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AVIATION SUPPORT FACTORS FOR AIRMOBILITY

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CHAPTER 1

INTRODUCTION

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INTRODUCTION

PURPOSE

The purpose of this Report is to establish factors relative to aircraft readiness, utilization, maintenance and supply involved in Airmobile compared with Conventional Divisions. It is intended to provide factual data applicable for subsequent use in a computer simulation of support requirements under the respective concepts. Hence, emphasis is given to those parameters relative to the APJ AIMS simulation approach.

OBJECTIVES

The objectives of this program are threefold:

1. To provide a comparative analysis of the Airmobile concepts, policies and procedures as they affect organization of aviation support in practice.
2. To establish, insofar as possible, operating, maintenance and supply factors which describe Airmobile and Conventional Division aviation support operations.
3. To emphasize data applicable to the simulation of support requirements.

The first objective was discussed in the companion report, APJ 500-1 (Reference 1) which provides a comparative analysis of the Airmobile concept, policies and procedures, as they affect aircraft support.

Airmobility support has been studied by APJ in a series of reports beginning with the Howze Board, through the 11th Air Assault Division Tests, and current operations in Vietnam of the 1st Cavalry Division, APJ 401-107, (Reference 2). The continuing evolution of the Airmobile Division and the adaptation of its operating procedures to the Vietnam combat environment have produced changes in maintenance and support procedures which reflect the underlying concepts of airmobility in actual practice.

The second and third objectives are the primary subject of this Report and the following topics are covered, following a discussion of the concept and requirements of the support system of simulation.

1. Aircraft maintenance and readiness transition
2. Operational readiness
3. NORM maintenance at all levels
4. NORS maintenance at all levels
5. Utilization
6. Mission patterns, including missions per day, mission types and mission man-hours
7. Maintenance personnel requirements
8. Maintenance performance relationships.

DATA BASE

The data and information for this Report were obtained over a three-year period by APJ field representatives operating in Vietnam. Each man spent extended periods of time with each unit of both Divisions under all operating conditions. Emphasis has been given to observations during mid- and late 1967. Very substantial quantities of data were obtained from the following sources:

a. Special information data collection forms prepared by APJ for use in Vietnam.
b. The APJ designed Daily Aircraft Status Form 469-06-512(03).
c. Observations as documented in APJ Visit Reports and other standard APJ data collection procedures.
d. Records maintained by each unit under the Army TAERS system.
e. Reports and information received from the Airmobile and ROAD Divisions relating to their operations in Vietnam.
f. Army Regulations, Field and Technical Manuals governing supply and maintenance procedures at all levels within divisional operation.

Data collection was performed in accordance with the data collection plan established in Contract No. DA 23-204-AMC-03519(T), which provided for maximum intensity of sampling in key areas of maintenance and support. Where special operational technical conditions, e.g., special maintenance requirements arising from Modification Work Orders and the like, have an impact on the data cited, this is discussed in the analysis.

This Report must be viewed as a further step in the collection and analysis of empirical data which is essential for the continued progress of Army aviation. Without a strong factual basis for the establishment of doctrine, policies and procedures, there is a high probability that the desired objectives of innovation will not be attained. The major conclusion follows that there is a continuing requirement for data collection, analysis, and refinement of information which enables the best selection to be made among resources and their application.

CHAPTER 2

SIMULATION

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SIMULATION

DESCRIPTION

Simulation has broad applications in investigations of new ideas or hitherto untried courses of action. This powerful research tool allows a course of action to be tested, and its impact observed and estimated, without actually taking that particular course of action. The use of simulation requires the building of a model which, when operated, produces results similar or parallel to those which would occur under the actual implementation.

TYPES OF SIMULATION

A model may be physical or mathematical. The nature of the model used depends on the idea or course of action that is being investigated. The two main restrictions which dictate the type of model used are time and cost. In general, physical simulations are used only when the time and cost requirements of the simulation are low. Since these two requirements generally increase rapidly with the complexity of the idea or course of action to be simulated, physical simulations are most often reserved for the investigation of simple ideas or courses of action. An example of a simple physical model is a scaled down, operating replica of a large piece of mechanical equipment. Another example of a simple physical simulation is the repeated execution of a football play during practice in preparation for a game.

Not all simple simulations are physical simulations. Many simple simulations involve the use of mathematical models. The calculation of the required number of gallons of gasoline for an automobile trip is an excellent example of a simple mathematical simulation. Another example is the budgeting of earnings to anticipate future expenses. In this last example, we would be simulating future expenses on paper in order to determine whether or not we could meet them.

As ideas and courses of action become more complex, the rapidly increasing cost and time requirements of a physical simulation make a physical model impractical. An example of a complex course of action that would be very costly and time consuming, if investigated using a physical simulation, is a full scale involvement of men and materiel to test a tactical concept. This is clearly demonstrated by the costs and time requirements of maneuvers performed by the Army such as the 11th Air Assault Division tests and the Desert Strike maneuver.

COMPUTER SIMULATION

Until the development of the highly sophisticated digital computer now available to perform complicated and involved mathematical calculations, the only alternatives to large scale complex investigations (such as the maneuvers mentioned above) would be scaled-down maneuvers, maneuvers involving small elements of the larger force, highly simplified mathematical models, or combinations of these three. None of these alternatives provides a complete or unified solution for simulating complex ideas. The digital computer is capable of processing mathematical simulations of proportions equal to or greater than those of the abovementioned maneuvers. In addition to their large capacity for mathematical operations, digital computers are able to solve simulation problems in less time and at less cost than any other alternative available to date.

INPUTS

Mathematical models for computer simulations require three basic elements:

1. Simulation logic
2. Rules of simulation
3. A data base which defines initial as well as operating conditions of the problem being simulated.

The simulation logic defines the steps the computer takes to perform each mathematical calculation to simulate the system under investigation. Figure 2-1 presents an example of the logic flow that would be used in a computer simulation. This illustrates one approach to the determination of the flow of maintenance through organizational level, and is called the "Org Routine".

The logic of this routine requires the computer to determine whether or not the aircraft being reviewed is Operationally Ready. If the aircraft is not in an Operationally Ready condition, the computer then determines whether or not the aircraft is at Organizational Maintenance. If the aircraft is at Organizational Maintenance, the computer then estimates the number of elapsed hours that are required to complete the

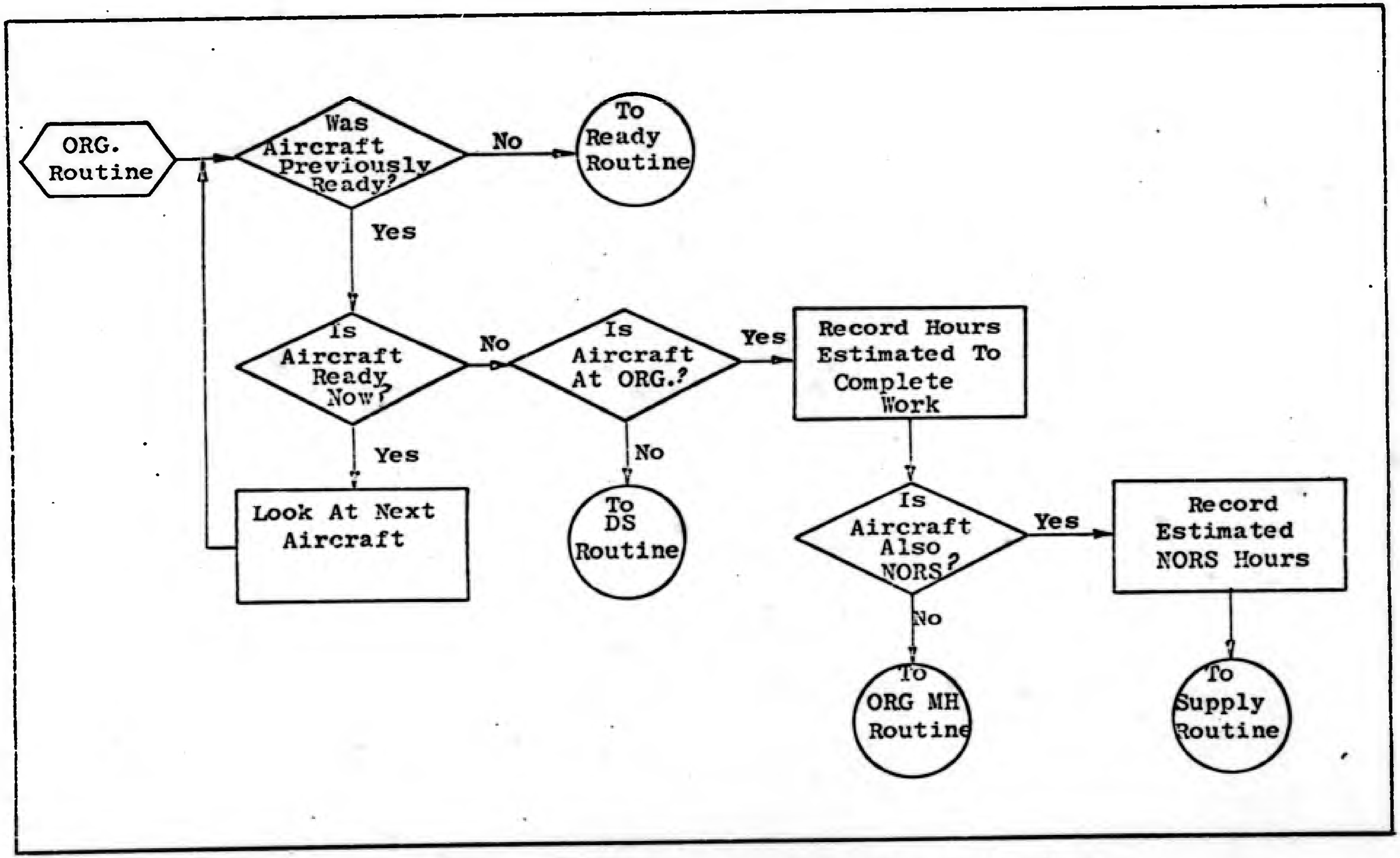

Figure 2-1. Example of Computer Simulation Logic Flow

maintenance and records this figure on the aircraft status record. Using this routine, the computer then determines whether or not the aircraft will be NORS, and if so, the number and type of parts that would cause the aircraft to be NORS, and the number of man-hours required to complete the total job. It accomplishes this by going to the "Org Man-hour Routine" and the "Supply Routine".

With a series of routines which essentially forms a chain, the logic of the simulation guides the computer in its calculations so that it can follow each aircraft by serial number through each level of maintenance and through its Operational Readiness condition. Generally, a computer simulation would contain many routines similar to that indicated in Figure 2-1 and, also, these routines would be much larger than that example.

The second major basic inputs to a computer simulation are the operating constraints which are defined by the policies and procedures used in aircraft maintenance and operation. These bounds are programmed into the logic flow to guide the computer through its calculations in agreement with universal as well as local practices in Army aviation logistical support and operations. A brief typical list of operating constraints that would be included as part of a computer program simulation are:

1. The time between inspections for each type of inspection
2. The number of types of inspections that would be performed on aircraft
3. Time limitations on maintenance by level of maintenance
4. The level of maintenance at which each maintenance function is to be performed, and the issue of replacement parts.

The final computer input is the data base which defines the initial as well as the operating conditions. The data base establishes the point in time at which the simulation is to begin and provides quantitative factors with which the computer operates.

The mathematical simulation of aviation maintenance and operating problems is best performed using a probabilistic mathematical model. This category of models requires that the data base inputs be of a statistical nature. The specific form of the statistical inputs is that of:

1. Probability distributions
2. Mathematical expectations.

All of the results presented in this and subsequent reports have been prepared in the form of probability distributions and mathematical expectations.

OUTPUTS

The outputs from a mathematical simulation are dependent upon the statistical and other inputs into the computer. If the data base and the operating constraints are the same as those of a system presently in operation, the computer will merely simulate the system from which the inputs were drawn. If the data inputs, the operating constraints, and logic flow are changed in any way to reflect a new course of action, the computer output will also reflect these changes. This output can then be compared with the system from which the original data base in other inputs were drawn. Thus, varying the inputs varies the output; that is, what is fed into the computer determines the simulation product. The type of outputs from the computer include:

1. Maintenance and support requirements per flying hour
2. Aircraft readiness measures
3. Aircraft utilization factors
4. Personnel requirements
5. Supply effectivity.

These outputs have the following applications:

1. The determination of the organization and configuration of the maintenance posture and assets which will provide the required support capability to optimize aircraft operation and availability.
2. The determination of the most effective maintenance management of available maintenance resources considering policies, procedures, distribution of assets, etc.
3. The comparison of maintenance and support differences between aircraft by type, model and series in terms of availability and cost of support as they are affected by maintenance resource policies and procedures.

Thus a simulation provides a means by which:

a. A given concept may be measured based on data, rules and the pertinent logic
b. Changes to a concept by comparison can be evaluated
c. New concepts can be measured and compared with previously established concepts.

SIMULATION IN THIS REPORT

The results presented in this Report are concerned with two elements of the simulation picture. The first is the flow of aircraft between levels of maintenance. This is demonstrated in Figure 2-2 which graphically presents a typical time sequence flow of an aircraft between levels of maintenance. The movement of aircraft between levels of maintenance is determined by the maintenance level transition probability which is discussed in Chapter 3. As data inputs, the computer utilizes these probability distributions to simulate the movement of aircraft between levels of maintenance. In Figure 2-2, we find that an aircraft was at Organizational maintenance at some point in time. From Organizational maintenance it was made Operationally Ready and, subsequently was down for maintenance at Organizational level again. Returning to Operational Readiness, it was later to experience some extensive maintenance as it passed through the levels of Direct Support and General Support eventually returning to Operational Readiness. The remainder of the flow can be followed in a similar manner.

The time variable in Figure 2-2 is not to scale as time was used merely to give direction. No quantitative values were assigned to an aircraft at each level of maintenance. This is the second element that is covered in this Report. With the probabilistic distributions and mathematical expectations presented in Chapters 4 through 6 , the computer during the simulation can assign quantitative values to a stay by an aircraft at each maintenance level. This is shown in Figure 2-3 in which the length of time spent

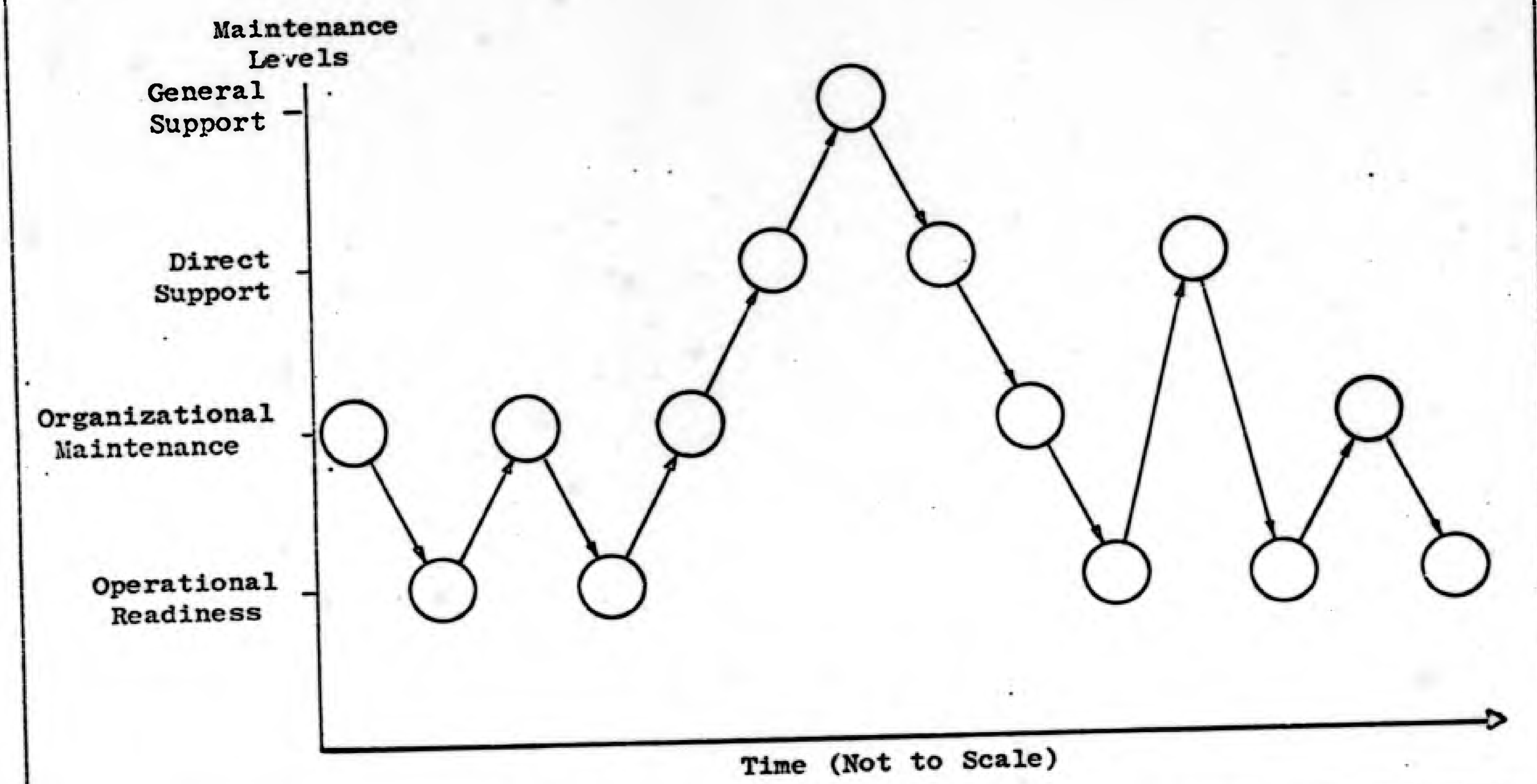

Figure 2-2. Typical Time Sequence Maintenance Flow

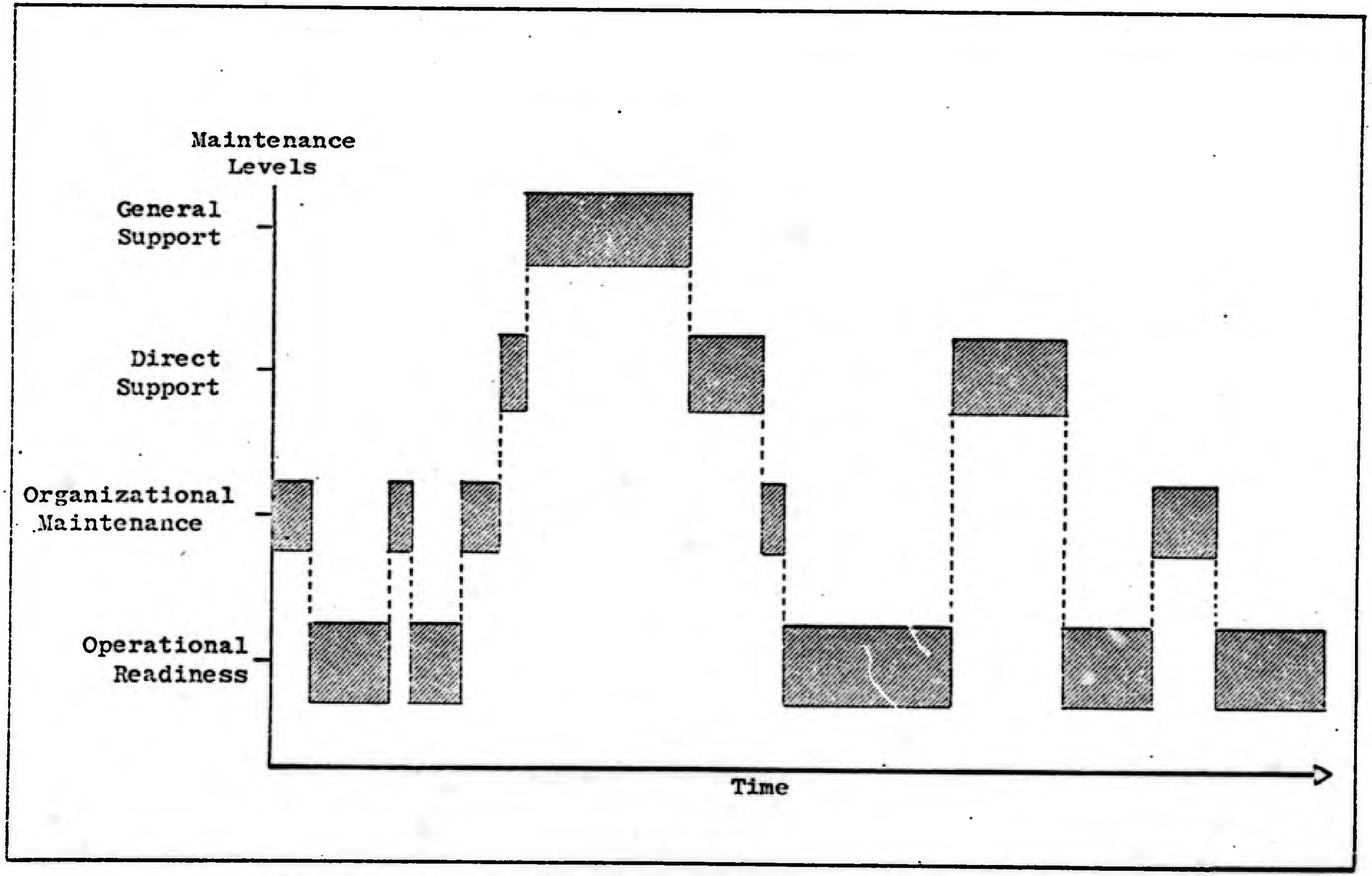

Figure 2-3. Typical Time Sequence Readiness Simulator

at each level of maintenance is indicated for each state of maintenance illustrated in Figure 2-2. The information in Figure 2-3 is for illustration purposes, and only relative values were assigned. It can be seen from these two figures that neither item of information is complete in itself but complement each other and are required to present a complete picture of the movements of aircraft between maintenance levels.

In addition to knowing the level of maintenance and the amount of time spent at a level of maintenance, it is essential to know the details of maintenance performed at each level in order to perform a proper evaluation of each course of action studied. The third element studied for this Report consists of the details associated with Operational Readiness including utilization and mission. These results are discussed in detail in Chapters 7 and 8.

CHAPTER 3

TRANSITION PROBABILITIES

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TRANSITION PROBABILITIES

MAINTENANCE LEVELS

In order to study the flow of aircraft between levels of maintenance, a system of four maintenance states was established. The first state, Operational Readiness, is the maintenance state in which maintenance requirements are accumulated on aircraft through utilization. This is a negative maintenance state, since an aircraft moves towards a non-operationally ready condition. When an aircraft becomes Not Operationally Ready, it moves into one of the other three maintenance states; e.g., Organizational Maintenance, Direct Support, and General Support. These are positive states, because maintenance is performed to place an aircraft in condition to fly.

