures will be charged as separate maintenance actions, chargeable to the applicable time period. The MTBUMA includes all deferred maintenance actions at the end of the test period.

b. (U) Maintainability.

(1) (U) Definition of maintainability. AR 702-3 defines maintainability as a characteristic of design and installation which provides inherently for the item to be retained in, or restored to, a specified condition within a given time when the maintenance is performed in accordance with prescribed procedures and resources.

(2) (U) Maintainability measures.

(a) (U) Mean time to repair (MTTR). MTTR is the average corrective maintenance time to perform a corrective maintenance action. It applies to all maintenance excluding depot-level repair. All time associated with maintenance tasks as defined in MIL-STD 721C; i.e., fault isolation, system checkout, etc.; will be charged to the appropriate maintenance action. Tasks which relate to work area preparation will be included.

(b) (U) Maintenance ratio (MR). MR is the total number of man-hours of maintenance performed both on- and off-system during a given period of time divided by the total flight time during the period. The MR is expressed as an overall value and also for specific levels of maintenance. Both corrective and preventive maintenance are included.

(3) (U) On-system maintenance. On-system maintenance includes all maintenance performed on the system and components still identified with the system.

c. (U) Availability.

(1) (U) Definition of availability. MIL-STD 721C defines availability as a measure of the degree to which an item is in operable and committable state at the start of the mission, when the mission is called for at an unknown (random) point in time. It does not imply a mission success rate and, therefore, must be considered in concert with the R&M parameters.

(2) (U) Operational availability (A_o). A_o is a measure of the degree to which an item is either operating or is capable of operating at any random point in time when used in a typical maintenance and supply environment. The definition for A_o incorporates clock time over a given calendar period. The formula is:

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(3) (U) System readiness objective (SRO). Based on AR 95-33, SRO is the ratio of the amount of time the item is in mission capable (MC) condition to the amount of total time under consideration. The item is in MC condition when it is in either FMC condition (and therefore able to perform all primary missions) or in PMC condition (and therefore able to perform at least one primary mission). The item is not in MC condition (NMC) when it is down for maintenance (NMCM) or down because parts are not available from supply (NMCS). AR 95-33 provides readiness objectives for specific types of aircraft, giving percentages of MC, NMCS, and NMCM time, to be used as standards for fielded equipment.

$$\text{SRO} = \frac{\text{Total time - total downtime}}{\text{Total time}}$$

or

$$\text{SRO} = \frac{\text{OT} + \text{ST}}{\text{OT} + \text{ST} + \text{TCM} + \text{TPM} + \text{TALDT}}$$

where: OT = Operating time during a given calendar period.

ST = Standby time (not operating but presumed operable) per given calendar time period.

TCM = Total downtime for corrective (unscheduled) maintenance in clock hours during the stated period. Any corrective maintenance actions found during preventive maintenance, that could be corrected within 2 hours, will not be counted. (IAW AR 95-33)

TPM = Total downtime for preventive maintenance in clock hours during the stated period. Any preventive maintenance action which does not cause the aircraft system to be in a nonoperational status for more than 2 hours will not be counted. (IAW AR 95-33)

TALDT = Total administrative and logistic downtime spent waiting for parts, maintenance personnel, or transportation per given calendar period.

ANNEX II TO APPENDIX T

MATERIEL DEVELOPER ANALYSIS (U)

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ANNEX II TO APPENDIX T

MATERIEL DEVELOPER ANALYSIS (U)

T-II-1. (U) INTRODUCTION. The LHX is an Army development effort for a new family of light rotorcraft intended to replace the more aged aircraft systems in the current light fleet. The LHX is expected to be more reliable and less of a maintenance burden than these current light aircraft. The following analysis for the LHX was completed by the materiel developer.

T-II-2. (U) MATERIEL DEVELOPER'S ANALYSIS.

a. (U) Support Concept. The LHX is expected to use a two-level support/three-level supply system. The two maintenance support levels are aviation user maintenance (AVUM) and depot. AVUM will encompass all flight line and unit level type maintenance as is currently performed for Army aviation. This will basically limit AVUM maintenance to removal/replacement actions to effect an aircraft/system repair. Actual component repair will then be performed at the depot level. Variations within the two-level maintenance concept will be studied through additional independent contractual studies and the LSAR process. These variations will be effected by the degree of functional partitioning, integrated diagnostics, and improved testability that will be employed in the aircraft design.

b. (U) Administrative and Logistics Downtime (ALDT). ALDT is the administrative and logistics downtime spent waiting for parts, maintenance personnel, or transportation caused by essential maintenance actions (EMA). For this analysis, an ALDT decision tree model was developed for both peacetime and wartime conditions.

(1) (U) Figure T-II-1 presents the schematic for determining the ALDT in a wartime condition. Figure T-II-2 6-1 presents the supporting rationale and figure T-II-3 presents the analytical calculations. The outcome of this analysis determined the ALDT in this condition to be 5.0 hours.

(2) (U) Figure T-II-4 presents the schematic for determining the ALDT in a peacetime condition. Figure T-II-5 presents the supporting rationale and figure T-II-6 presents the analytical calculations. The outcome of this analysis determined the ALDT in this condition to be 22 hours.

(3) (U) The in-house analysis was performed using HQ AVSCOM resources and personnel from Product Assurance, Integrated Logistics, and from expertise within the LHX PMO.

(4) (U) Data Elements.

(a) (U) Order ship time for priority group 1 part requisitions: 35 days (estimate).