Together, there are four maintenance states: Operational Readiness (the negative maintenance state) and Organizational Maintenance, Direct Support and General Support (the positive maintenance states). There are other possible maintenance states such as Depot Level Maintenance, aircraft in transit, aircraft which have been rated as a total loss because of combat damage or crash damage, and aircraft which are entering the system either from an aircraft manufacturer or from another Army theater. These last states were not considered for this analysis because they represent the transfer of the aircraft outside the combat operational (and its Direct and General support) areas.

Since the maintenance system for this analysis has been defined to include only four levels, an aircraft must be in one of these four levels at all times. Thus, if an aircraft is Not Operationally Ready, it must be at Direct Support, General Support, or Organizational Maintenance. Likewise, if an aircraft is not at Organizational Maintenance, Direct Support or General Support, it must be Operationally Ready.

TRANSITION PROBABILITY

From one maintenance level an aircraft can move to any of the others. If it is Operationally Ready it can go to Organizational Maintenance, Direct Support, or General Support. Once at a new level, say Organizational level, it then can move to one of the other levels, Operational Readiness, Direct Support, or General Support. The movement of an aircraft from one level to another can continue in this manner. A movement between levels of maintenance is defined to be a transition between maintenance levels. With each transition there is associated a probability, i.e., the percent of chance associated with an aircraft moving from one level to another.

OPERATIONAL READINESS

The concept of transition probability is presented in Figure 3-1. The transition probabilities discussed in this Figure are those for the UH-1B/C aircraft for movement from Operational Readiness to the other levels.

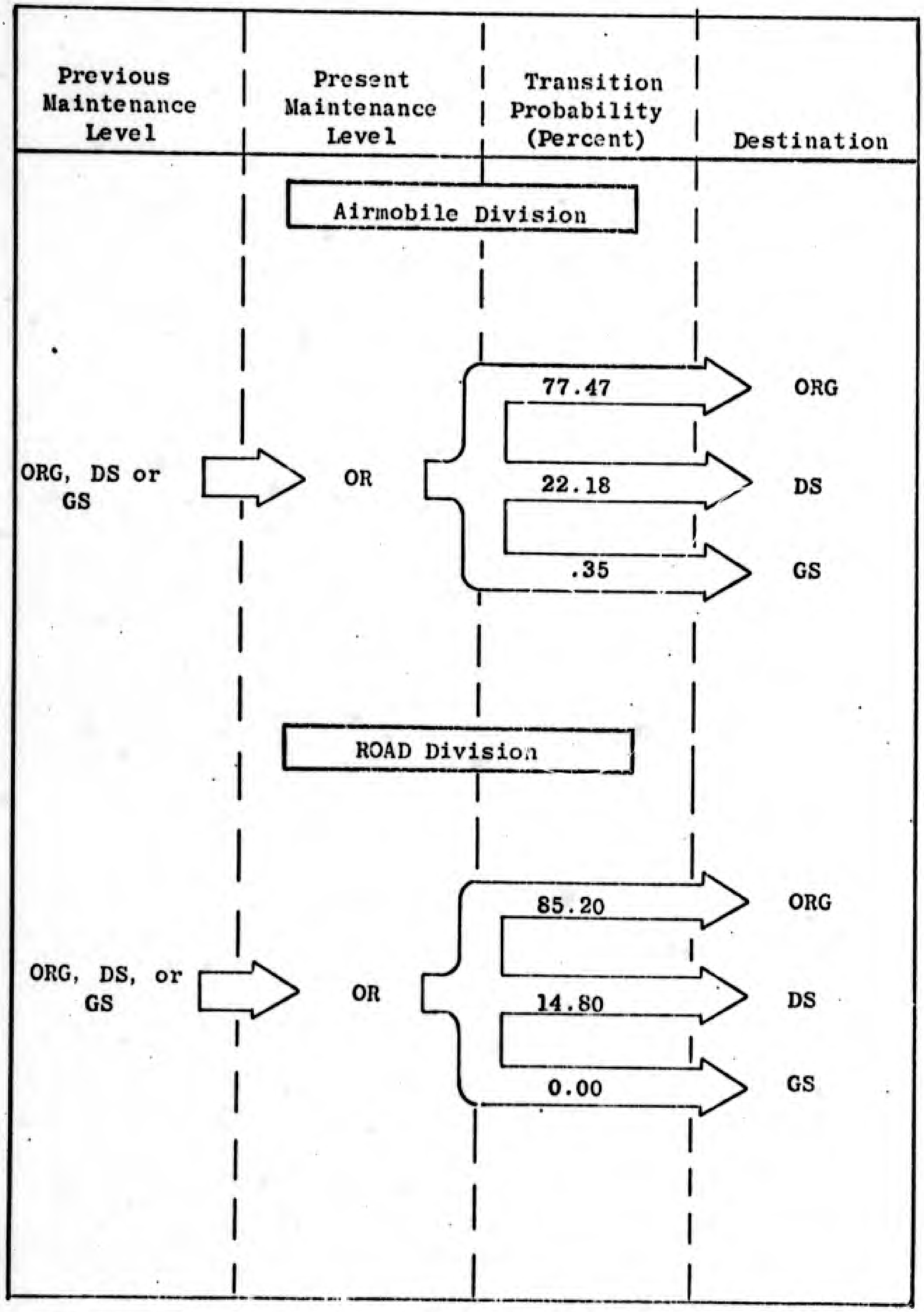


Figure 3-1. UH-1B/C Maintenance Transition Probability Flow Through Operational Readiness

For the Airmobile Division, an Operationally Ready aircraft can move to the Organizational Maintenance with a probability of 77.47%, to the Direct Support with a probability of 22.18% and to the General Support with a probability of .35%. The summation of all probabilities equals 100%, because an aircraft can move from Operational Readiness to only one of three other levels, as mentioned above.

Also shown in Figure 3-1 are the Operational Readiness transition probabilities for the UH-1B aircraft assigned to the ROAD Division. The transition probability from Operational Readiness to Organizational Maintenance is 85.20% and to Direct Support is 14.80%. The transition probability for movement of the UH-1B in the ROAD Division from Operational Readiness to General Support is zero. Aircraft do not move from Operational Readiness to the General Support within the ROAD Division. Rather, all aircraft move to General Support from Operational Readiness via Direct Support.

In addition to the present maintenance level, Figure 3-1 also includes the previous maintenance level. In using the Operational Readiness transition probabilities, the previous maintenance level is not critical. An aircraft can previously have been at any of the other three levels of maintenance: Organizational Maintenance, Direct Support level or General Support level. In studying the transition probability of other maintenance levels, the previous maintenance level is of importance, and will be discussed in more detail where it applies.

In Figure 3-1 the Operational Readiness to Organizational Maintenance transition probabilities are greater than those between Operational Readiness and Direct Support. Both of these probabilities are greater than those between Operational Readiness and General Support. In fact, the probability of an aircraft going from Operational Readiness to General Support is so small it is considered equal to zero for comparative purposes.

The UH-1B aircraft of the ROAD Division have a greater probability of going to Organizational Maintenance from Operational Readiness than those of the Airmobile Division. Because of the complementary nature of the statistics, UH-1B aircraft of the Airmobile Division have a greater probability of going from Operational Readiness to Direct Support than the UH-1Bs of the ROAD Division.

ORGANIZATIONAL MAINTENANCE TRANSITION PROBABILITIES

Figure 3-2 presents the transition probability for aircraft moving from Organizational Maintenance to the other levels. Here the pattern of flow is similar to that studied in the previous Figure. The major change is in the importance of the previous maintenance level. If an aircraft was previously Operationally Ready, and is now at Organizational Maintenance, it can move to any of the other levels. But if the aircraft was previously at Direct Support or General Support maintenance, and is presently at Organizational Maintenance, it can move only into the Operational Readiness state. This last probability is a special condition imposed for the purpose of simulation. It is possible for an aircraft to move from Direct Support or General Support level maintenance down to Organizational level maintenance, and to return to Direct Support

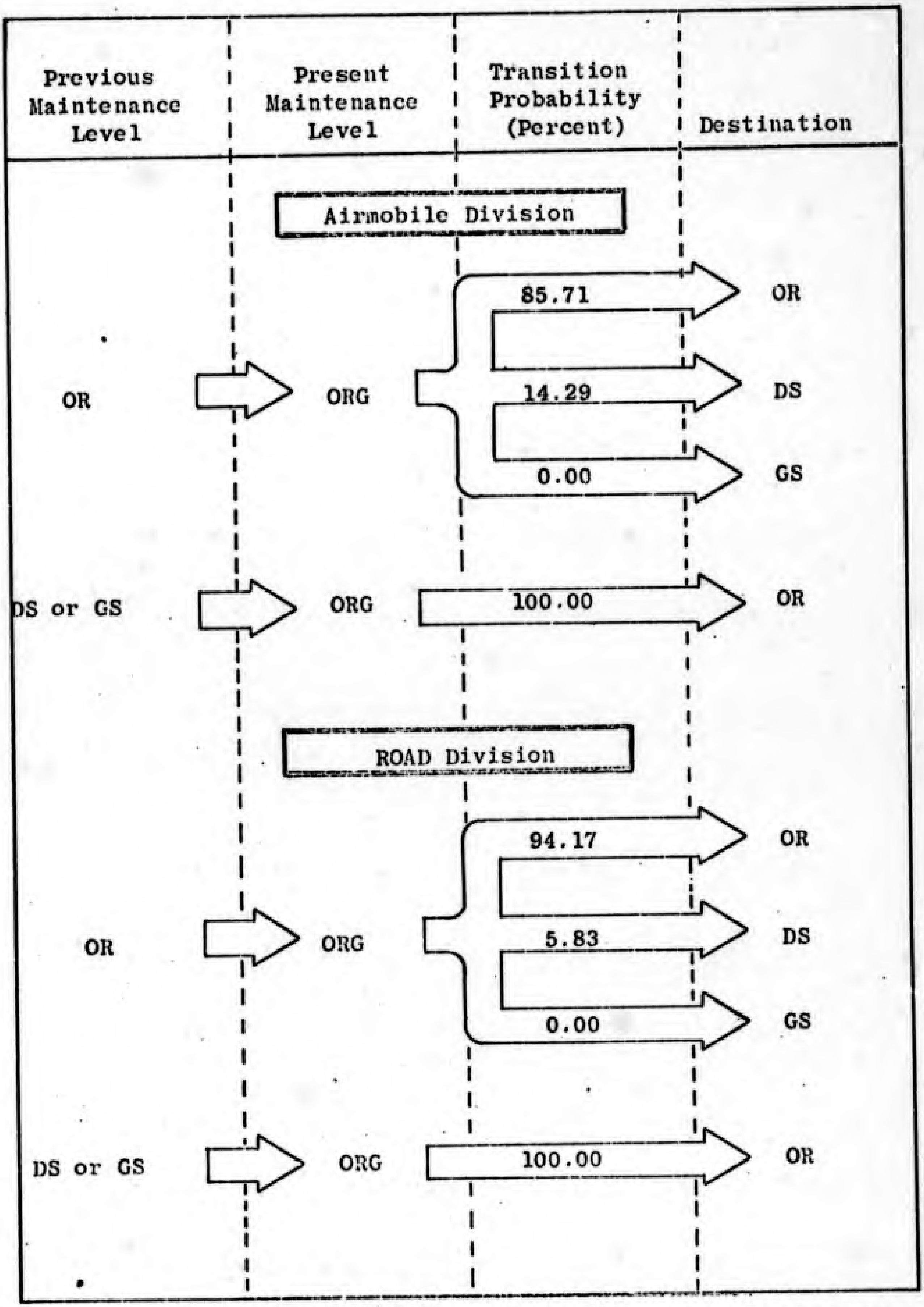


Figure 3-2. UH-1B/C Maintenance Transition Probability Flow Through Organizational Maintenance

or General Support level maintenance. However, this flow of aircraft between levels of maintenance is extremely improbable. Thus, their transition probabilities are essentially equal to zero, and only one transition remains. Therefore, the transition probability from Organizational Maintenance to Operational Readiness has a value of 100%.

For the UH-1B aircraft of both Divisions, the transition from Organizational Maintenance to Operational Readiness has a higher probability than to either of the other two states. Since the transition probabilities from Organizational Maintenance to General Support are zero in both Divisions, the only remaining level into which an aircraft can move is Direct Support. Aircraft of the ROAD Division move more frequently from Organizational Maintenance to Operational Readiness than the UH-1B aircraft of the Airmobile Division (94% versus 86%). Again, because of the complementary relationship between the transition probabilities, UH-1B aircraft of the Airmobile Division have a greater probability of moving from Organizational Maintenance to Direct Support than UH-1B aircraft of the ROAD Division (15% versus 6%).

DIRECT SUPPORT TRANSITION PROBABILITIES

The Direct Support transition probabilities in Figure 3-3 are more complex than those presented for either of the previously discussed levels. Here, as at Organizational Maintenance, the previous maintenance level is critical in determining the movement of UH-1Bs from Direct Support to the other levels. If the previous maintenance level was either Operational Readiness or Organizational Maintenance, aircraft at Direct Support

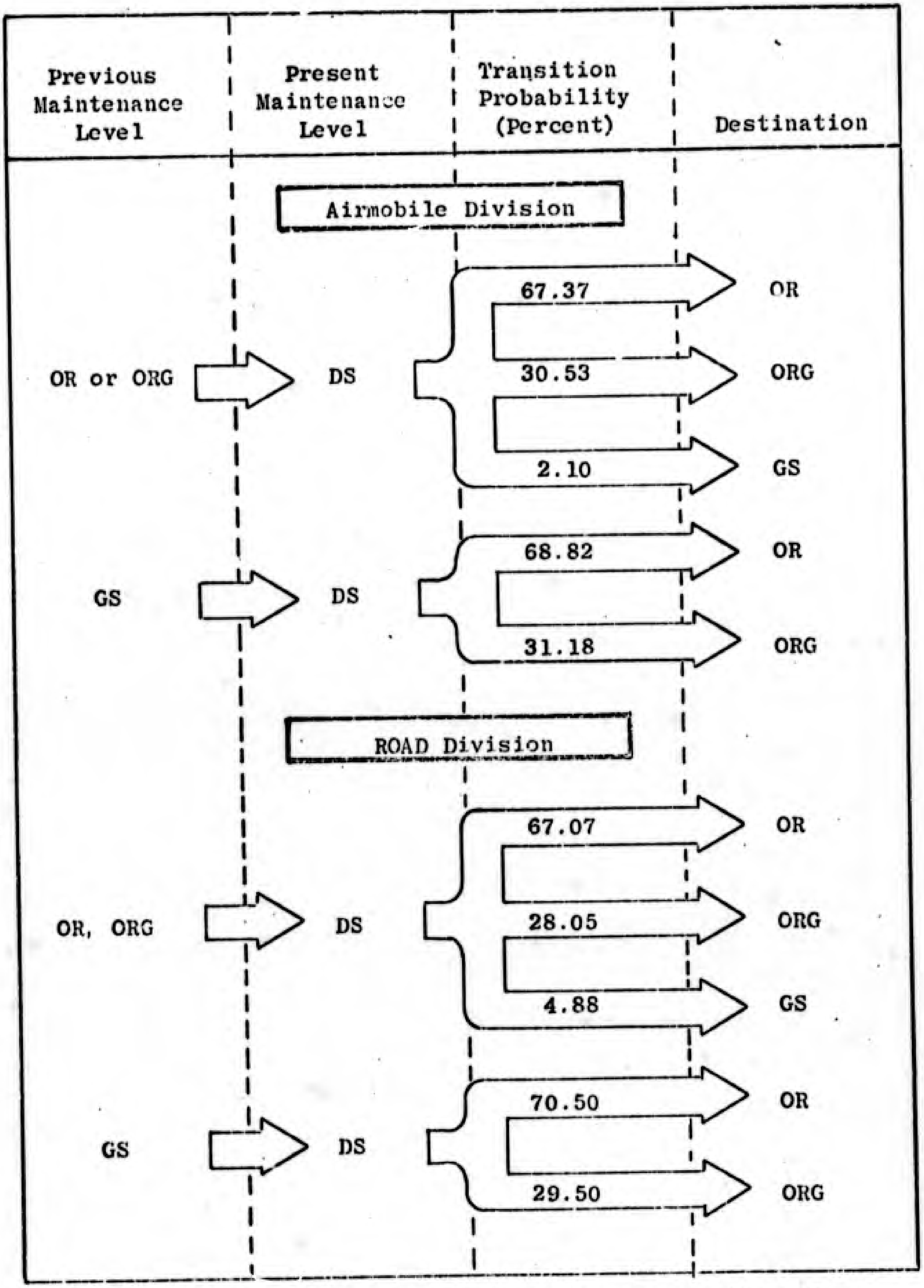


Figure 3-3. UH-1B/C Maintenance Transition Probability Flow Through Direct Support

can move to any of the other levels. But if the previous level was General Support, aircraft have only two alternative levels; Operational Readiness and Organizational Maintenance.

Regardless of the previous maintenance level, probabilities for Direct Support to Operational Readiness are greater than those for Direct Support to Organizational Maintenance. These two probabilities are in turn greater than those for UH-1B movement from Direct Support to General Support.

The transition probabilities for the UH-1B for movement from Direct Support to other levels are approximately the same for both Divisions. Those to Operational Readiness are approximately 67%; those to Organizational Maintenance are approximately 28 to 31%. Here also, the probability of movement from Direct Support to General Support is small with values ranging from 2% to 5%.

GENERAL SUPPORT TRANSITION PROBABILITIES

Figure 3-4 presents the transition probabilities for maintenance flowing from General Support to the other maintenance levels. For these transition probabilities, the previous maintenance level is of no importance. Any maintenance flowing from General Support can move to any of the other levels.

For the UH-1B, these probabilities indicate the general practices within the Divisions concerning the movement of aircraft from General Support. Within the ROAD Division all UH-1B aircraft moving to and from General Support must move through Direct Support

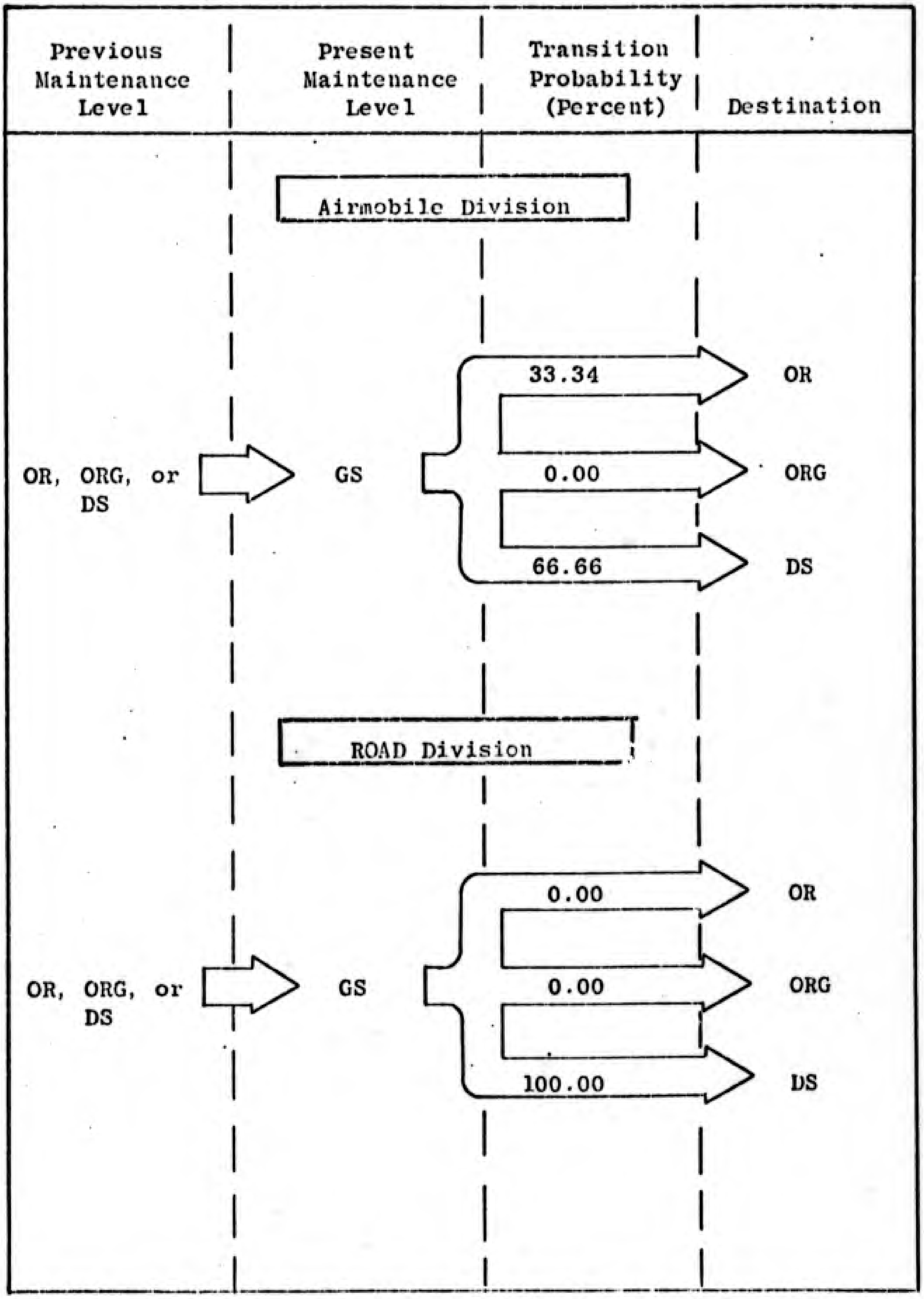


Figure 3-4. UH-1B/C Maintenance Transition Probability Flow Through General Support

Maintenance. Although in the Airmobile Division most aircraft move to and from General Support through Direct Support, some are moved directly to and from Operational Readiness. One-third of the aircraft at General Support goes directly to Operational Readiness. Thirty-two percent of the aircraft at General Support come from Operational Readiness.

TRANSITION PROBABILITY FLOW

The previous four figures present the maintenance flow relationships between specific maintenance levels. Figure 3-5 illustrates a typical time sequence of maintenance which could result from the sequential application of transition probabilities. The flow of an aircraft between maintenance levels is pictured based on the transition probabilities between each pair of levels. The heavy arrows indicate the course followed by the aircraft. The dotted arrows indicate the other possible paths the aircraft might have taken at each maintenance level juncture. These paths were rejected by the random transition probability process. The aircraft moved from an Operational Readiness to the highly probable Organizational Maintenance to the less probable Direct Support to the even less probable General Support. The flow of maintenance between the four maintenance levels can be followed in Figure 3-5.

OTHER AIRCRAFT TRANSITION PROBABILITIES

The transition probabilities for the other aircraft studied are presented in Figures 3-6 through 3-10. Since the data for the OV-1 aircraft of the Airmobile Division were insufficient to establish transition probabilities, only those for OV-1 aircraft of

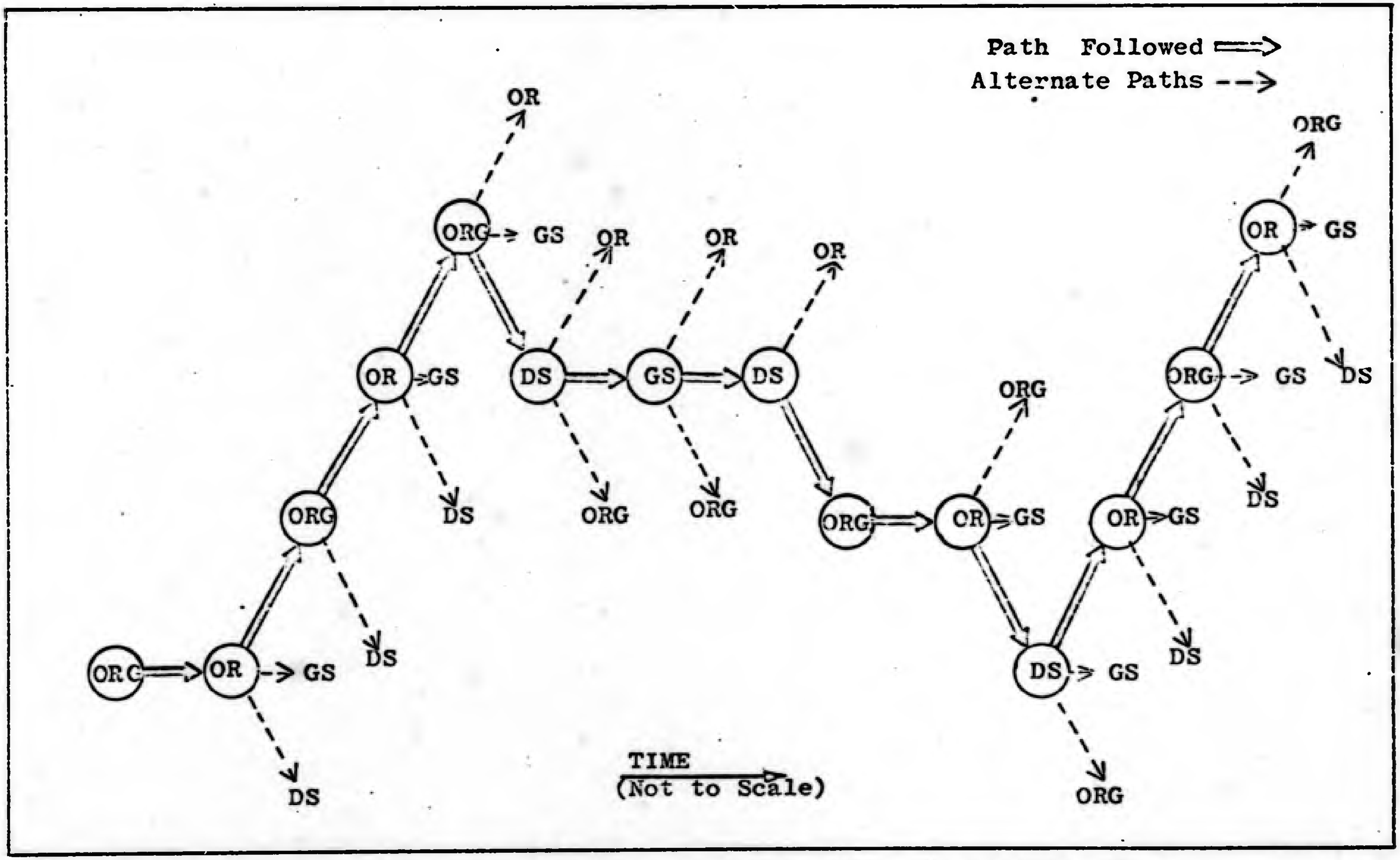


Figure 3-5. Typical Time Sequence Maintenance Transition Probability Flow

Previous Maintenance Level	Present Maintenance Level	Transition Probabilities (Percent) ROAD* Division	Destination
ORG, DS, or GS	OR	73.08	ORG
		26.92	DS
		0.00	GS
OR	ORG	82.22	OR
		17.78	DS
		0.00	GS
DS or GS	ORG	100.00	OR
OR or ORG	DS	62.50	OR
		29.17	ORG
		8.33	GS
GS	DS	68.20	OR
		31.80	ORG
OR, ORG or DS	GS	0.00	OR
		100.00	ORG
		0.00	DS

*The data for the OV-1 aircraft of the Airmobile Division were insufficient.

Figure 3-6. OV-1 Maintenance Transition Probabilities

Previous Maintenance Level	Present Maintenance Level	Transition Probability (Percent)		Destination
		Airmobile Division	ROAD Division	
ORG, DS or GS	OR	91.35	75.68	ORG
		8.65	24.32	DS
		0.00	0.00	GS
OR	ORG	96.45	83.82	OR
		3.55	16.18	DS
		0.00	0.00	GS
DS or GS	ORG	100.00	100.00	OR
OR or ORG	DS	82.35	85.45	OR
		17.65	12.21	ORG
		0.00	2.34	GS
GS	DS	82.35	87.50	OR
		17.65	12.50	ORG
OR, ORG or DS	GS	0.00	0.00	OR
		0.00	0.00	ORG
		0.00	100.00	DS

Figure 3-7. OH-13 Maintenance Transition Probabilities

Previous Maintenance Level	Present Maintenance Level	Transition Probability (Percent)		Destination
		Airmobile Division	ROAD Division	
ORG, DS or GS	OR	57.77	75.21	ORG
		41.53	24.79	DS
		.70	0.00	GS
OR	ORG	84.10	76.89	OR
		15.61	23.11	DS
		.29	0.00	GS
DS or GS	ORG	100.00	100.00	OR
OR or ORG	DS	57.31	68.14	OR
		39.13	30.97	ORG
		3.56	.89	GS
GS	DS	59.43	68.75	OR
		40.57	31.25	ORG
OR, ORG, or DS	GS	20.00	0.00	OR
		80.00	0.00	ORG
		0.00	100.00	DS

Figure 3-8. UH-1D/H Maintenance Transition Probabilities

Previous Maintenance Level	Present Maintenance Level	Transition Probability (Percent)	Destination
ORG, DS, or GS	OR	78.68	ORG
		21.32	DS
		0.00	GS
OR	ORG	73.76	OR
		26.24	DS
		0.00	GS
DS or GS	ORG	100.00	OR
OR or ORG	DS	47.74	OR
		52.26	ORG
		0.00	GS
GS	DS	47.74	OR
		52.26	ORG
OR, ORG or DS	GS	0.00	OR
		0.00	ORG
		0.00	DS

Figure 3-9. CH-47 Maintenance Transition Probabilities

Previous Maintenance Level	Present Maintenance Level	Transition Probability (Percent)	Destination
ORG, DS, or GS	OR	29.73	ORG
		70.27	DS
		0.00	GS
OR	ORG	56.00	OR
		44.00	DS
		0.00	GS
DS or GS	ORG	100.00	OR
OR or ORG	DS	95.16	OR
		4.84	ORG
		0.00	GS
GS	DS	95.16	OR
		4.84	ORG
OR, ORG or DS	GS	0.00	OR
		0.00	ORG
		0.00	DS

Figure 3-10. CH-54 Maintenance Transition Probabilities

the ROAD Division are presented in Figure 3-6. Transition probabilities are presented for both the Airmobile and ROAD Divisions, for the OH-13 and the UH-1D/H aircraft. (Figures 3-7 and 3-8.) Finally, since the CH-47 and CH-54 are assigned to the Airmobile Division only, their transition probabilities are included for that Division only (Figures 3-9 and 3-10). The patterns discussed for the UH-1B/C aircraft tend to hold true for these aircraft also. General transition probability relationships are discussed below.

DIVISIONAL TRANSITION PROBABILITIES

A weighted set of transition probabilities is presented in Figure 3-11 for both Divisions. These probabilities are composites of the probabilities established by level of maintenance for each Division and properly weighted for each TMS studied. Some broad comparisons between maintenance level and between Divisions are made below.

Generally, aircraft move into maintenance levels with the following decreasing order of probability:

1. Operational Readiness,
2. Organizational Maintenance
3. Direct Support
4. General Support.

Thus, it is more probable that an aircraft will become Operationally Ready from another maintenance level than go to one of the two remaining Not Operationally Ready Maintenance levels. Additionally, it is more probable that an aircraft will go to Organizational Maintenance from Operational Readiness than go to Direct Support or General Support.

Previous Maintenance Level	Present Maintenance Level	Transition Probability (Percent)		Destination
		Airmobile Division	ROAD Division	
ORG, DS or GS	OR	71.88	78.07	ORG
		27.74	21.93	DS
		.38	0.00	GS
OR	ORG	85.58	84.89	OR
		14.30	15.11	DS
		.12	0.00	GS
DS or GS	ORG	100.00	100.00	OR
OR or ORG	DS	64.21	75.30	OR
		33.78	21.79	ORG
		2.01	2.91	GS
GS	DS	65.45	77.53	OR
		34.55	22.47	ORG
OR, ORG or DS	GS	25.08	0.00	OR
		0.00	3.77	ORG
		74.92	96.23	DS

Figure 3-11. Airmobile and ROAD Division Weighted Maintenance Transition Probabilities

Maintenance flows from Operational Readiness to Organizational Maintenance with a slightly higher probability in the ROAD Division (78%) than in the Airmobile Division (72%). The flow from Operational Readiness to Direct Support has a slightly higher probability in the Airmobile Division (28%) than in the ROAD Division (22%).

Maintenance flowing from Organizational Maintenance to the other three levels has approximately equal probabilities in both Divisions. To Operational Readiness, the transition probability is 85% to 86%, to Direct Support it is 14% to 15%, and to General Support it is approximately zero.

There is a higher probability in the ROAD than the Airmobile Division that aircraft at Direct Support return to Operational Readiness. The reverse is true for aircraft going to Organizational Maintenance. From Direct Support to General Support the probabilities for both Divisions are approximately equal at 2 to 3 percent.

For both Divisions, maintenance at General Support has the greatest probability of moving to Direct Support. To a lesser extent, some maintenance in the Airmobile Division becomes Operationally Ready directly from General Support, while a very small amount moves from General Support to Organizational Maintenance in the ROAD Division.

MOST PROBABLE PATHS

Figure 3-12 presents the most probable paths for moving between maintenance levels when the aircraft starts and finishes in an Operationally Ready condition. Five paths are shown. They include at least 96.5% of the movement of aircraft through maintenance. The most probable path followed through maintenance is from Operational Readiness to Organizational Maintenance and back to Operational Readiness. With the exception of the CH-54 aircraft of the Airmobile Division, all aircraft within both Divisions follow this path approximately 50 to 90% of the time.

The second most probable path for an aircraft to follow through maintenance is from Operational Readiness to Direct Support and returning to Operational Readiness. This path and the one discussed above represent some 68 to 95% of all movement of aircraft from Operational Readiness through maintenance and back to Operational Readiness.

For the CH-54 aircraft of the Airmobile Division, the above two paths play reversed roles. While most other aircraft move from and to Operational Readiness through Organizational Maintenance about two-thirds of the time, the CH-54 moves from and to Operational Readiness through Direct Support two-thirds of the time. This reflects the special maintenance considerations being given the CH-54 aircraft in Vietnam. Though these two paths are reversed, together they represent most (84%) of the movement of the CH-54 aircraft through maintenance.

Paths	Aircraft									
	OV-1		OH-13		UH-1B/C		UH-1D/H		CH-47	CH-54
	Air-* Mobile	ROAD	Air-Mobile	ROAD	Air-Mobile	ROAD	Air-Mobile	ROAD	Air-Mobile	Air-Mobile
OR → ORG → OR	-	60.09	88.11	63.43	66.40	80.23	48.58	57.81	58.03	16.65
OR → ORG → DS → OR	-	8.12	2.67	10.47	7.46	3.33	5.17	11.83	9.86	12.45
OR → ORG → DS → ORG → OR	-	3.79	.57	1.50	3.38	1.39	3.53	5.37	10.79	.63
OR → DS → OR	-	16.83	7.12	20.78	14.94	9.92	23.80	16.88	10.18	66.87
OR → DS → ORG → OR	-	7.85	1.53	2.96	6.77	4.15	16.25	7.68	11.14	3.40
Sum of Probabilities	-	96.68	100.00	99.14	98.95	99.02	97.33	99.57	100.00	100.00

*Insufficient Data

Figure 3-12. Most Probable Paths for Aircraft Moving Between Maintenance Levels (Greater Than 1.00 Percent)

The ranking in decreasing order of probability of the paths shown in Figure 3-12 is the same for ROAD and Airmobile Divisions. They are ranked as follows:

1. OR-ORG-OR
2. OR-DS-OR
3. OR-ORG-DS-OR
4. OR-DS-ORG-OR
5. OR-ORG-DS-ORG-OR

The infrequency of General Support Maintenance is indicated by absence of flow through General Support in the five most probable paths. In fact, since these five paths account for 100% of the movements of the OH-13, CH-47 and CH-54 aircraft, it can be concluded that these aircraft rarely or never go to General Support.

CHAPTER 4

OPERATIONAL READINESS

CHAPTER 4

OPERATIONAL READINESS

READINESS HOURS

Operational Readiness is one of the four maintenance states discussed in Chapter 3. It is the state in which maintenance requirements are accummulated. When sufficient maintenance is accummulated to cause an aircraft to become non-operationally ready, the aircraft then moves into one of the other maintenance levels as determined by the transition probabilities. The readiness hours or time to accummulate maintenance requirements are described by the Operational Readiness Hour Distributions in Figures 4-1 through 4-6.

The distribution for the OV-1 is presented in Figure 4-1. Since the data for the OV-1 aircraft of the Airmobile Division were insufficient for analysis, only results for those of the ROAD Division are shown. The average number of hours that an OV-1 of the ROAD Division remains Operationally Ready is 240 hours, or 10 days. At least one-third of the Operational Readiness events studied were 240 hours long. Moreover, 40% of all events exceeded one week.

The Operational Readiness Hour Distributions for OH-13s of the Airmobile and ROAD Divisions are presented in Figure 4-2. Though the distributions are similar, the Airmobile Division tends to have a slightly greater number of longer periods of Operational Readiness. This is shown in the average number of hours per OH-13 Operational Readiness event for both Divisions. The average for the Airmobile Division is 165 hours, compared with an average of 155 hours for

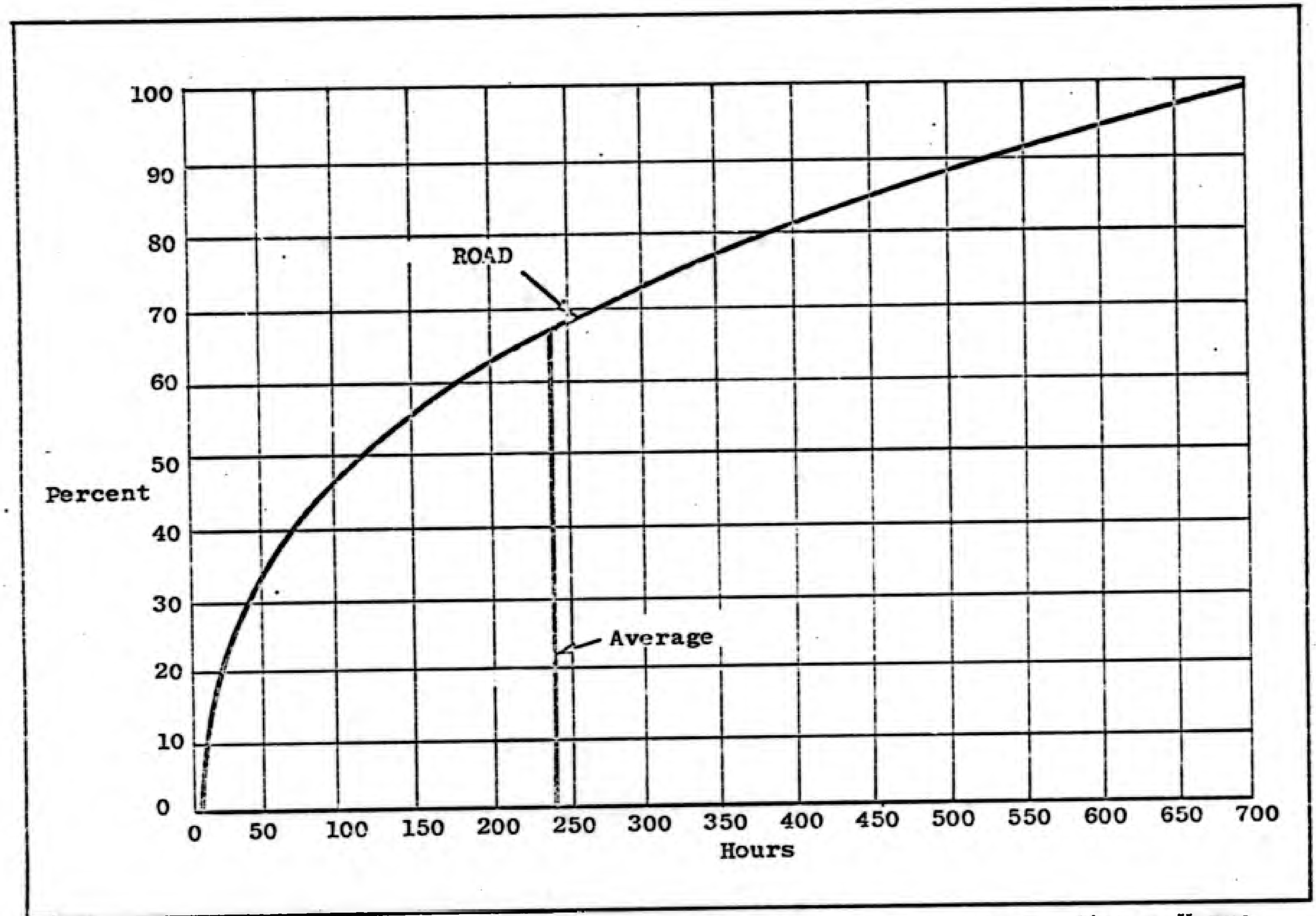


Figure 4-1. Cumulative Event Distribution for OV-1 Operational Readiness Hours

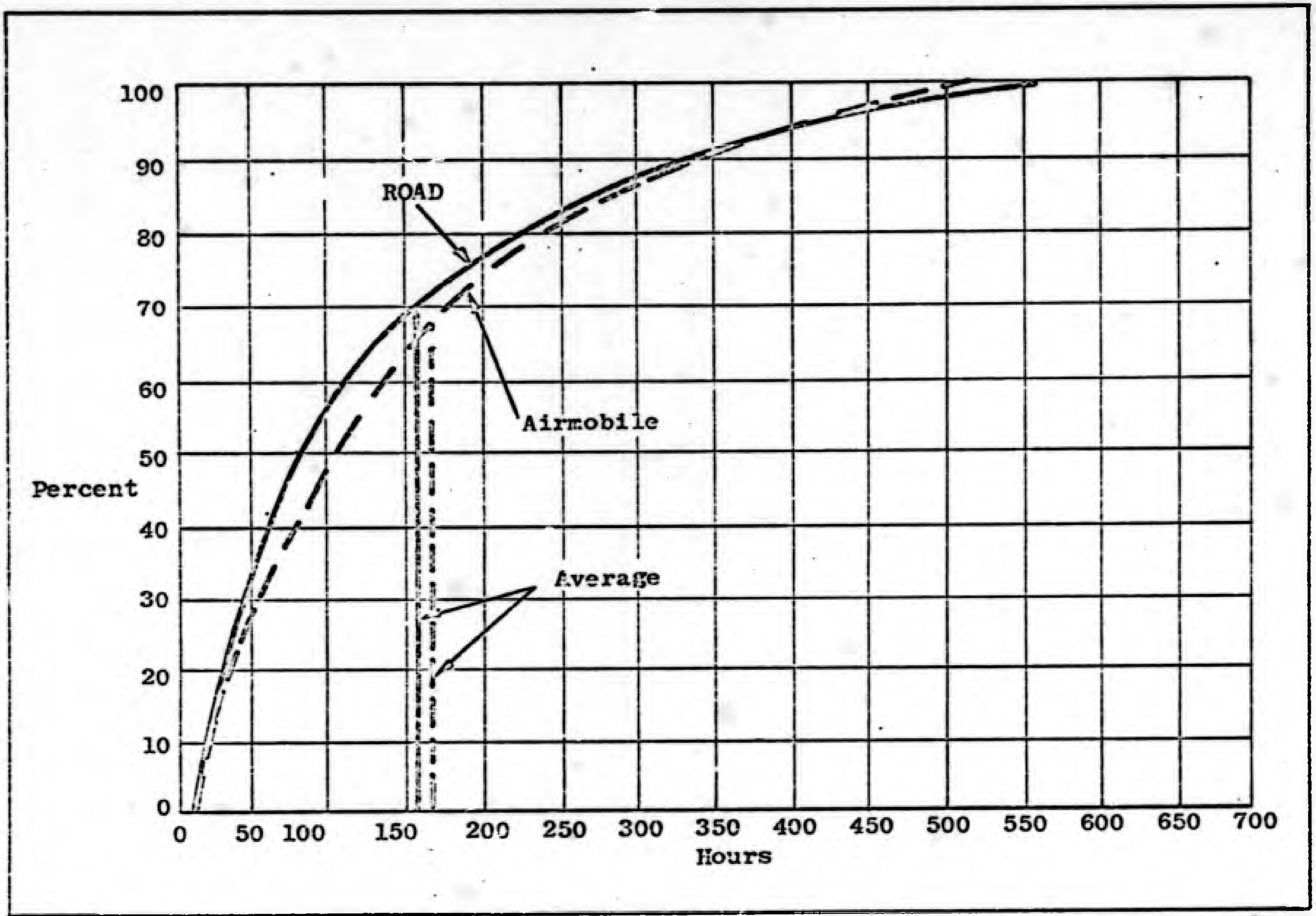


Figure 4-2. Cumulative Event Distribution for OH-13 Operational Readiness Hours

the ROAD Division. In general, OH-13s seem to be Operationally Ready for shorter periods of time than other types of aircraft. Only 27% of the events from the ROAD Division, and 29% of those from the Airmobile Division exceeded one week.

The two distributions for UH-1B/C aircraft in Figure 4-3 are also very similar. Furthermore, the aircraft of the Airmobile Division again tend to be available for slightly longer periods of time than those of the ROAD Division. The average hours per Operational Readiness event for the Airmobile Division is 205 hours while the average for the ROAD Division is 185 hours. UH-1B aircraft of both Divisions were observed to exceed one week periods of Operational Readiness 35% of the time.