Wartime ALDT

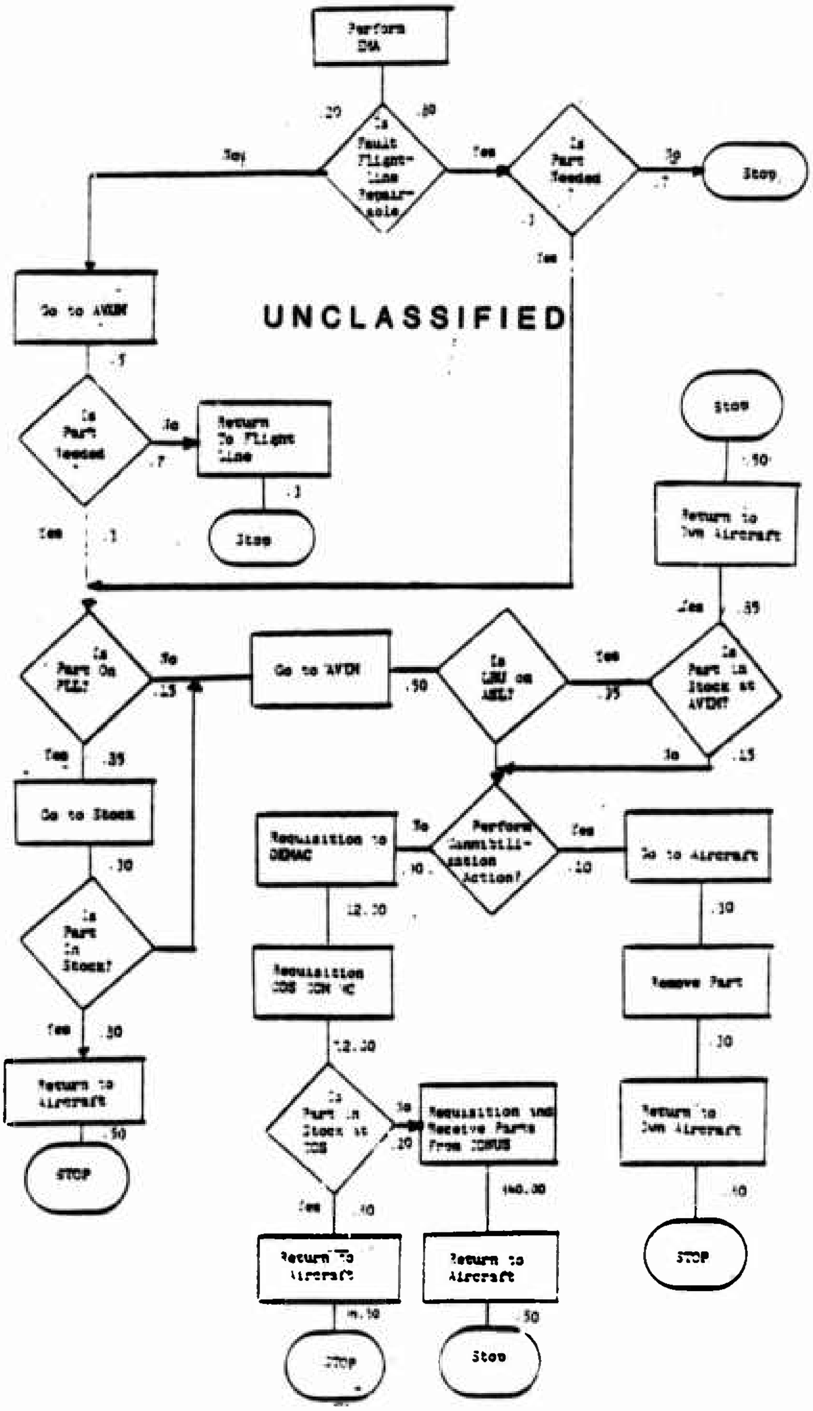

Figure T-II-1. (U) Wartime ALDT decision tree.

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Decision Point/Delay Time	Probability of Yes	Delay (hours)	Source
Can flight line repair failure?	0.8		
Is part required to repair?	.3		Sample data collection and in-house analysis
Delay to go to aviation unit maintenance (AVUM).		.5	In-house analysis
Is part required to repair?	.20		Sample data collection
Failure?			
Is part on prescribed load list (PLL)?	.85		In-house analysis
Delay to go to stock.		.3	In-house analysis
Is part in stock at AVUM?	.80		In-house analysis
Delay to return to aircraft.		.5	In-house analysis
Delay to go to aviation intermediate maintenance (AVIM).		.5	In-house analysis
Is line-replaceable unit (LRU) on authorized stockage list (ASL)?	.95		In-house analysis
Is LRU in stock at AVIM?	.85		In-house analysis
Delay to return to aircraft.		.5	In-house analysis
Is LRU available by cannibalization?	.10		In-house analysis
Go to aircraft.		.3	In-house analysis
Remove LRU.		.3	In-house analysis
Delay to return to own aircraft.		.8	In-house analysis
Requisition to DMAC.		12.0	In-house analysis
Requisition to COSCOM MMC.		12.0	In-house analysis
Are parts in COSCOM stock?	.80		In-house analysis
Deliver parts to AVIM and return to aircraft.		96.5	In-house analysis
Send requisition and receive part from CONUS at AVIM.		840.00	ALOC Performance Evaluation
Return to aircraft.		.5	In-house analysis

NOTE: Sample data collection source on the UH-60 Black Hawk and AH-1S Cobra aircraft.

Figure T-II-2. (U) Two-level wartime data.

(Sectional Method)

Section I. This section considers the probabilities and delay time after the delay for going to AVIM.

		Time (Hours)
((((96.50 + 12.00 + 12.00).80).90).05)	=	4.34
(((((96.50 + 12.00 + 12.00).80).90).15).95)	=	12.36
((((.50 + 840.00 + 12.00 + 12.00).20).90).05)	=	7.78
((((.50 + 840.00 + 12.00 + 12.00).20).90).15).95)	=	22.17
(((.80 + .30 + .30).10).05)	=	.01
((((.80 + .30 + .30).10).15).95)	=	.02
(.50)(.85)(.95)	=	.40
Section I Total:		47.08

Section II. This section considers the probabilities and delay times after initiating a repair action up to and including the delay for going to AVIM. The total for this section represents the ALDT for this condition.