There is no similarity in the UH-1D/H distributions presented in Figure 4-4. In fact, the gap between the UH-1D/H experience in Airmobile and ROAD Divisions is quite large. This is emphasized when the averages are compared. The average of the Airmobile Division is 210 hours; that of the ROAD Division is 255 hours. Over 52% of the UH-1Ds in the ROAD Division are Operationally Ready for more than one week, while only 41% of the UH-1D aircraft in the Airmobile Division are Operationally Ready as long.

As shown in Figure 4-5, the CH-47 Helicopter of the Airmobile Division is Operationally Ready for an average of 125 hours per readiness event. Only 26% of the readiness events exceed one week periods of Operational Readiness. The CH-54 has an average readiness event of 165 hours, which is much greater than that of the CH-47. Additionally, 32% of the CH-54 readiness events shown in Figure 4-6 exceed one week periods of time.

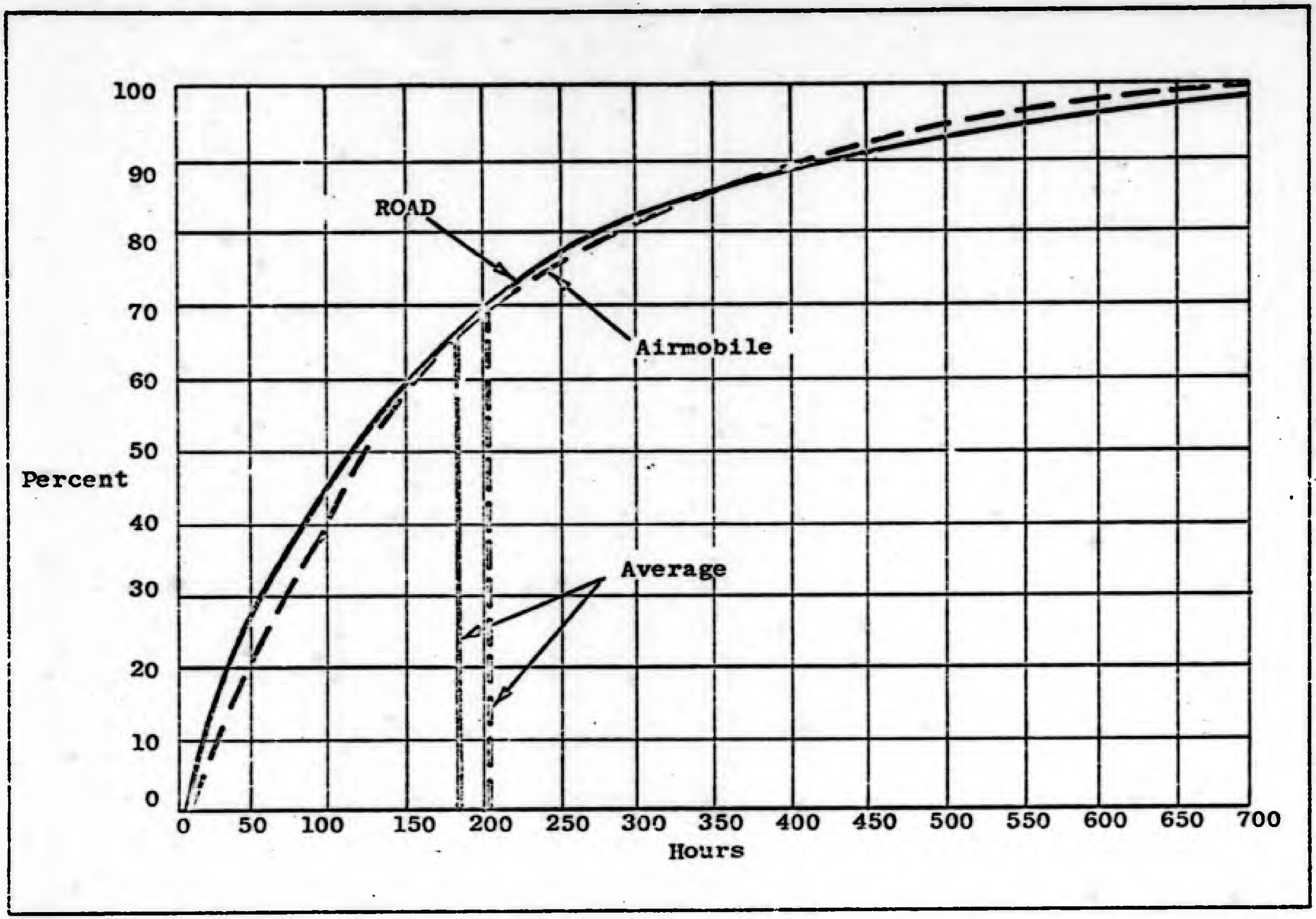


Figure 4-3. Cumulative Event Distribution for UH-1B/C Operational Readiness Hours

5b

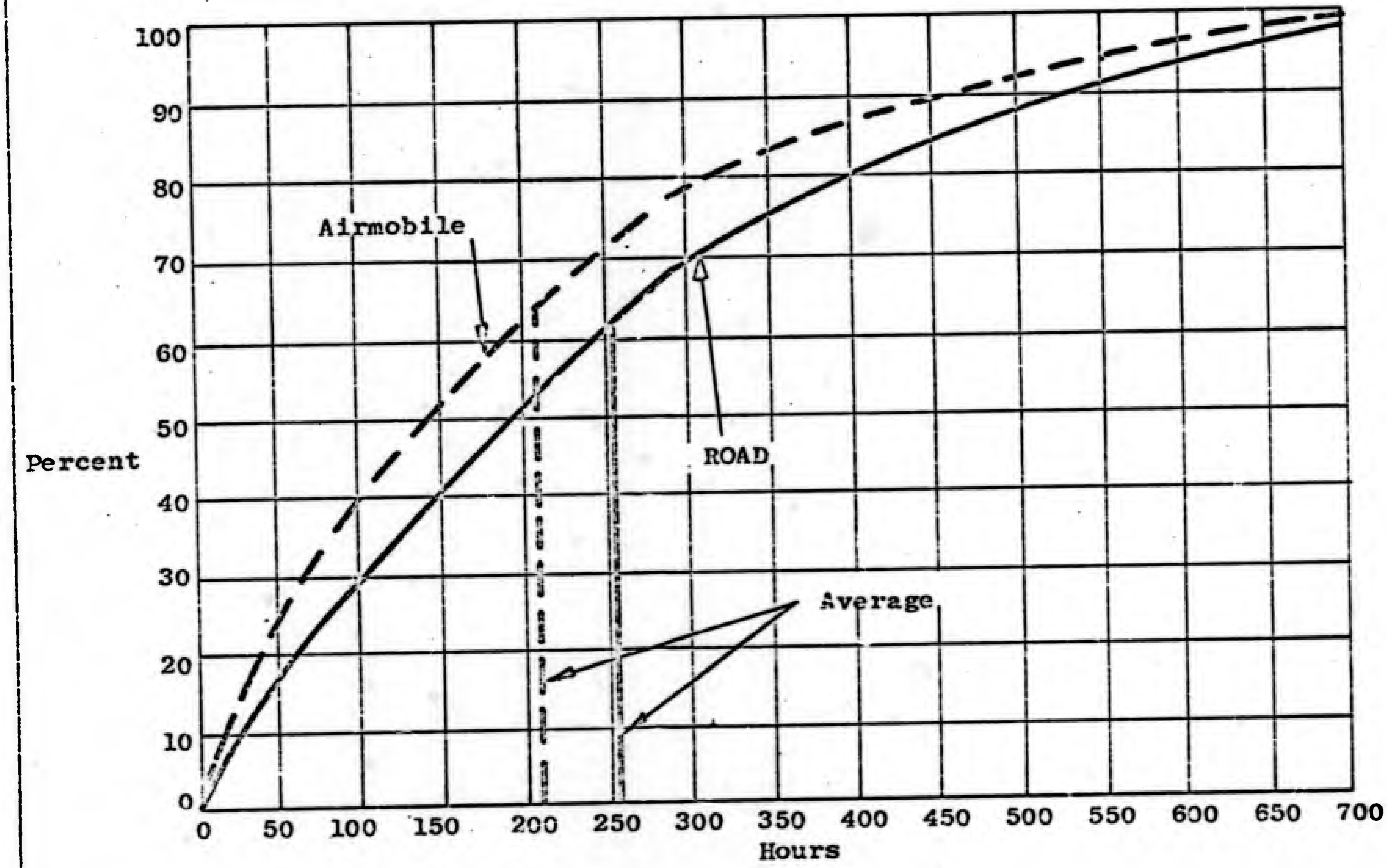


Figure 4-4. Cumulative Event Distribution for UH-1D/H Operational Readiness Hours

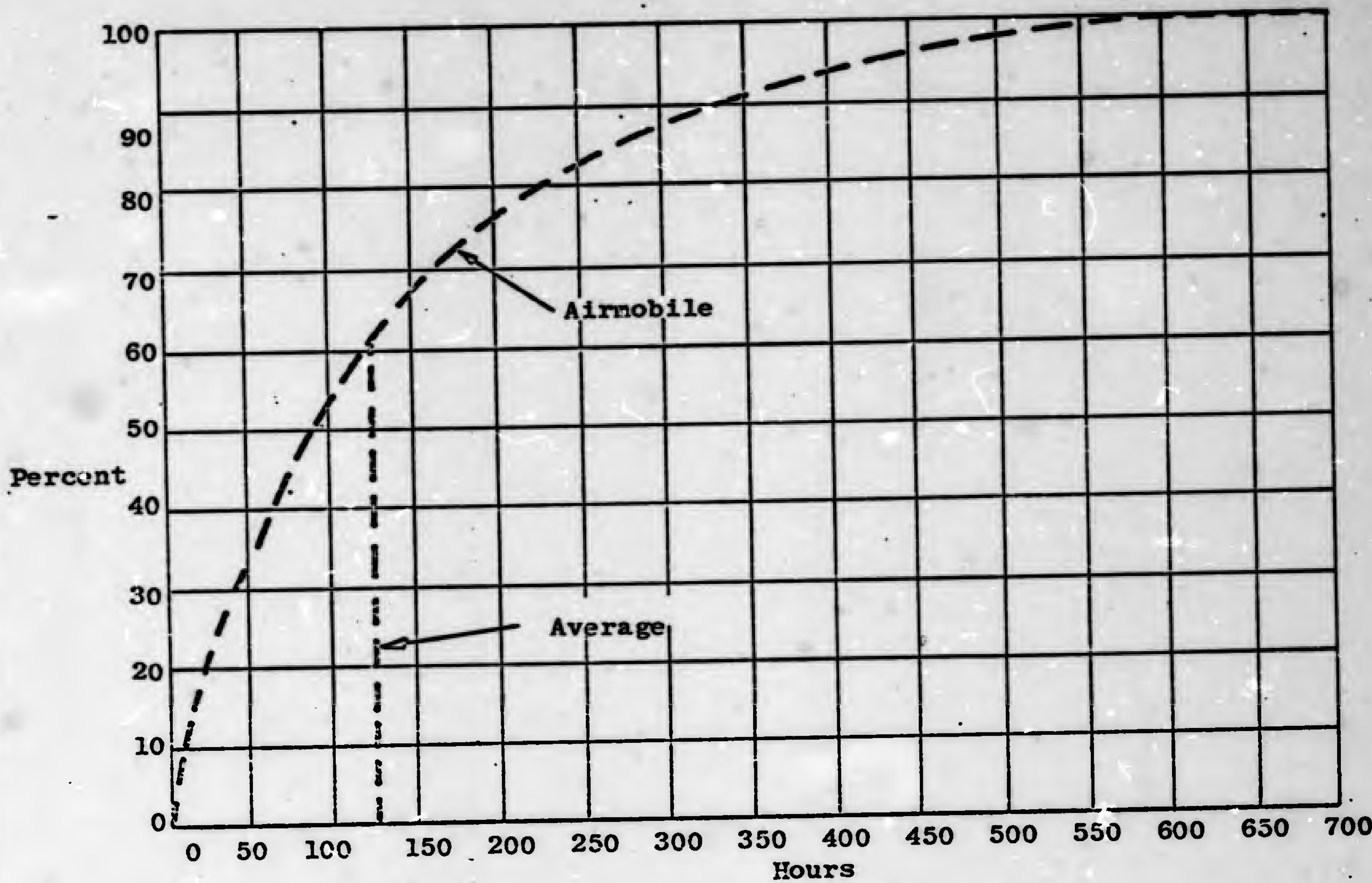


Figure 4-5. Cumulative Event Distribution for CH-47 Operational Readiness Hours

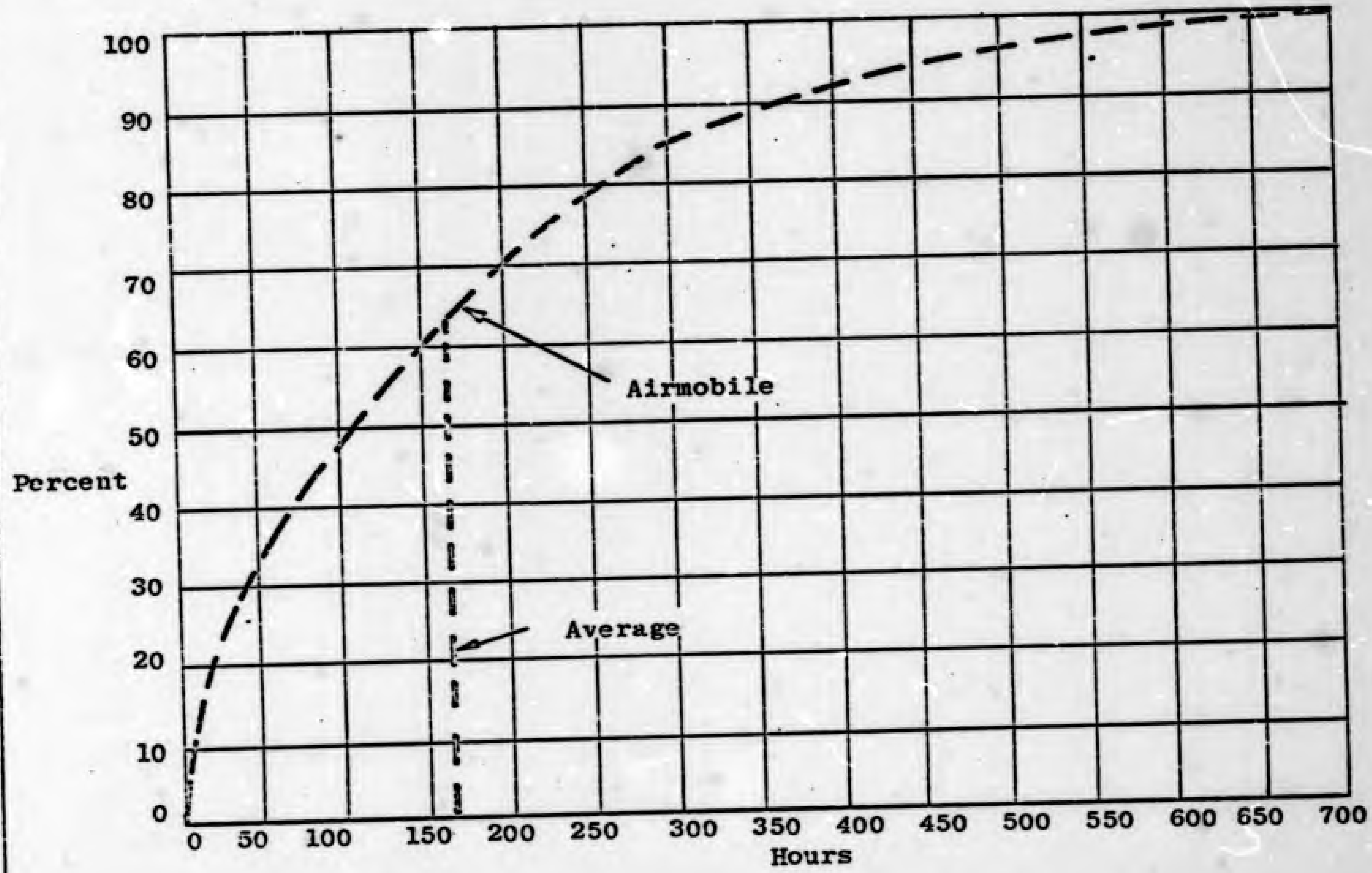


Figure 4-6. Cumulative Event Distribution For CH-54 Operational Readiness Hours

In summary, at least 25% of the readiness events for all aircraft in both Divisions studied exceeded periods of one week. In the case of the UH-1D, over 50% exceeded this time period. The average number of hours per readiness event ranged from 125 for the CH-47 aircraft in the Airmobile Division to 255 hours for the UH-1D in the ROAD Division. With the exception of these two extreme values, most of the other aircraft ranged between 155 hours and 210 hours. Generally, the aircraft of the Airmobile Division are ready longer than those of the ROAD Division. The one exception studied is the UH-1D. The ROAD Division average was substantially larger than that of the Airmobile Division. It was 45 hours greater.

MONTHLY READINESS RATES

The readiness hours studied above reflect only the length of each readiness event and do not describe the frequency with which each readiness event occurs. This frequency can be determined only through the use of the probabilities described in Chapter 3.

An indication of the interaction of the length of each readiness event with the frequency with which they occur is given in the monthly readiness rate. It reflects both periods of readiness and periods of downtime. The average monthly readiness rates for the six aircraft studied in both Divisions are shown in Figure 4-7. A comparison of both Divisions reveals that aircraft of the ROAD Division have higher average monthly readiness rates than those of the Airmobile Division. The rates do not contradict the distributions above, but rather reflect a higher frequency of readiness events for aircraft within the ROAD Division. Thus,

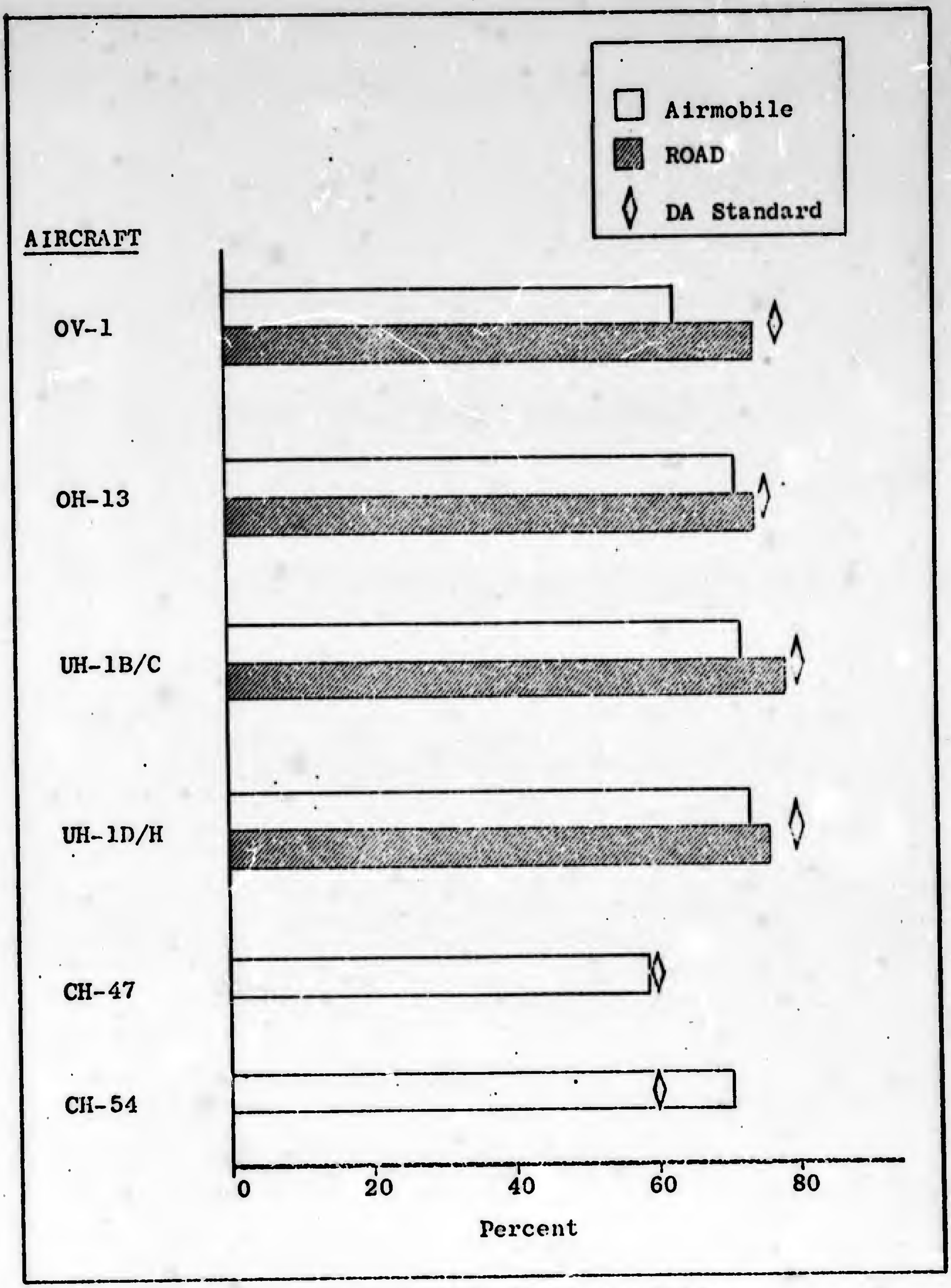


Figure 4.7. Average Monthly Readiness Rates (October 1966 - September 1967)

although the average hours per readiness event for aircraft of the Airmobile Division are greater than those of the ROAD Division, the events of the ROAD Division occur more often and thereby offset what appears to be the better readiness condition of the Airmobile Division.

The average monthly readiness rates of the ROAD Division exceed those of the Airmobile Division by 3% for the UH-1D and OH-13 aircraft, 7% for the UH-1B, and 11% for the OV-1. In no case do any of the aircraft common to both Divisions exceed the Department of the Army Standards. The aircraft of the ROAD Division are all within 5% of the DA Standard, but those of the Airmobile Division are all at least 4% below. In fact, the OV-1 is 14% below the DA standard.

The CH-47 and CH-54 aircraft of the Airmobile Division have substantially better readiness records in comparison with the other four aircraft studied. The CH-54 exceeds the DA Standard by 10%, with a monthly average readiness rate of 70%. The CH-47 is approximately one percent below the DA Standard with an average monthly readiness rate of 59%.