		Time (Hours)
(((((47.08 + 0.5 + 0.3 + 0.5).2).85).3).2)	=	.493
((((47.08 + 0.5 + 0.3).2).85).3).8)	=	1.95
((((47.08 + 0.5 + 0.5).15).3).2)	=	.435
((((47.08 + 0.5).15).3).8)	=	1.710
(((((0.5 + 0.3 + 0.5).8).85).3).2)	=	.060
(((((0.5 + 0.3).8).85).3).8)	=	.135
(((0.3 + 0.5).7).2)	=	.112
Section II Total:		5.0

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Figure T-II-3. (U) Two-level wartime condition ALDT calculations.

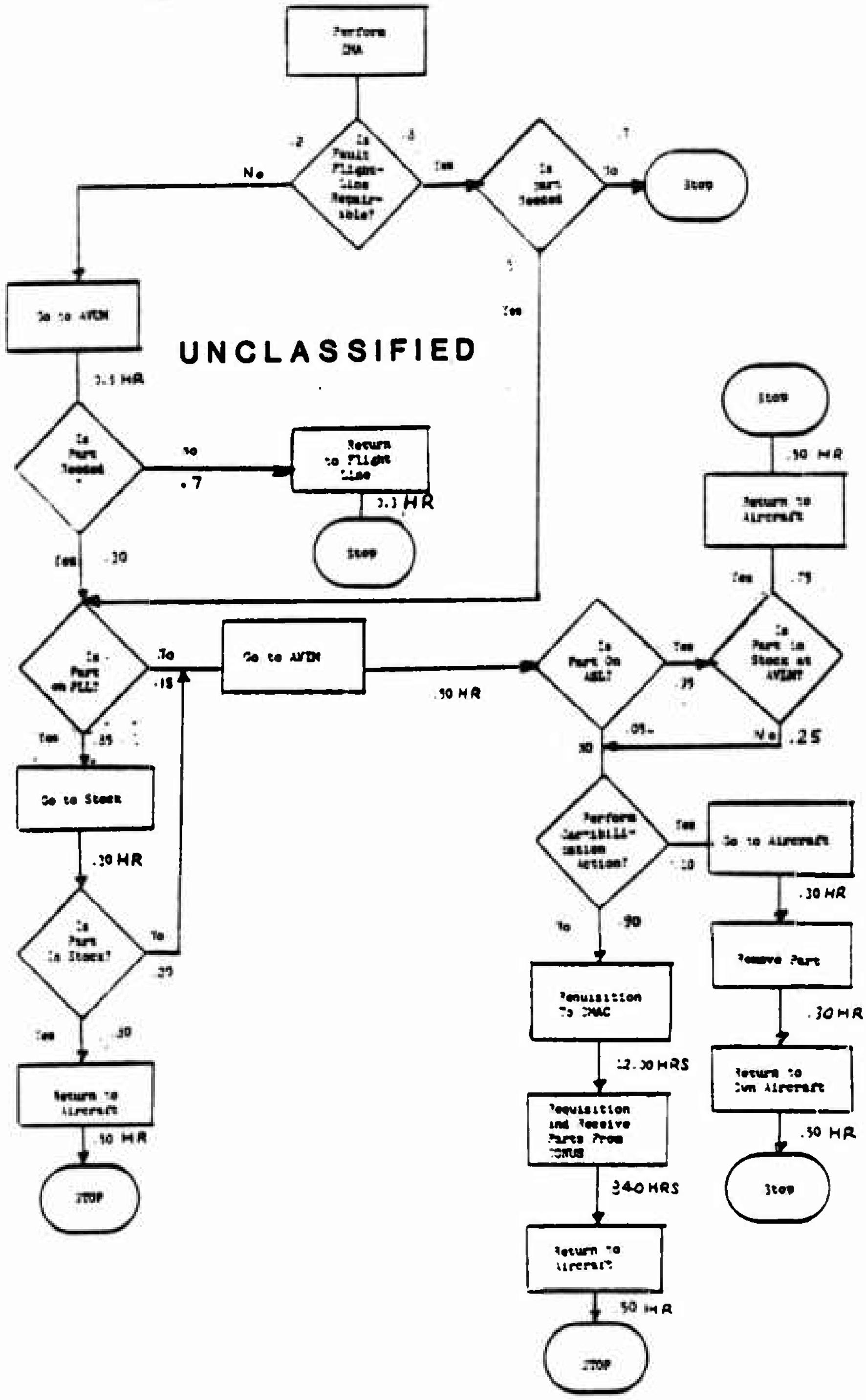

Figure T-II-4. (U) Peacetime ALDT decision tree.

DECISION POINT/DELAY TIME	PROBABILITY OF YES	DELAY (HRS)	SOURCE
Can flight-line repair failure?	.80		
Is part required to repair?	.3		Sample data collection
Delay to go to AVUM.	.3	.5	In-house analysis
Is part required to repair failure?	.20		Sample data collection
Is part on PLL?	.85		In-house analysis
Delay to go to stock.		.3	In-house analysis
Is part in stock at AVUM?	.80		In-house analysis
Delay to return to aircraft.		.5	In-house analysis
Delay to go to AVIM.		.5	In-house analysis
Is LRU on ASL?	.95		In-house analysis
Is LRU in stock at AVIM?	.75		In-house analysis
Delay to return to aircraft.		.5	In-house analysis
Is LRU available by cannibalization?	.10		In-house analysis
Go to aircraft.		.3	In-house analysis
Remove LRU.		.3	In-house analysis
Delay to return to own aircraft.		.8	In-house analysis
Requisition to DMAC.		12.0	In-house analysis
Send requisition and receive part from CONUS at AVIM.		840.0	ALOC performance
Return to aircraft.		.5	In-house analysis

NOTE: Sample data collection source is on the UH-60 Black Hawk and AH-1S Cobra aircraft.