CHAPTER 5

NOT OPERATIONALLY READY, MAINTENANCE (NORM)

CHAPTER 5

NOT OPERATIONALLY READY, MAINTENANCE (NORM)

ORGANIZATIONAL MAINTENANCE

The analysis of the hours spent at Organizational Maintenance is shown in the Cumulative Event Distributions in Figures 5-1 through 5-6. Data for the OV-1 aircraft (Figure 5-1) were available only from the ROAD Division. For these aircraft, the average per Organizational Maintenance event is 29 hours. Approximately 37% of the Organizational Maintenance events studied exceed 24 hours, but less than 13% exceed 72 hours.

A comparison of the OH-13 aircraft distributions in both the Airmobile and ROAD Divisions is presented in Figure 5-2. The average per event at Organizational Maintenance is 19 hours for the ROAD Division, and 21 hours for the Airmobile Division. While 25% of the OH-13 maintenance events in the Airmobile Division and 21% of the maintenance events of the ROAD Division exceed 24 hours in length, less than 5% of the events for the OH-13 in both Divisions exceed 72 hours. Thus, the distributions of OH-13 Organizational Maintenance events are essentially the same in both Divisions.

For the UH-1B aircraft (Figure 5-3), the difference between the two Divisions is clear. The average per event for the Airmobile Division is 25 hours, or 6 hours greater than the average of 19 hours for the ROAD Division. A comparison of the number of events that exceed 24 hours indicates 30% for the Airmobile Division, and only 21% for the ROAD Division.

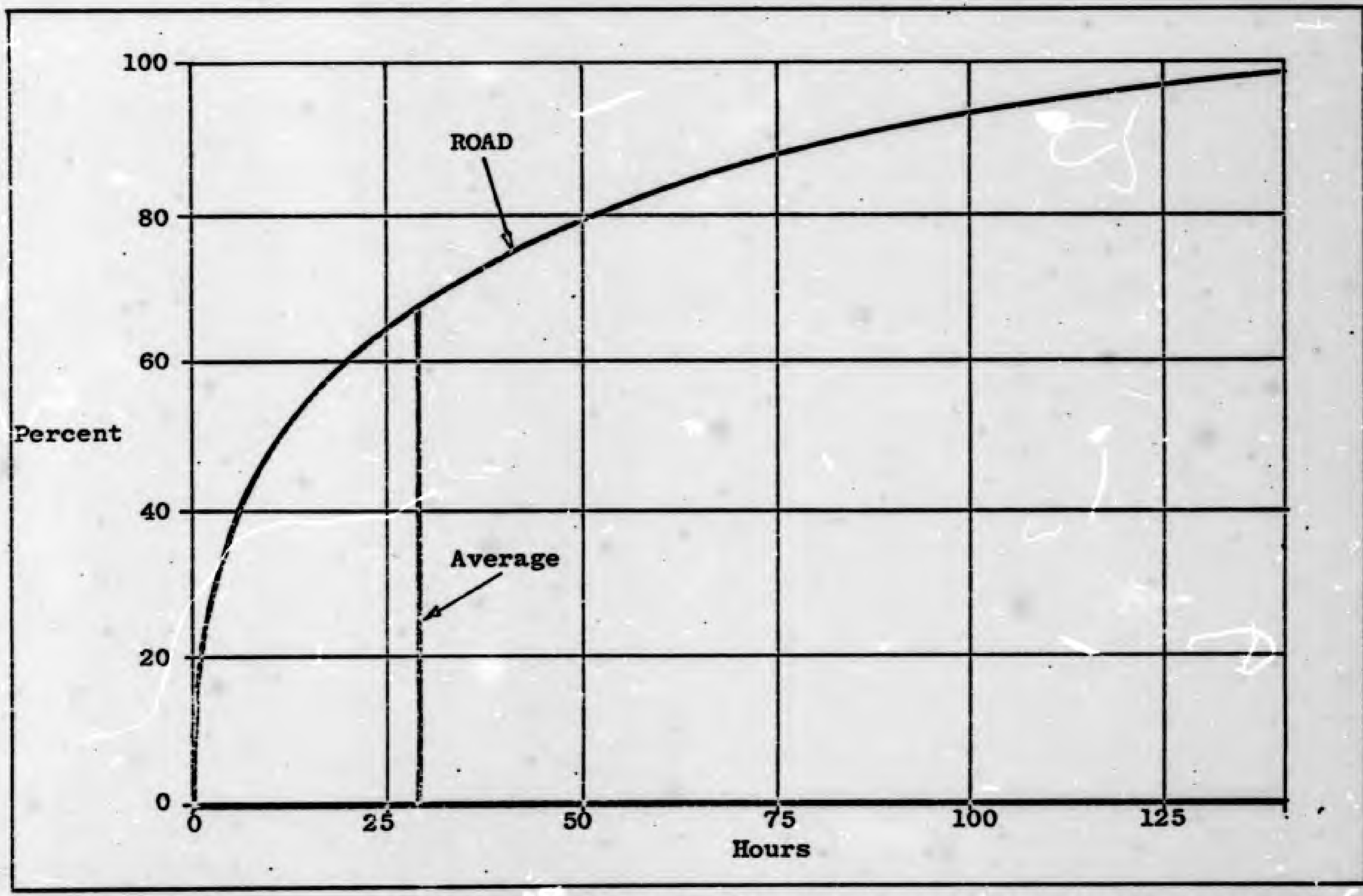


Figure 5-1. Cumulative Event Distribution for OV-1 Organizational Maintenance Hours

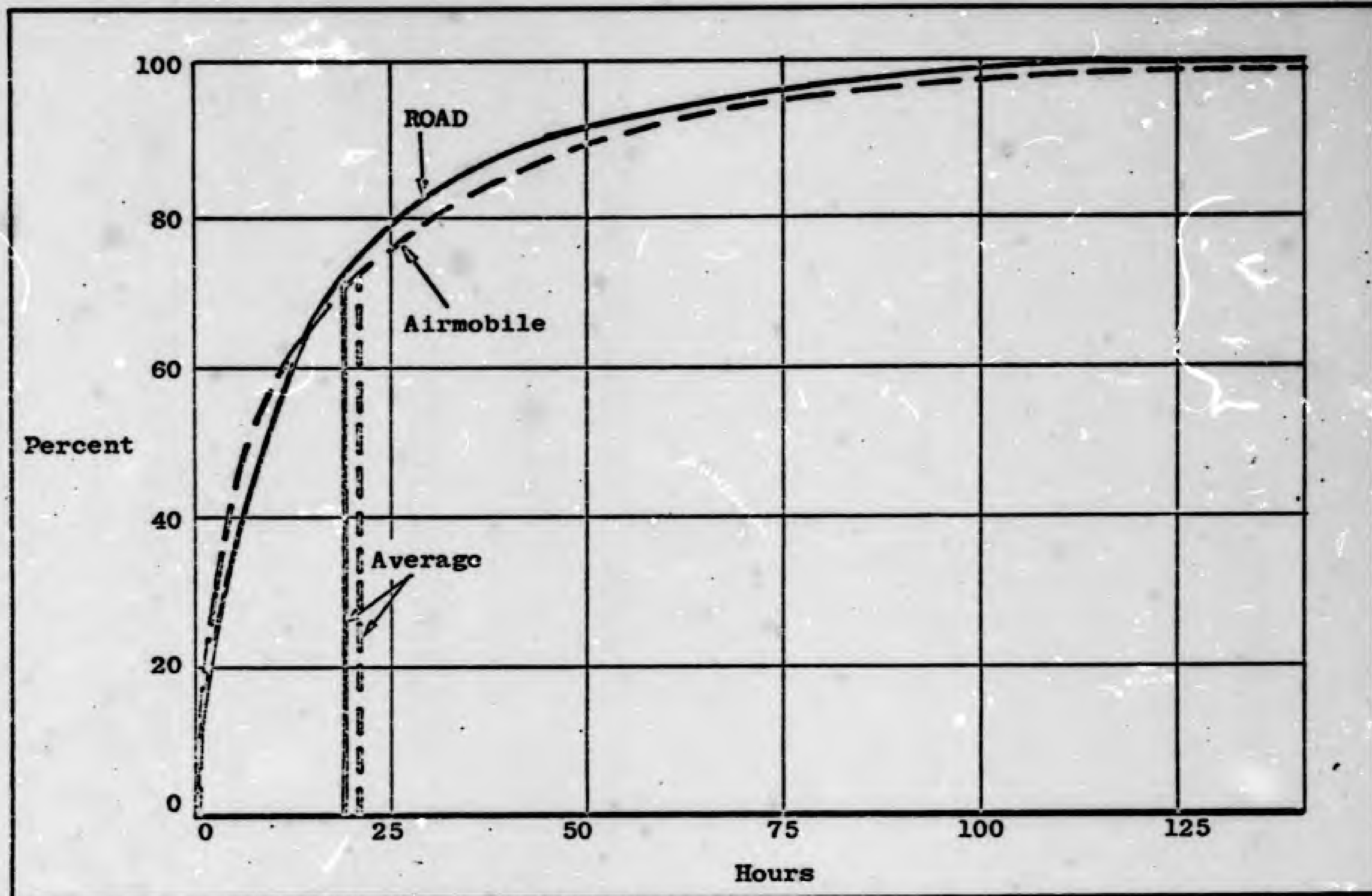


Figure 5-2. Cumulative Event Distributions for OH-13 Organizational Maintenance Hours

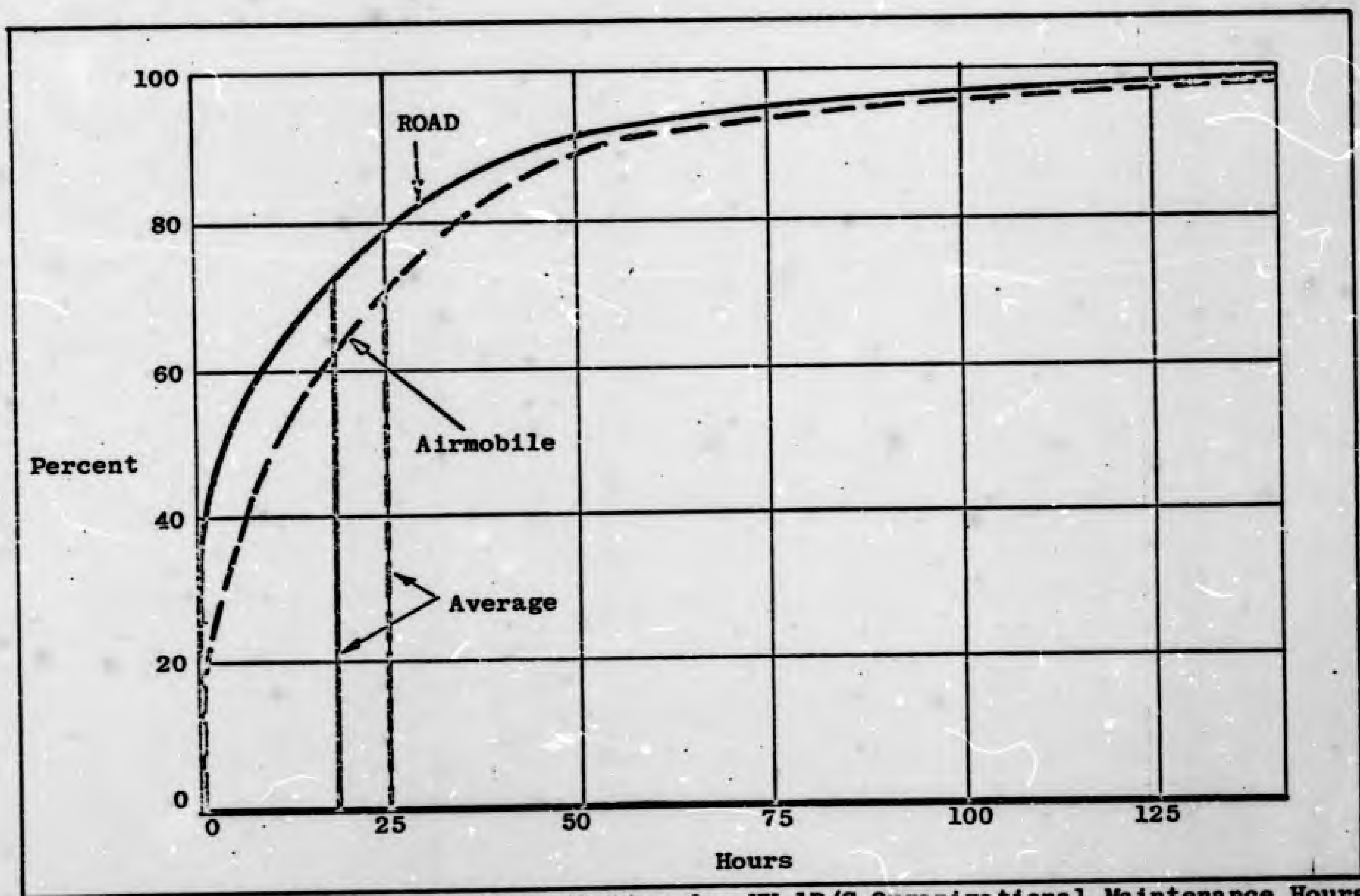


Figure 5-3. Cumulative Event Distribution for UH-1B/C Organizational Maintenance Hours

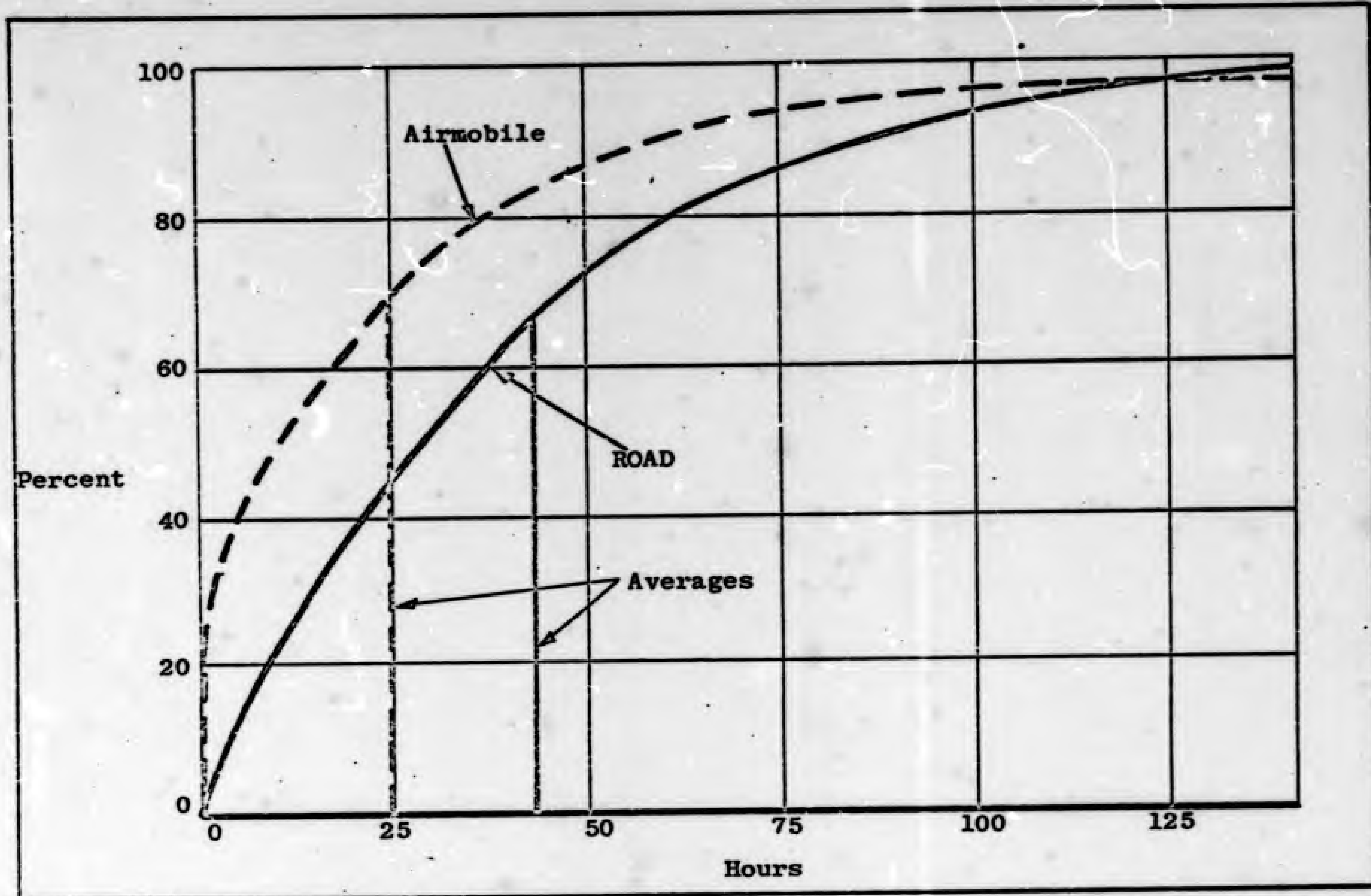


Figure 5-4. Cumulative Event Distribution for UH-1D/H Organizational Maintenance Hours

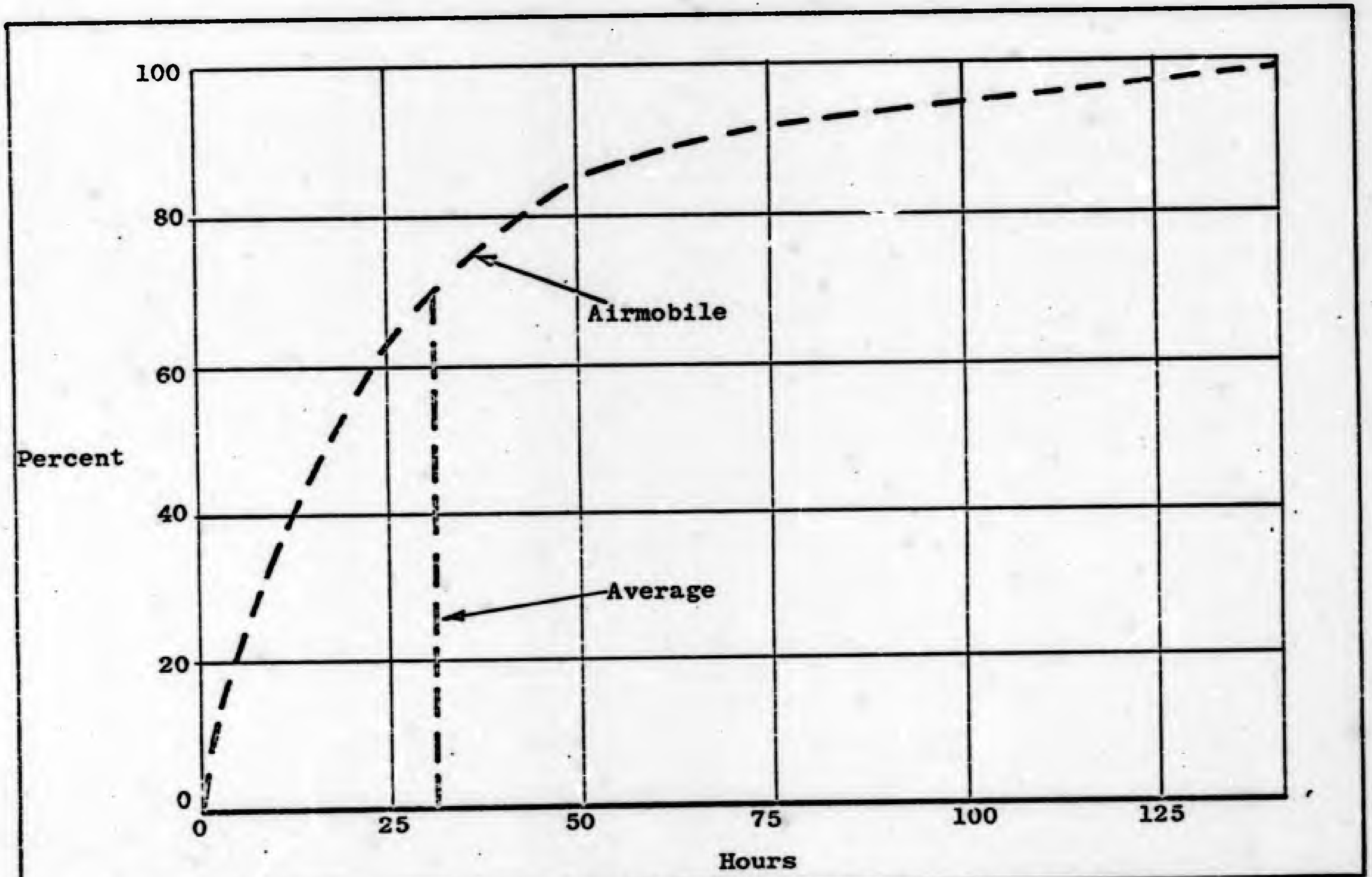


Figure 5-5. Cumulative Event Distribution for CH-47 Organizational Maintenance Hours

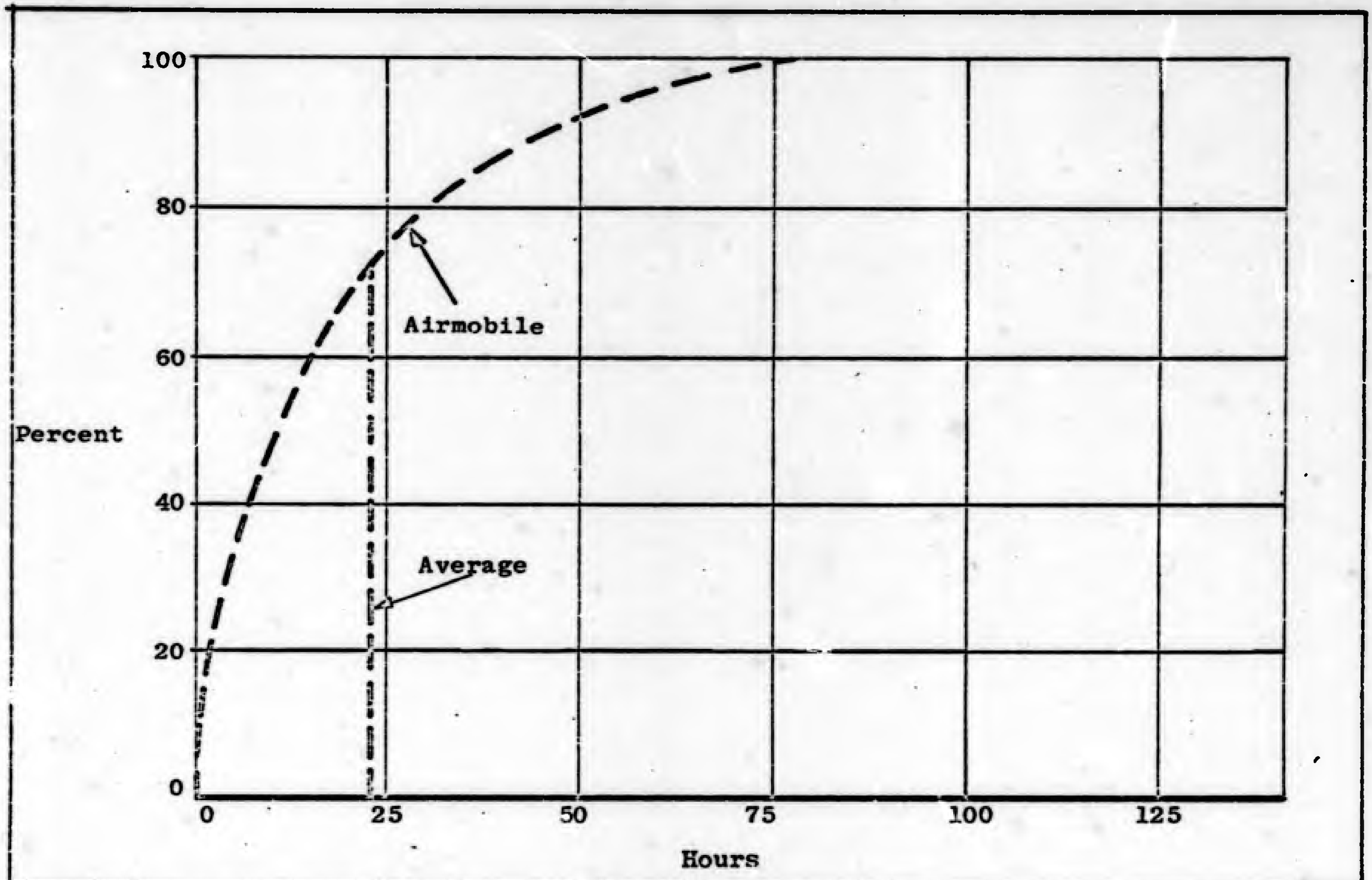


Figure 5-6. Cumulative Event Distribution for CH-54 Organizational Maintenance Hours

The percentage of events that exceed 72 hours is 7% for the Airmobile Division and 5% for the ROAD Division. Thus, the UH-1B aircraft of the ROAD Division remain in Organizational Maintenance less time per event than those of the Airmobile Division.

The relationship between the ROAD and Airmobile Divisions reverses with the UH-1D aircraft.(Figure 5-4). Moreover, the difference between the Divisions is substantial. The average is 44 hours. This average is 70% greater than the 26 hour average of the Airmobile Division. The significantly less time spent at Organizational Maintenance by the UH-1D aircraft of the Airmobile Division is further demonstrated by the other two measures analyzed. Over 55% of the ROAD Division UH-1D aircraft maintenance events are more than 24 hours, as opposed to less than 32% in the Airmobile Division. Additionally, the percentages of events exceeding 72 hours in the ROAD and Airmobile Divisions are 15% and 7%, respectively. Therefore, both the UH-1B discussed above, and the UH-1D of the Airmobile Division exceed 72 hours for 7% of their Organizational Maintenance events. Our analysis of the data thus far indicates nothing to lead us to believe that this fact is other than coincidental. But since the aircraft are of very similar design, this relationship may greatly influence this last statistic. To summarize, the UH-1D aircraft not only reverses the Divisional patterns set by the other aircraft studied, but it does so with great differences in performance.

The means of the CH-47 and CH-54 shown in Figures 5-5 and 5-6 are within the general value range of the other aircraft. The CH-54 has an average of 23 hours per Organizational Maintenance event, while the CH-47 has a value of 31 hours. The CH-54 tends to spend substantially less time per maintenance event at Organizational Maintenance than the CH-47. In fact, only 26% of the events for the CH-54 exceed 24 hours, while for the CH-47, 37% exceed 24 hours. The difference between the two aircraft is more dramatically indicated in comparing the number of events that exceed 72 hours; i.e., 8% for the CH-47, but only a very low 1% for the CH-54.

In general, all aircraft of both Divisions had approximately 20 to 45 hours per maintenance event at Organizational Maintenance. If the UH-1D aircraft of the ROAD Division are excluded, this range per event narrows to 20 to 30 hours. At least one-fifth of all events for all aircraft are more than 24 hours long. The UH-1D aircraft of the ROAD Division are very high, with 55% of the events exceeding 24 hours. For most aircraft, the ROAD Division aircraft spend less time per event at Organizational Maintenance than the Airmobile Division aircraft. The one exception is the UH-1D aircraft of the ROAD Division.

DIRECT SUPPORT MAINTENANCE

The number of hours spent at Direct Support are shown in the Cumulative Event Distributions for all aircraft of both Divisions in Figures 5-7 through 5-12. The average time spent at Direct Support by the OV-1 aircraft in the ROAD Division is 63 hours.

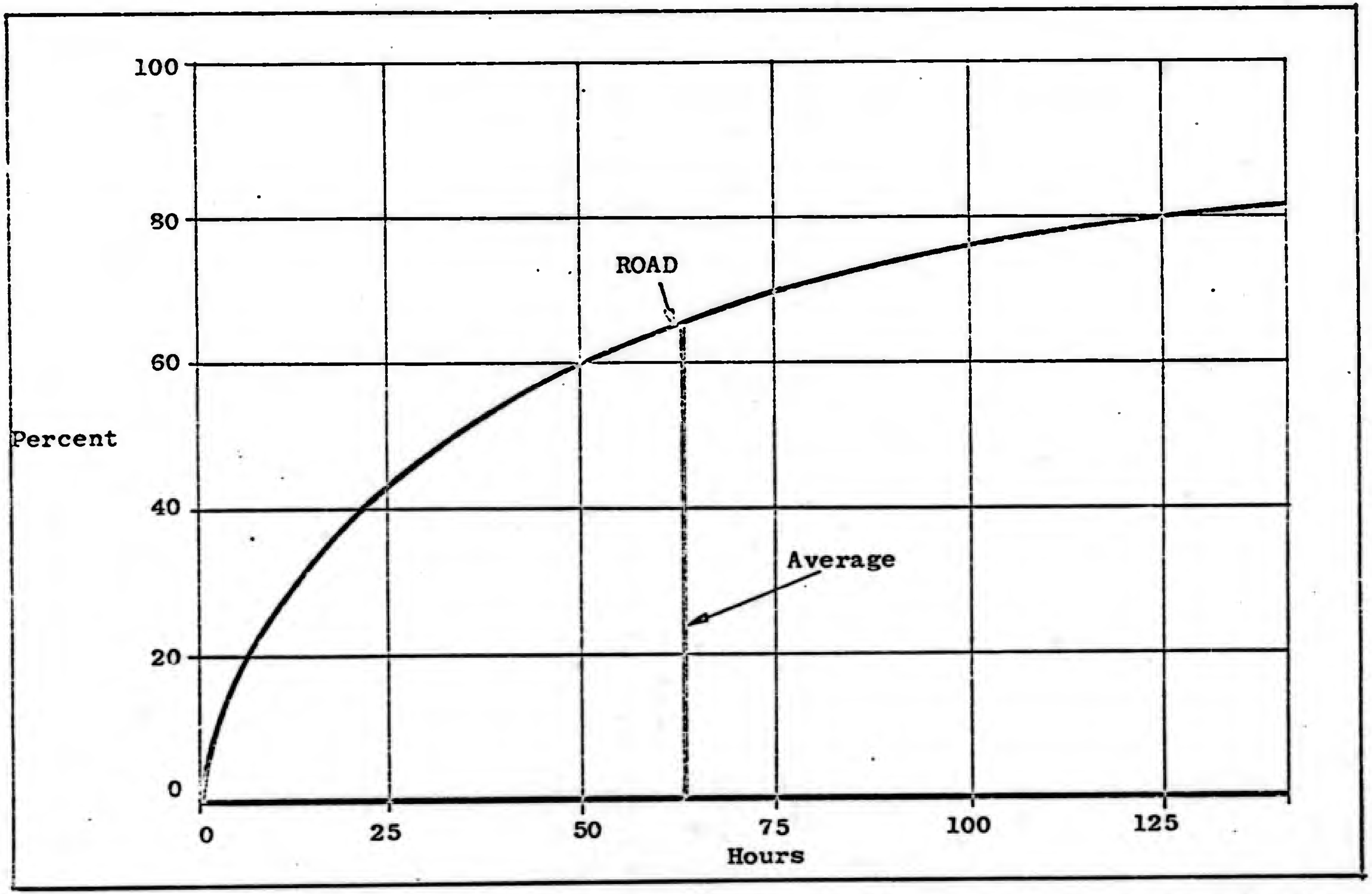


Figure 5-7. Cumulative Event Distribution for OV-1 Direct Support Maintenance Hours

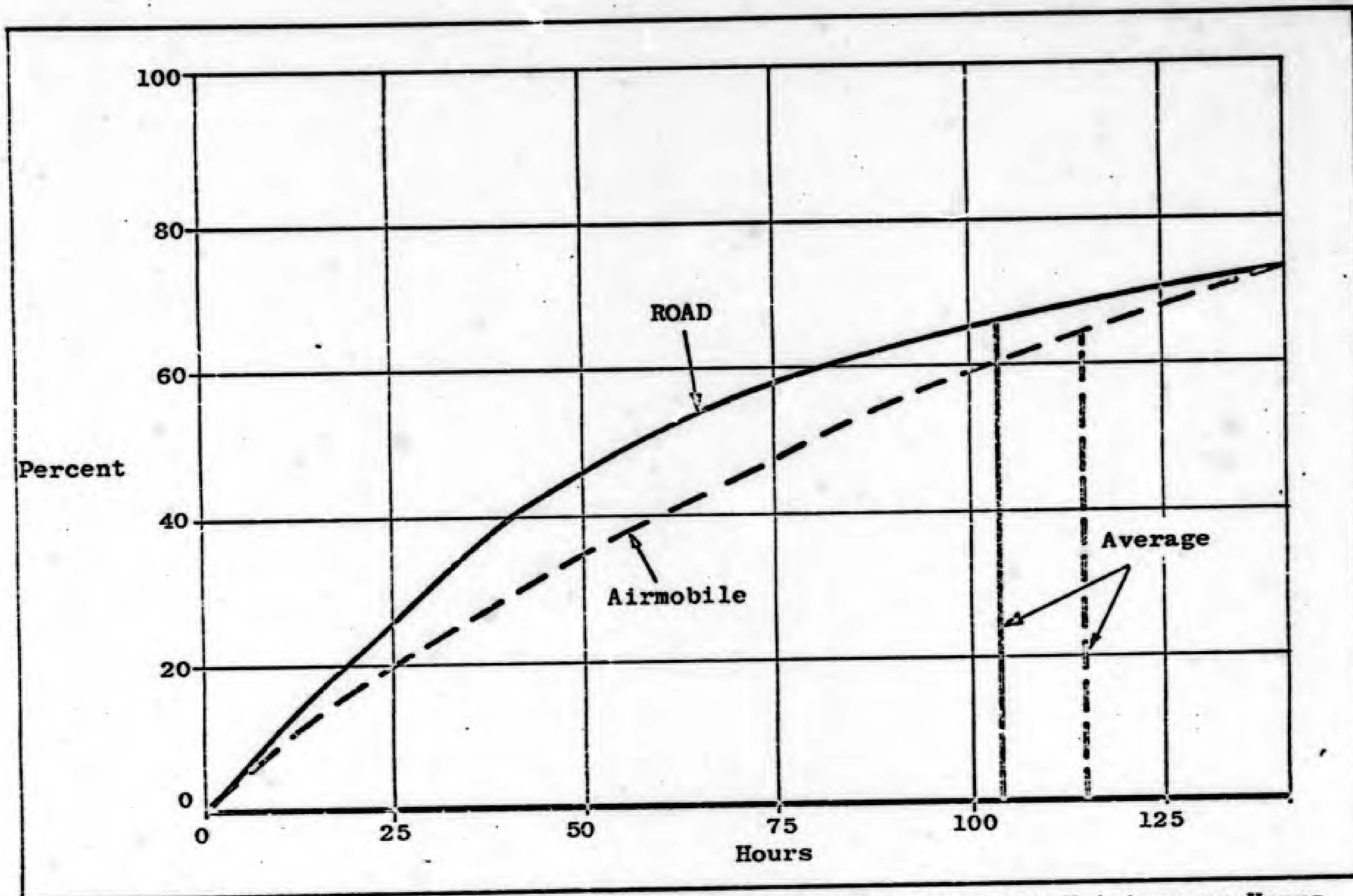


Figure 5-8. Cumulative Event Distribution for OH-13 Direct Support Maintenance Hours

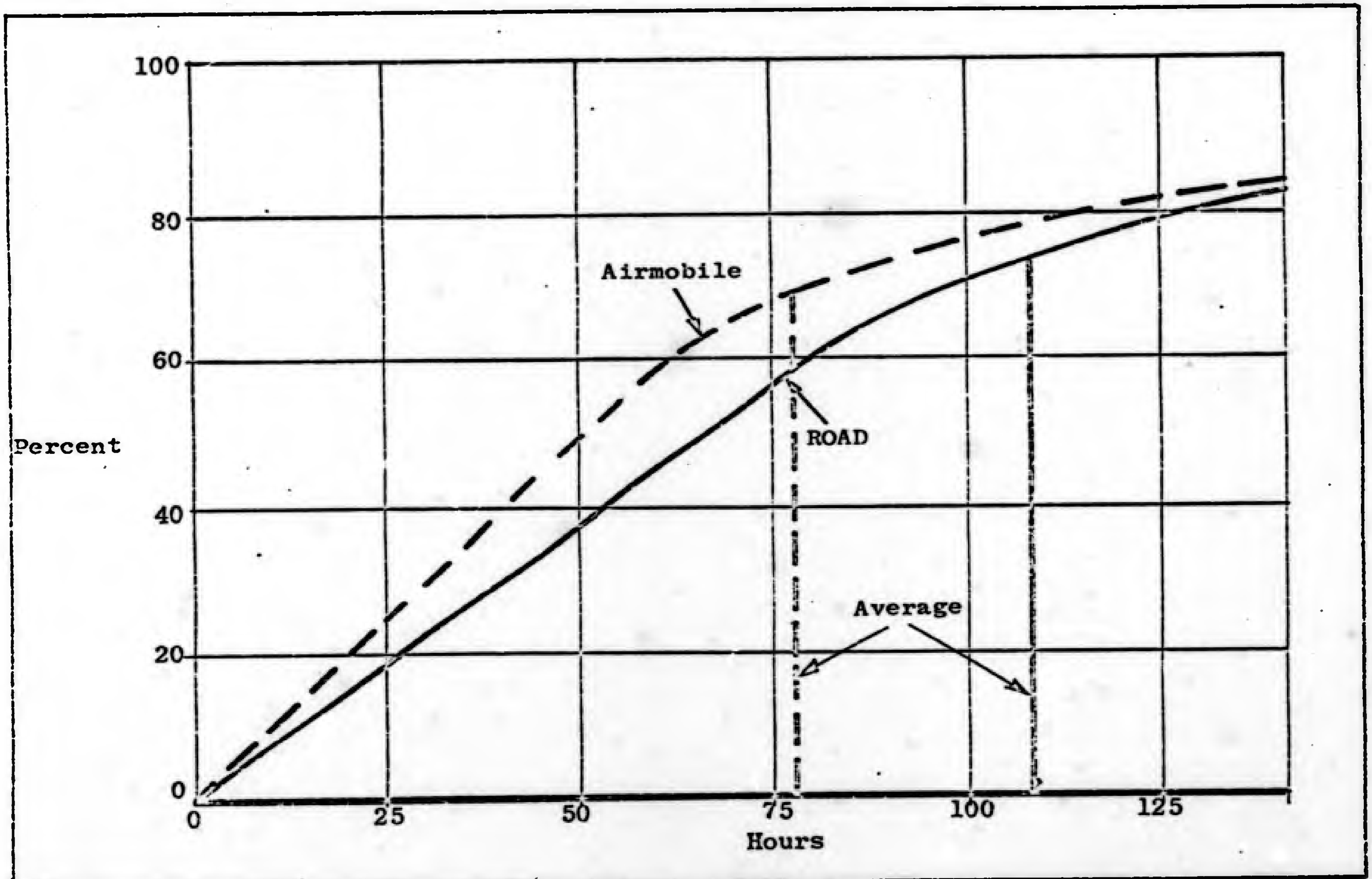


Figure 5-9. Cumulative Event Distribution for UH-1B/C Direct Support Maintenance Hours

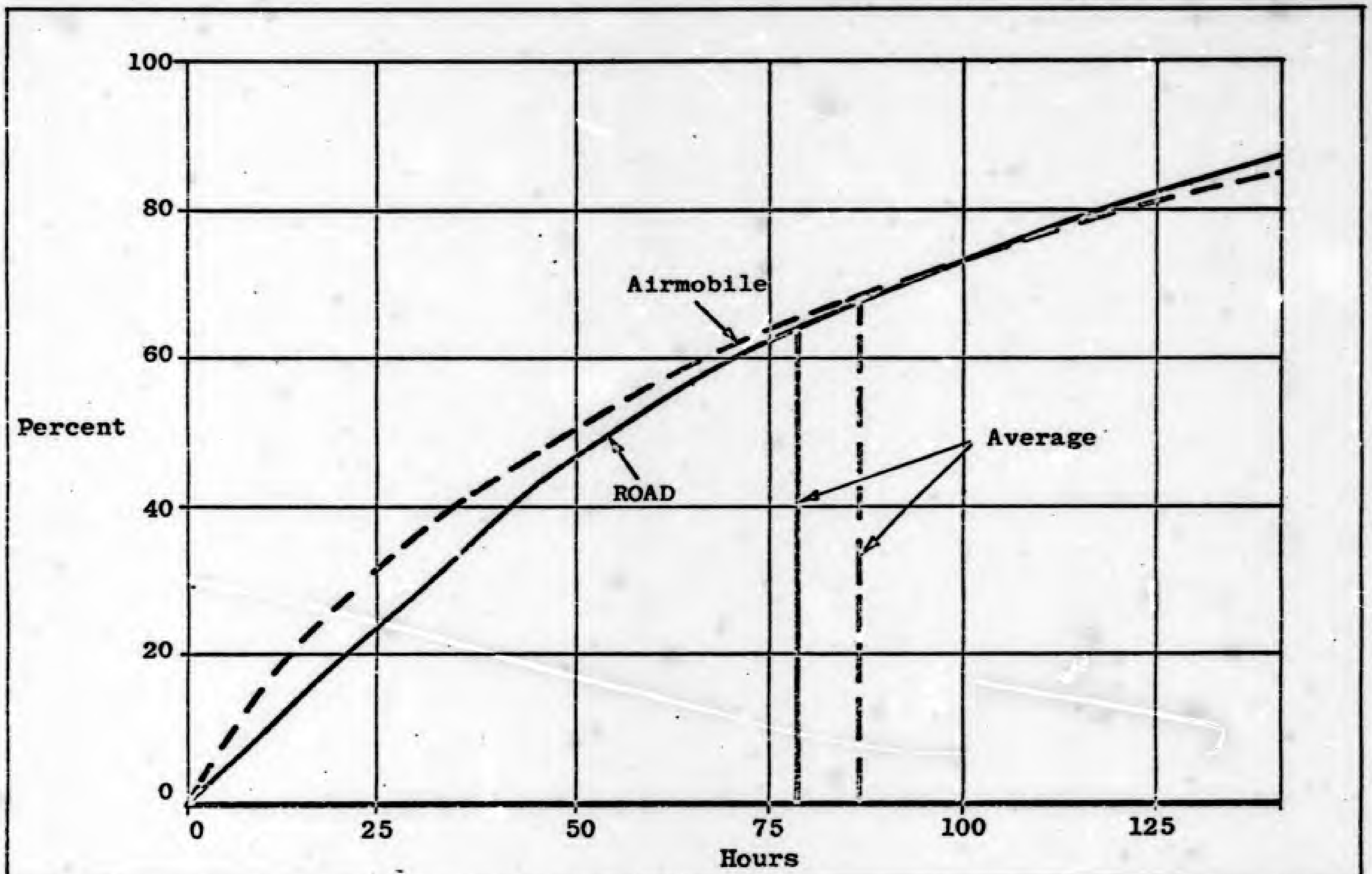


Figure 5-10. Cumulative Event Distribution for UH-1D/H Direct Support Maintenance Hours

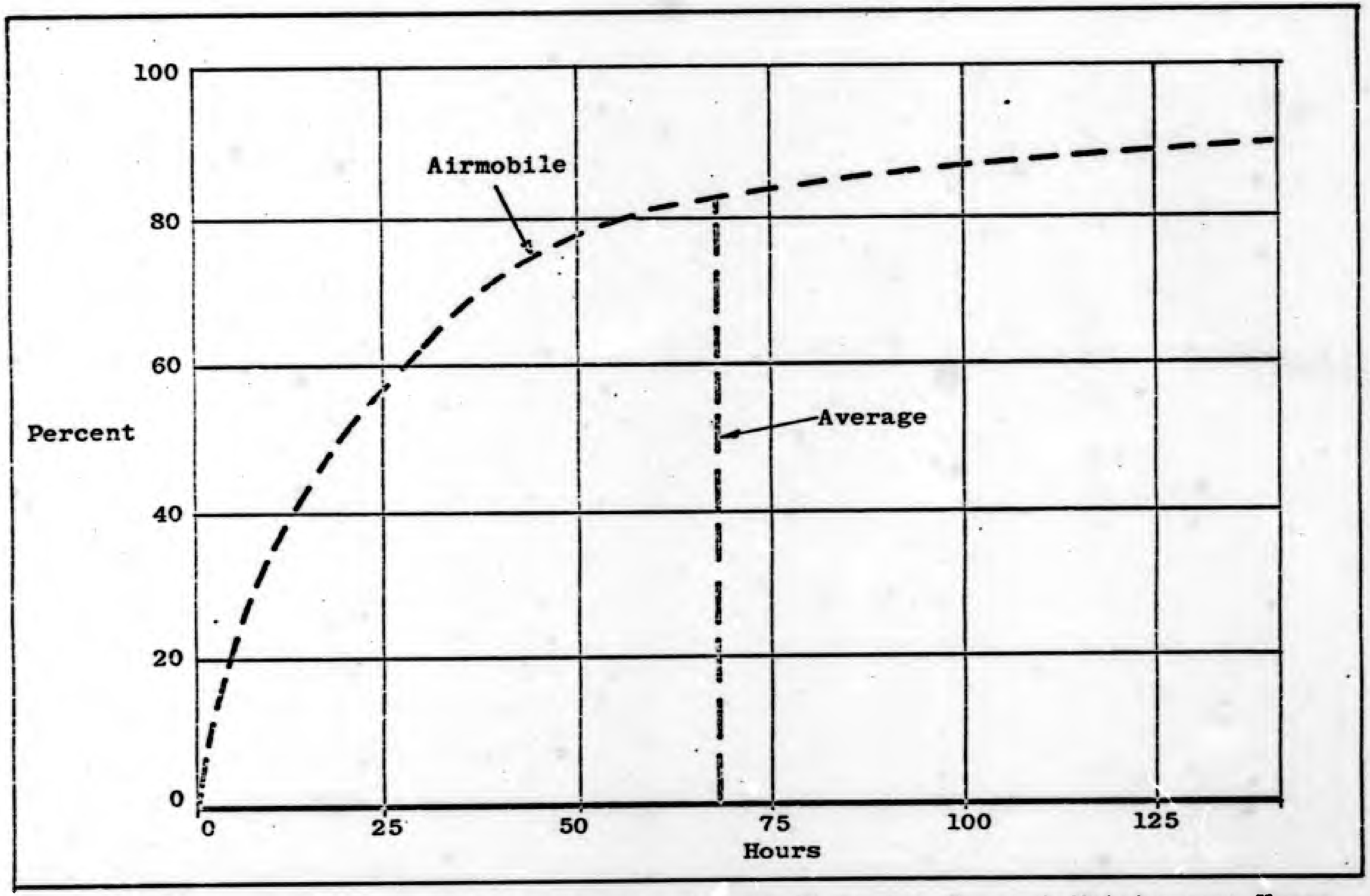


Figure 5-11. Cumulative Event Distribution for CH-47 Direct Support Maintenance Hours