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Figure T-II-5. (U) Two-level ALDT peacetime data.

(Sectional Method)

Section I. This section considers the probabilities and delay time after the delay for going to AVIM.

		Time (Hours)
(((.50 + 840.00 + 12.00).90).05)	=	38.36
((((.50 + 840.00 + 12.00).90).25).95)	=	182.2
(((.80 + .30 + .30).10).05)	=	.01
((((.80 + .30 + .30).10).25).95)	=	.033
(.50)(.75)(.95)	=	.36
Section I Total:		221.

Section II. This section considers the probabilities and delay times after initiating a repair action up to and including the delay for going to AVIM. The total for this section represents the ALDT for this condition.

		Time (Hours)
(((((148.12 + .5 + .3 + .5).2).85).3).2)	=	2.27
(((((148.12 + .5 + .3).2).85).3).8)	=	9.05
((((148.12 + .5 + .5).15).3).2)	=	2.00
((((148.12 + .5).15).3).8)	=	7.97
(((((0.5 + 0.3 + 0.5).8).85).3).2)	=	.053
(((((0.5 + 0.3).8).85).3).8)	=	.131
(((0.5 + 0.3).7).2)	=	.112
Section II Total:		22.

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Figure T-II-6. (U) Two-level peacetime condition ALDT calculations.

(b) (U) Sample data collection was queried to determine the percent of red X and circle red X events requiring a part. For the AH-1SM, 9.74 percent of all red X and circle red X events required a part. The percentage for the UH-60A was 11.0 percent. For the LHX, the percentage is estimated to essentially triple due to increased/improved fault detection capabilities and increased mission equipment which is basically repaired by replacement. The LHX part replacement is estimated at 30 percent.