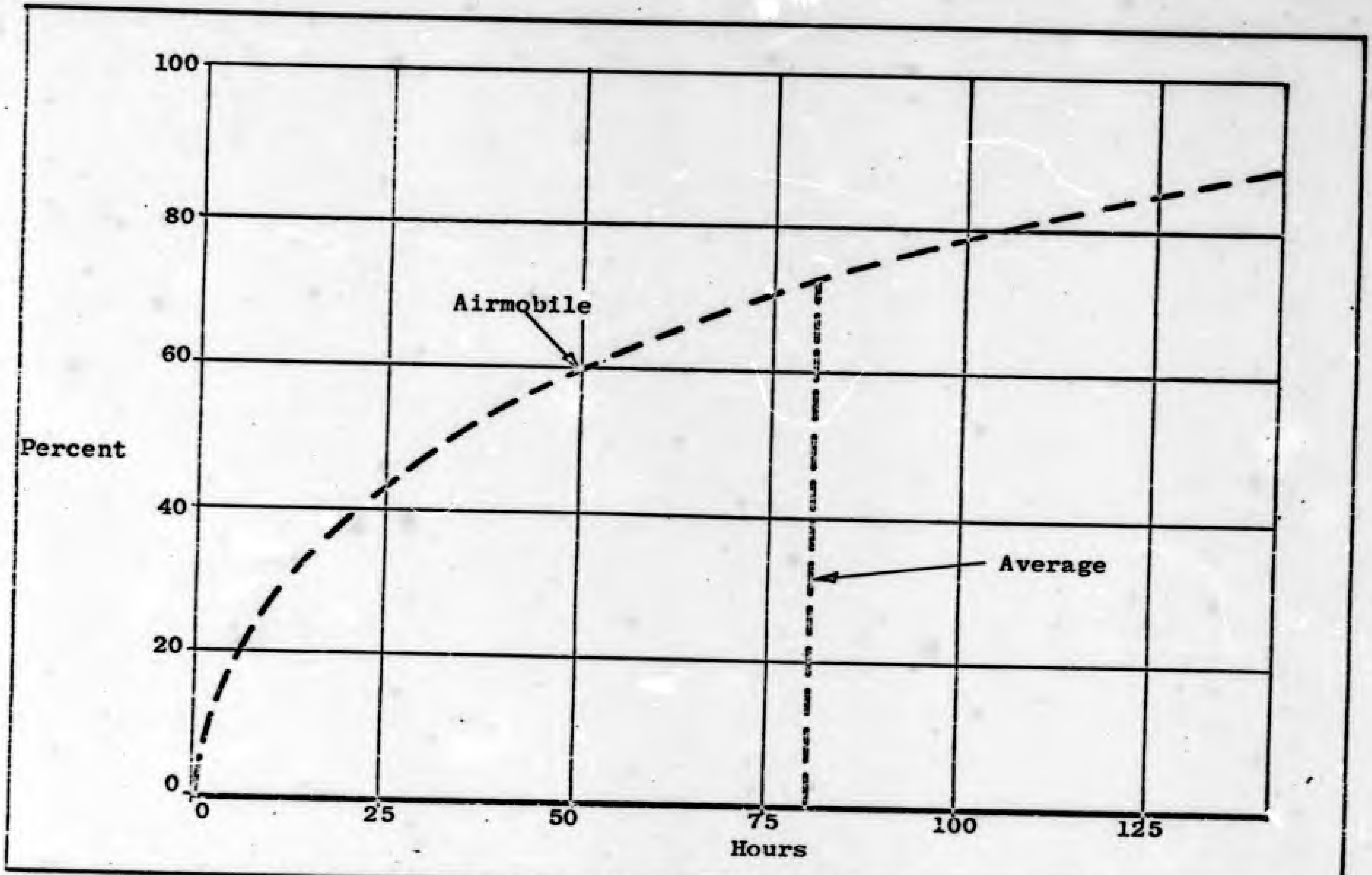


Figure 5-12. Cumulative Event Distribution for CH-54 Direct Support Maintenance Hours

This is the lowest average of all the aircraft studied. In fact, only 4% of the events for the OV-1 at Direct Support exceed a period of one week.

The distributions for the OH-13s of both Divisions appear in Figure 5-8. The Airmobile Division aircraft spends more time per event at Direct Support than the ROAD Division aircraft. The averages are 114 hours for the Airmobile Division and 103 hours for the ROAD Division. This is similar to the relationship between both Divisions discussed for Organizational Maintenance. A comparison of the number of events greater than one week indicates a minor reversal in the relationship of the two Divisions. More than 17% of the events of the ROAD Division and only 8% of the events of the Airmobile Division exceed one week. Though the difference is large, it does not affect the overall relationship between the OH-13s of both Divisions.

Figure 5-9 presents the Cumulative Event Distributions for the UH-1B Direct Support hours. In contrast to the relationship between the two Divisions of the UH-1B at Organizational Maintenance, the ROAD Division has a greater average for Direct Support than the Airmobile Division. The averages are 108 and 77 hours, respectively. Thus, the UH-1B aircraft of the Airmobile Division spend much less time at Direct Support maintenance per event than the ROAD Division UH-1Bs. This difference is further demonstrated in comparing the percentage of aircraft that are at Direct Support for more than one week. For the UH-1B, 11 percent of the events in the Airmobile Division and 18% in the ROAD Division exceed one week in length.

The results of the UH-1D at Direct Support also contrast with those at Organizational level. As shown in Figure 5-10, Direct Support events for the Airmobile Division are longer than Direct Support events for the ROAD Division. The Airmobile Division average is 86 hours; that of the ROAD Division is 78 hours. This pattern continues throughout the length of both distributions with 8% of the UH-1D events of the ROAD Division exceeding a period of one week, while 13% do so in the Airmobile Division.

An interesting relationship exists between Organizational Maintenance and Direct Support for the UH-1B and UH-1D aircraft in both Divisions. The ROAD Division UH-1Bs have longer events at Direct Support than those of the Airmobile Division, while at Organizational Maintenance, the events of the ROAD Division are shorter than those of the Airmobile Division. For the UH-1D, the reverse is true. The ROAD Division UH-1Ds have shorter events at Direct Support than those of the Airmobile Division. But at Organizational Maintenance, the UH-1D events of the ROAD Division are longer than those of the Airmobile Division. The data analyzed in these studies do not explain these curious relationships between the Divisions, maintenance levels, and UH-1 aircraft. The analysis of Organizational Maintenance and Direct Support parameters to be presented in a future report will study this situation in detail.

The distributions for the CH-47 and the CH-54 aircraft of the Airmobile Division are presented in Figures 5-11 and 5-12, respectively. The average per event for the CH-47 is 68 hours and for the CH-54, 80 hours. The CH-54 has a higher average at Direct Support than the CH-47 aircraft. This is in contrast with their relative relationship at

Organizational Maintenance where the CH-47 had a greater average than the CH-54. Further examination of these figures reveals both aircraft to have 10% of their Direct Support events exceeding one week.

At Direct Support, the average hours per maintenance event are approximately two or three times as large as those at Organizational Maintenance. All averages at Direct Support level exceed 60 hours, but do not exceed 115 hours. Generally, 8 to 17 of all events studied exceeded the one week time period. The only exception is the OV-1 with 4%. Thus, as with Organizational Maintenance, the length of time spent in maintenance per event at Direct Support is approximately the same for all aircraft in both Divisions.

GENERAL SUPPORT MAINTENANCE

The final maintenance level discussed for a transition probability simulation is General Support. General Support data were very sparse since aircraft seldom go to this level. Therefore, for most of the aircraft studied, the data were not adequate for calculating means. This was particularly true of the Airmobile Division, for which sufficient data were collected on only two aircraft. The average hours per General Support event are shown in Figure 5-13.

In comparing the UH-1B and UH-1D of both Divisions, the Airmobile Division has smaller averages than the ROAD Division. For the UH-1B, the averages are 410 and 470 respectively, while for the UH-1D the averages are 285 and 335. These averages for the ROAD Division are 15 to 18% greater than those of the Airmobile Division. From this

AIRCRAFT	AIRMOBILE DIVISION	ROAD DIVISION
OV-1	*	240
OH-13	*	390
UH-1B/C	410	470
UH-1D/H	285	335
CH-47	*	N/A
CH-54	*	N/A

*Insufficient Data N/A Not Applicable

Figure 5-13. Average Hours per GS Maintenance Event

[redacted]

limited comparison of the two Divisions, one might conclude that the aircraft of the ROAD Division spend more time per maintenance event at General Support Maintenance than the aircraft of the Airmobile Division. But since there is little data for the other aircraft, there is no basis for a broad conclusion.

The UH-1B/C model spent 40% more time per event at General Support than the D/H model.

The remaining two aircraft for which results were obtainable are the OV-1 and the OH-13 aircraft in the ROAD Division. The average hours per General Support event for these two aircraft were 240 and 390 respectively.

MONTHLY NORM RATES

The average monthly NORM rates for the six aircraft studied in both Divisions appear in Figure 5-14. The NORM rates included in these averages are for Direct Support and General Support Maintenance (combined) and for Organizational Maintenance. Except for the ROAD Division OV-1s, all aircraft exceed the DA Standard established for the total NORM rate for each aircraft. The DA standard is exceeded by as little as 2% for the OH-13 of the Airmobile Division, and as much as 8% for the CH-47. For most of the other aircraft, the DA standard is exceeded by approximately 3 to 5%. The OV-1 is approximately 1% below the DA standard.

Comparing the Divisions, the OV-1 and UH-1B aircraft of the Airmobile Division have higher monthly average NORM rates than those

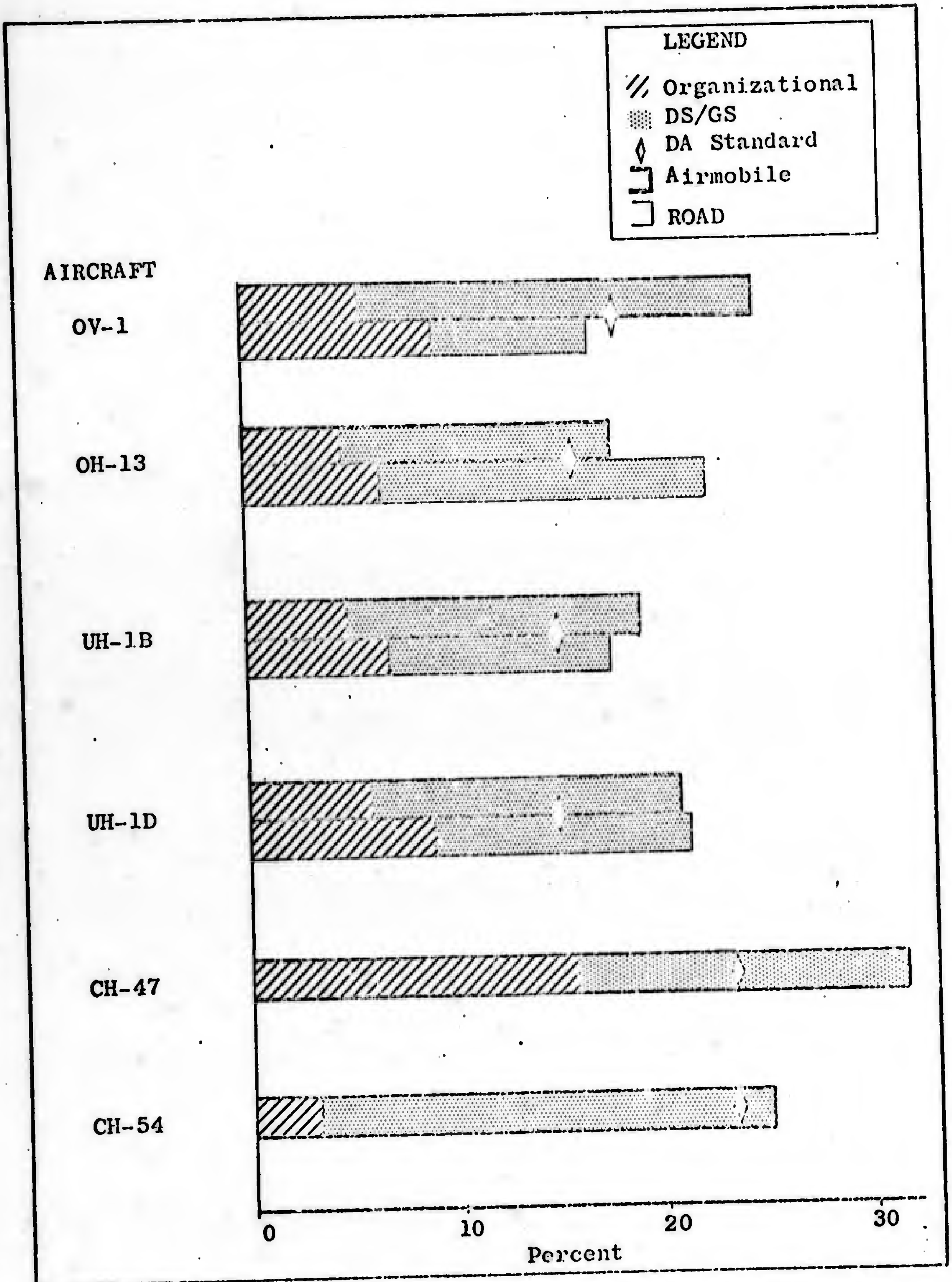


Figure 5-14. Average Monthly NORM Rates
(October 1966 - September 1967)

of the ROAD Division. For the UH-1B, the difference in the rates of both Divisions is a little over 1%, while for the OV-1, the difference in the rates is approximately 8% to 9%.

For the UH-1D, the rates for both Divisions are approximately the same, with only a fractional difference. For the OH-13 aircraft, the ROAD Division has higher monthly average NORM rates than the aircraft of the Airmobile Division. The difference between the two Divisions is approximately 5%. A comparison between the maintenance levels indicates that the average monthly NORM rates at Direct Support/General Support are greater than those at Organizational Maintenance. They range from the 1.0 to 1.0 ratio between levels for the CH-47, to the 7.5 to 1.0 ratio for the CH-54 aircraft.

Organizational Maintenance NORM rates of the ROAD Division are greater than those of the Airmobile Division by approximately 2 to 3%. On the other hand, the Direct Support/General Support NORM rates of the ROAD Division are less than, or equal to, those rates for the corresponding aircraft of the Airmobile Division.

Thus, the aircraft of the ROAD Division spend less time down for maintenance than the aircraft of the Airmobile Division. This difference is very small. Furthermore, the distributions of the downtime within each of the Divisions lean heavily toward Organizational Maintenance for the ROAD Division and toward the Direct Support/General Support for the Airmobile Division. These results generally agree with those obtained for each Division in the earlier discussions of this Chapter. The agreement is not complete since the distributions previously presented do not consider the frequency with which the maintenance events occur at each level, while they are considered in the average monthly NORM rates in Figure 5-14.

CHAPTER 6

NOT OPERATIONALLY READY, SUPPLY (NORS)

CHAPTER 6

NOT OPERATIONALLY READY, SUPPLY (NORS)

GENERAL

The discussion of downtime in Chapter 5 was limited to downtime for maintenance. The use of transition probability in a maintenance simulation requires not only maintenance downtime but also the downtime for which an aircraft is Not Operationally Ready for reasons of supply. The NORS factors required for a maintenance simulation are discussed in this Chapter. Factors were derived only for Organizational Maintenance and Direct Support. As with the NORM analysis, the data at General Support level were very sparse and, in many cases, insufficient to derive valid factors. Therefore, General Support NORS time was included in the NORM rates presented in Figure 5-13 and are not discussed in this Chapter.

NORS PROBABILITY

Once transition probabilities have determined the maintenance level into which an aircraft will move, it is necessary to establish whether or not the aircraft will be down for NORS. This is a conditional probability, that is, if an aircraft is in a particular state of maintenance, what is the probability that it will be down for NORS? The NORS probabilities for each of the aircraft studied for both Divisions are presented in Figure 6-1. To illustrate

AIRCRAFT	MAINTENANCE LEVEL	AIRMOBILE DIVISION	ROAD DIVISION
OV-1	ORG	*	35.4
	DS	*	4.4
OH-13	ORG	6.3	14.3
	DS	23.1	8.4
UH-1B/C	ORG	5.9	6.3
	DS	22.7	7.4
UH-1D/H	ORG	2.8	4.9
	DS	16.9	8.7
CH-47	ORG	3.5	N/A
	DS	9.2	N/A
CH-54	ORG	3.9	N/A
	DS	5.9	N/A

*Insufficient Data
N/A - Not Applicable

Figure 6-1. NORS Probabilities

the conditional probability, the following example is given:

> A UH-1B aircraft of the Airmobile Division has a 77.5 percent probability of going from Operational Readiness to the Organizational Maintenance. Given that this event occurs, that same aircraft had a 5.9 percent probability that it will be down at Organizational Maintenance for NORS. Thus, the aircraft may be down for both a period of NORM and a period of NORS.

As shown in Figure 6-1, the NORS probabilities for the Airmobile Division at Direct Support are consistently greater than the NORS probabilities at Organizational Maintenance. In particular, the differences between the NORS probabilities of the two maintenance levels are quite large for the OH-13, UH-1B/C and UH-1D/H. For these aircraft, the differences in probabilities are 14 to 17 percent. The NORS probabilities of Organizational Maintenance range from about 3 to 6 percent, while the NORS probabilities of Direct Support range from 17 to 23 percent.

The Organizational Maintenance probabilities for the CH-47 and CH-54 helicopters are within the range of the other aircraft in the Airmobile Division with values of 3.5 and 3.9, respectively. The values of the NORS probabilities for Direct Support are much lower than those of the other aircraft in the Airmobile Division, with the CH-47 having a value of 9.2 percent and the CH-54, a value of 5.9 percent. For these aircraft the difference in the probabilities for the two maintenance levels ranges from 2 to 6 percent.

For the UH-1 aircraft in the ROAD Division, the NORS probabilities at both maintenance levels are approximately the same for both the B and the D series. The range of the NORS probabilities for the UH-1 aircraft at Organizational Maintenance is from 5 to 6 percent, while at Direct Support the range is from 7 to 9 percent. For all UH-1 aircraft the differences between the NORS probabilities at Organizational Maintenance and at Direct Support level are not very large. Here, as in the Airmobile Division, the probabilities at Direct Support are larger than the probabilities at Organizational Maintenance.

For the OV-1 and OH-13 aircraft of the ROAD Division, the NORS probabilities are much greater at Organizational Maintenance than at Direct Support. This is in contrast to the relationship between these two maintenance levels for all aircraft discussed thus far. For the OH-13, the difference in the NORS probability between levels is approximately 6 percent, with Organizational Maintenance having a value of 14.3 percent and Direct Support 8.4 percent. In the case of the OV-1, the difference between levels of maintenance is very large. At Direct Support the NORS probability is 4.4 percent, while at Organizational Maintenance the value is 35.4 percent. This is a difference of 31 percent; that is, Organizational Maintenance has a NORS probability which is approximately nine times as great as that of Direct Support level.

Thus, there appears to be a pattern in the Airmobile Division of more frequent NORS at Direct Support than at Organizational Maintenance. This pattern appears to be true of all aircraft of the Airmobile Division. For the aircraft of the ROAD Division, however, there appears to be no NORS pattern. Rather, each type of aircraft within the ROAD Division has its own NORS characteristics.

NORS HOURS

For aircraft down for NORS at Organizational Maintenance and Direct Support, the average hours per event are presented in Figure 6-2. These NORS hours are added to the NORM hours determined from use of the NORM probabilities and hour distributions discussed in Chapter 5.

Generally, the average number of hours an aircraft is in a NORS condition at Direct Support is greater than that at Organizational Maintenance. The difference between the averages of both levels ranges from 8 to 280 hours, with most differences falling into a smaller range of 32 to 75 hours.

For the OH-13 aircraft, the average hours of the Airmobile Division are greater than those of the ROAD Division at both maintenance levels. In fact, the average of the Airmobile Division at Organizational Maintenance is twice that of the ROAD Division.

For the UH-1D/H aircraft, the averages for the Airmobile Division are less than those of the ROAD Division. The difference in the Divisional averages at each level is much smaller than the difference for the OH-13. The difference at Organizational Maintenance is approximately four hours, while, at Direct Support, it is approximately 25 hours.

AIRCRAFT	MAINTENANCE LEVEL	AIRMOBILE DIVISION	ROAD DIVISION
OV-1	ORG	*	40.1
	DS	*	48.0
OH-13	ORG	87.2	40.3
	DS	124.0	103.1
UH-1B/C	ORG	42.9	54.9
	DS	71.0	46.3
UH-1D/H	ORG	29.0	33.5
	DS	83.3	107.5
CH-47	ORG	90.2	N/A
	DS	47.4	N/A
CH-54	ORG	72.0	N/A
	DS	360.0	N/A

*Insufficient Data N/A - Not Applicable

Figure 6-2. Average Hours Per NORS Event

For the UH-1B/C aircraft, there appears to be no particular pattern. The average for the ROAD Division is larger than that of the Airmobile Division at Organizational Maintenance, while the average for the ROAD Division at Direct Support is smaller than that of the Airmobile Division.

MONTHLY NORS RATES

Using Figures 6-1 and 6-2 to evaluate the relative NORS characteristics of aircraft common to both Divisions, it can be expected that the Airmobile Division aircraft would have a higher NORS rate than the aircraft of the ROAD Division. This conclusion is verified by the data presented in Figure 6-3. A comparison of the average monthly NORS rates for those aircraft common to both Divisions reveals that the NORS rates for the Airmobile Division are, in fact, greater than the ROAD Division NORS rates. Moreover, the NORS rates for the OH-13 and the UH-1B/C aircraft of the Airmobile Division are more than two and one-half times the rates for these aircraft in the ROAD Division.

With the exception of the CH-47 and CH-54 aircraft, all other aircraft studied in the Airmobile Division exceeded the DA Standard for monthly NORS rates. The rate for the OV-1 (11 percent) was more than twice that of the DA Standard. The rate of the UH-1B (9 percent) was not quite twice that of the standard.

The OH-13 (11 percent) and UH-1D/H (6 percent) aircraft exceed the DA Standard by approximately 1 percent. The CH-54 (5 percent) aircraft had a NORS rate which was

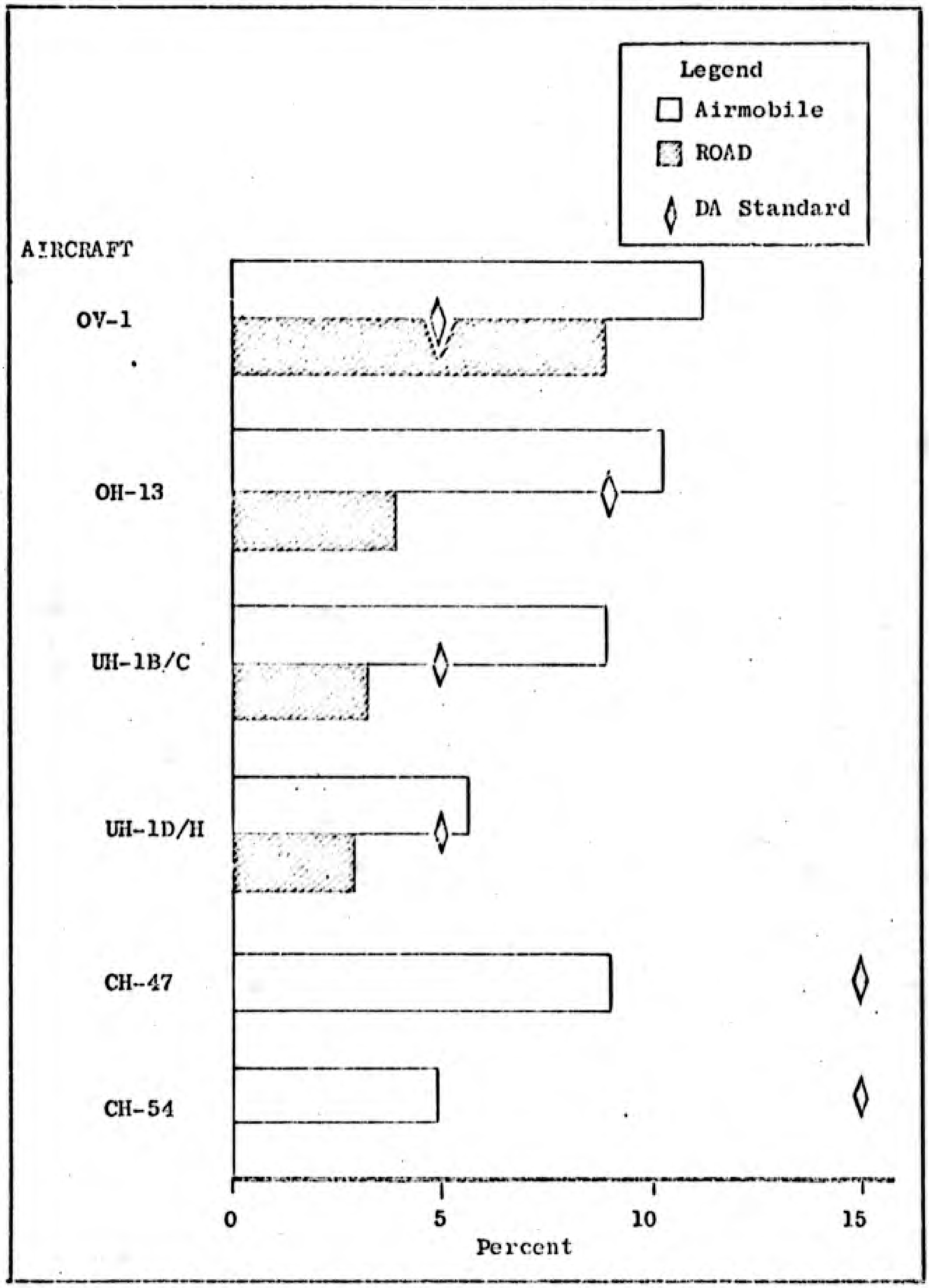


Figure 6-3. Average Monthly NORS Rates
(October 1966 - September 1967)

one-third of the DA Standard while that of the CH-47 (9 percent) was slightly over half the value of its DA Standard.

In the ROAD Division only the OV-1 (9 percent) aircraft exceeded its standard.

The fact that the UH-1B (3 percent), UH-1D (3 percent), and OH-13 (4 percent) rates are only one-half to two-thirds the DA standard indicates that the ROAD Division was performing exceptionally well in meeting its supply requirements.

CHAPTER 7

AIRCRAFT UTILIZATION

CHAPTER 7

AIRCRAFT UTILIZATION

UTILIZATION PROBABILITY

If an aircraft is Operationally Ready, what is its probability of being utilized? The answers are found in Figure 7-1 which presents the Daily Utilization Probability Factors for all aircraft. These probabilities are conditional. They are dependent upon the probability that an aircraft is Operationally Ready and in condition to be utilized. Given that an aircraft is Operationally Ready, it then has a probability of being utilized on a daily basis as indicated by the factors presented in Figure 7-1.

As seen in this Figure, most of the aircraft assigned to the two Divisions studied are flown approximately 60 to 70 percent of the time. The OV-1 aircraft are utilized most often and have approximately 70 percent Daily Utilization Probability.

The UH-1B/C and UH-1D/H aircraft are the next most utilized aircraft. For the UH-1B/C, the Airmobile Division aircraft have a higher probability of being utilized on the day they are available than the UH-1B/C aircraft of the ROAD Division. Respectively, the percents of probability are 68 percent and 60 percent. The utilization pattern of the UH-1D/H aircraft is the reverse of the UH-1B/C. The UH-1D/H aircraft of the ROAD Division have a 67 percent probability of being utilized on the day they are available, as opposed to the 59 percent probability of utilization

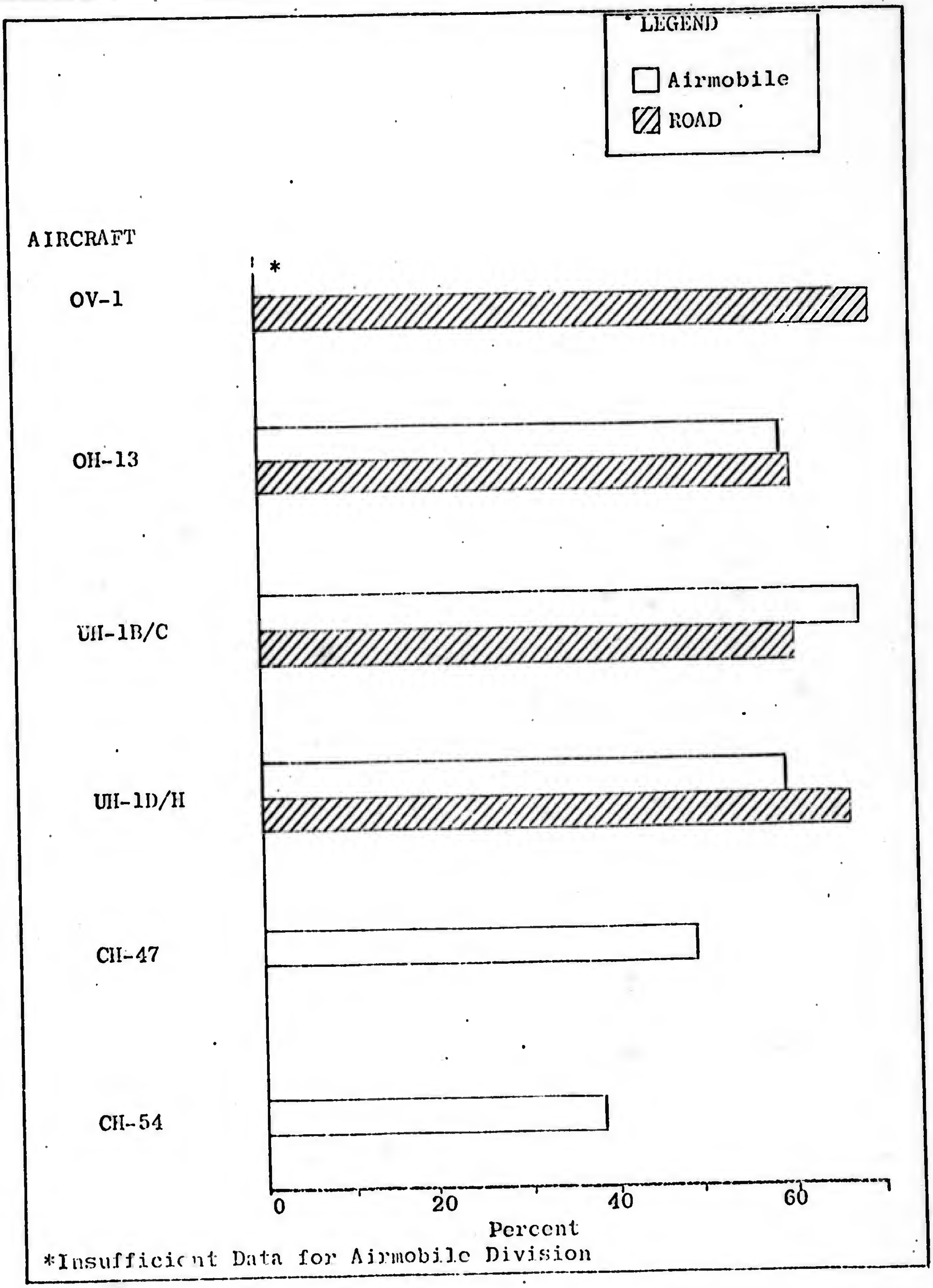


Figure 7-1. Daily Utilization Probability

of those assigned to the Airmobile Division.

As seen in Figure 7-1, the Daily Utilization Probabilities of the OH-13 aircraft in both the Airmobile and ROAD Division are approximately equal at 59 percent. The CH-47 helicopter is utilized with a daily probability of 50 percent, while the CH-54 with a probability of slightly over 35 percent.

TAKEOFF TIME

Figures 7-2 through 7-6 present takeoff schedules. The day is partitioned into two-hour intervals beginning with 2400. The first Figure contains the takeoff distribution for the OV-1. As shown in this distribution, there are many takeoffs during the evening and night hours. This night flying is not peculiar to either the Airmobile or the ROAD Division. It recognizes the continuing task of night surveillance that is performed by the OV-1 for both Divisions.

The OH-13 aircraft, as shown in Figure 7-3, takes off only during the daylight hours. The takeoff distribution for the OH-13 ranges from 0600 to 2000 hours. The distributions of the aircraft of both Divisions are approximately the same. The ROAD Division takeoffs are slightly more frequent in the morning, while the Airmobile Division has more takeoffs in the afternoon.

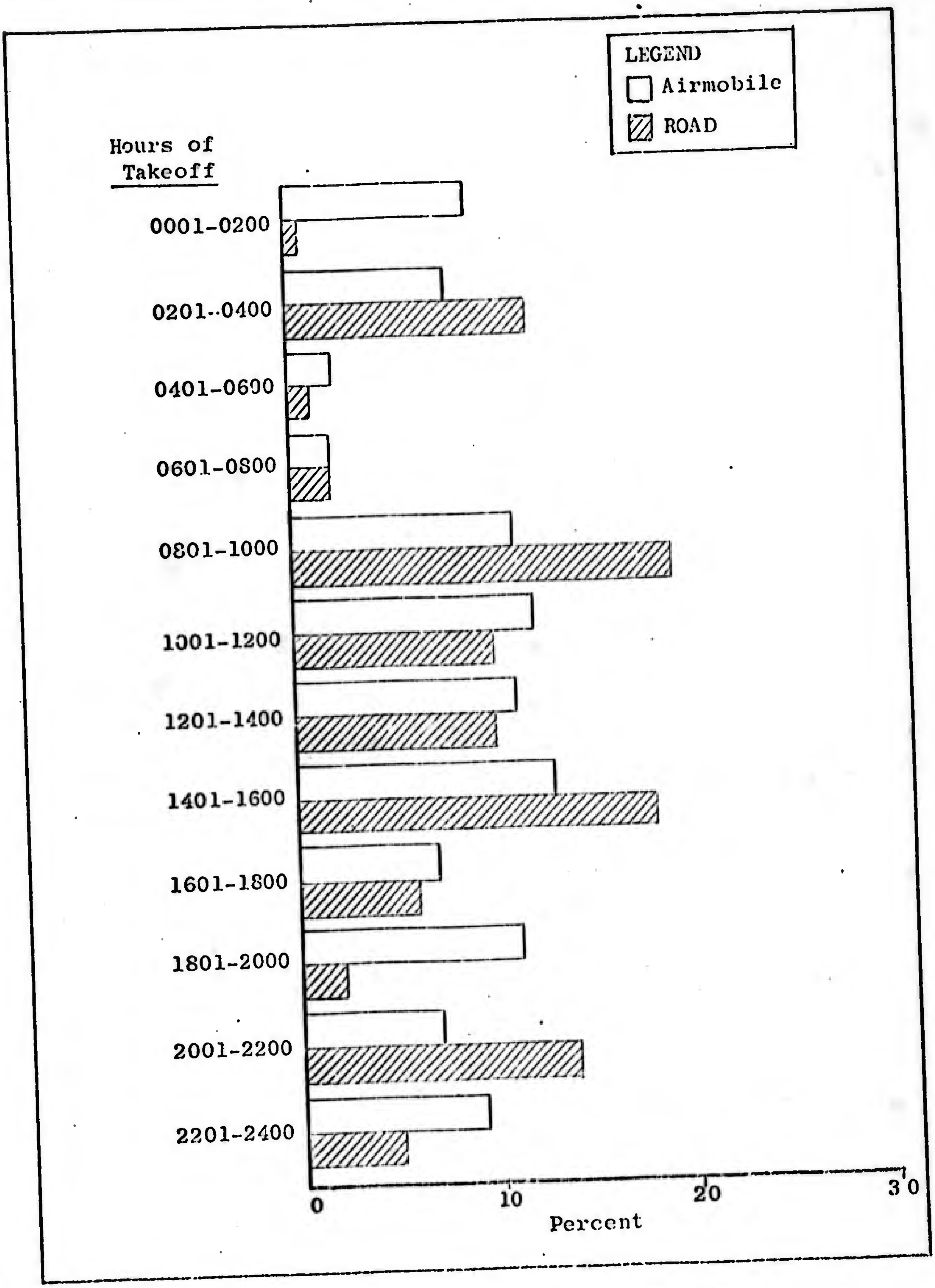


Figure 7-2. Distribution of OV-1 Takeoffs

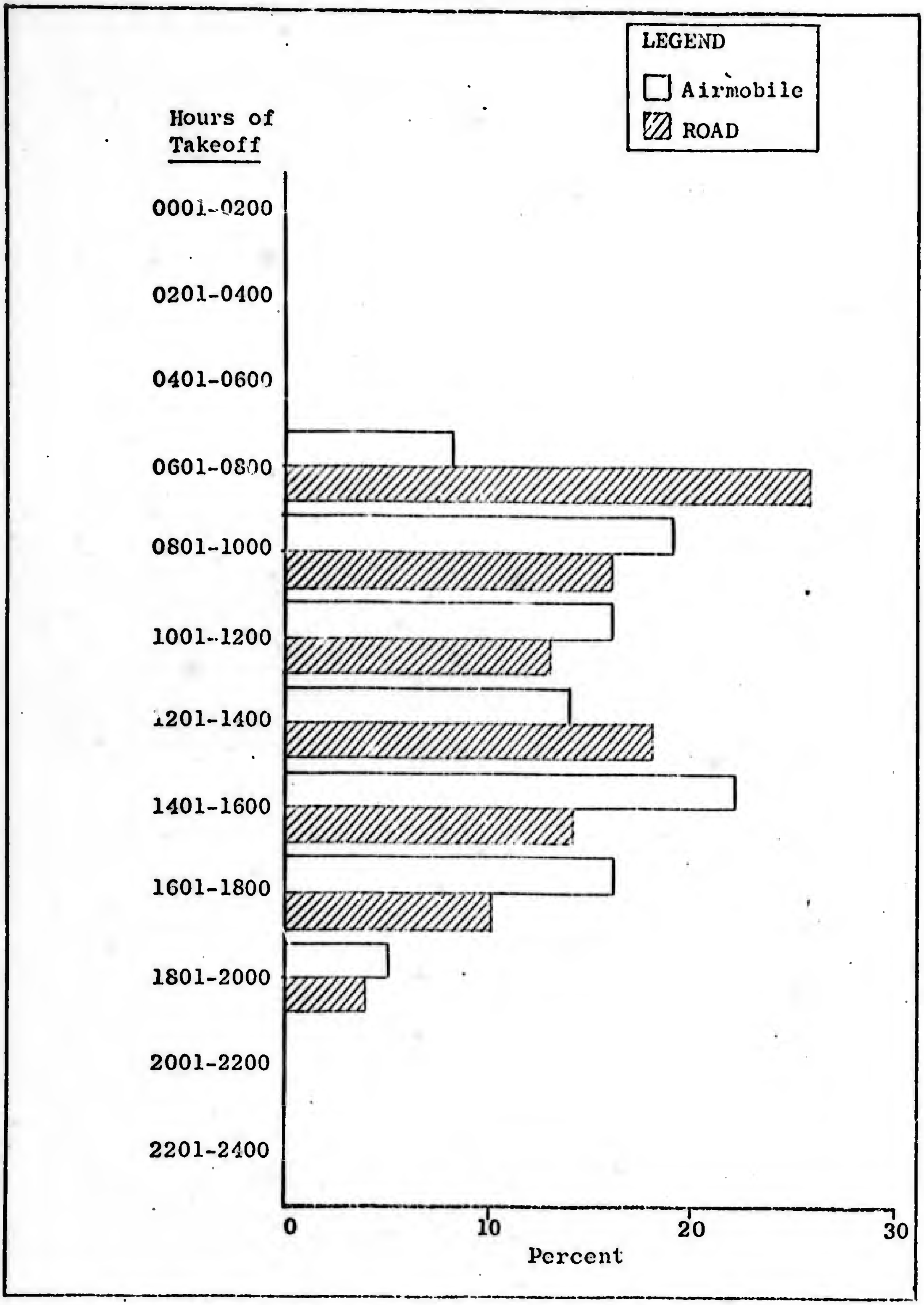


Figure 7-3. Distribution of OH-13 Takeoffs

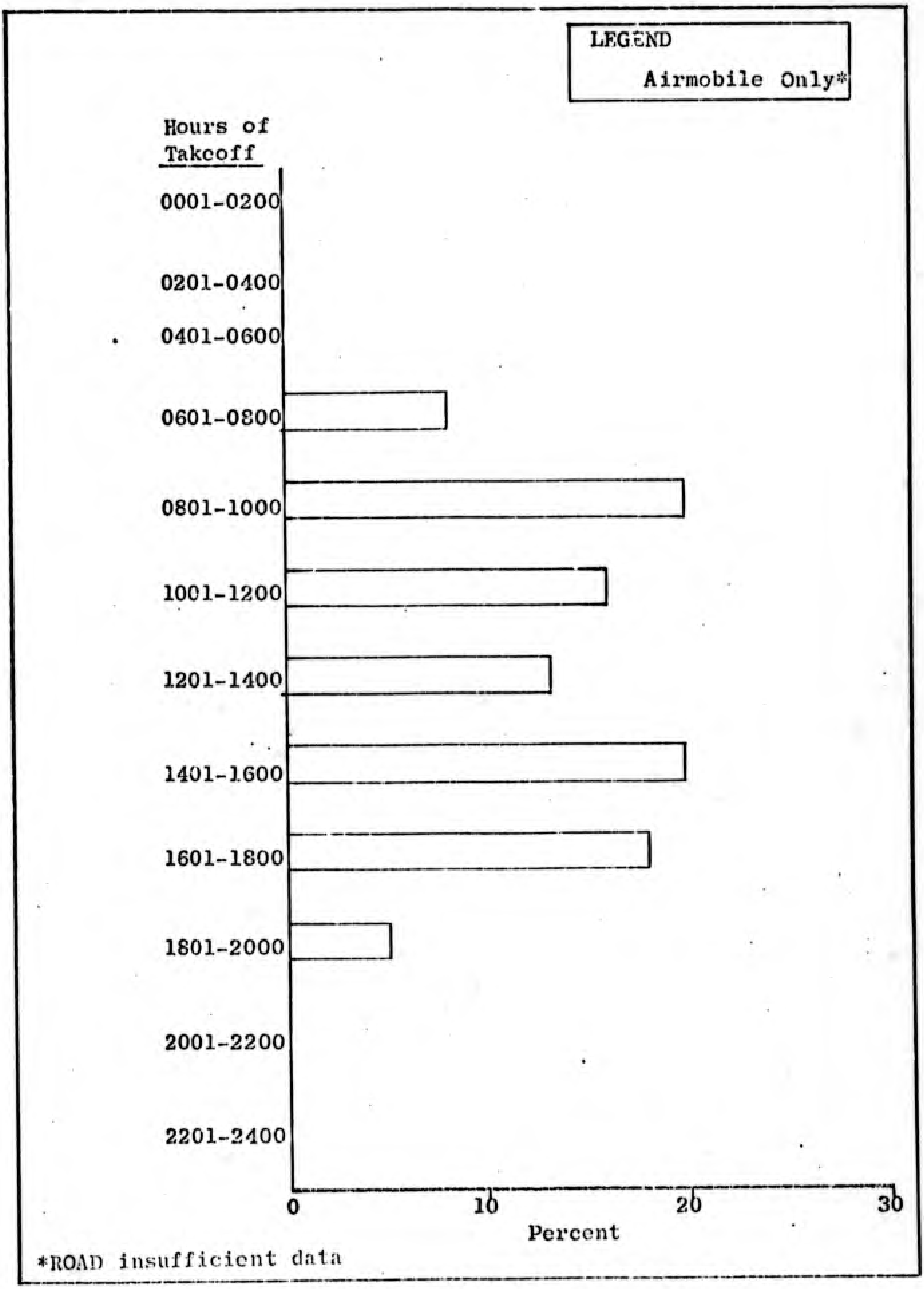


Figure 7-4. Distribution of UH-1B/C Takeoffs

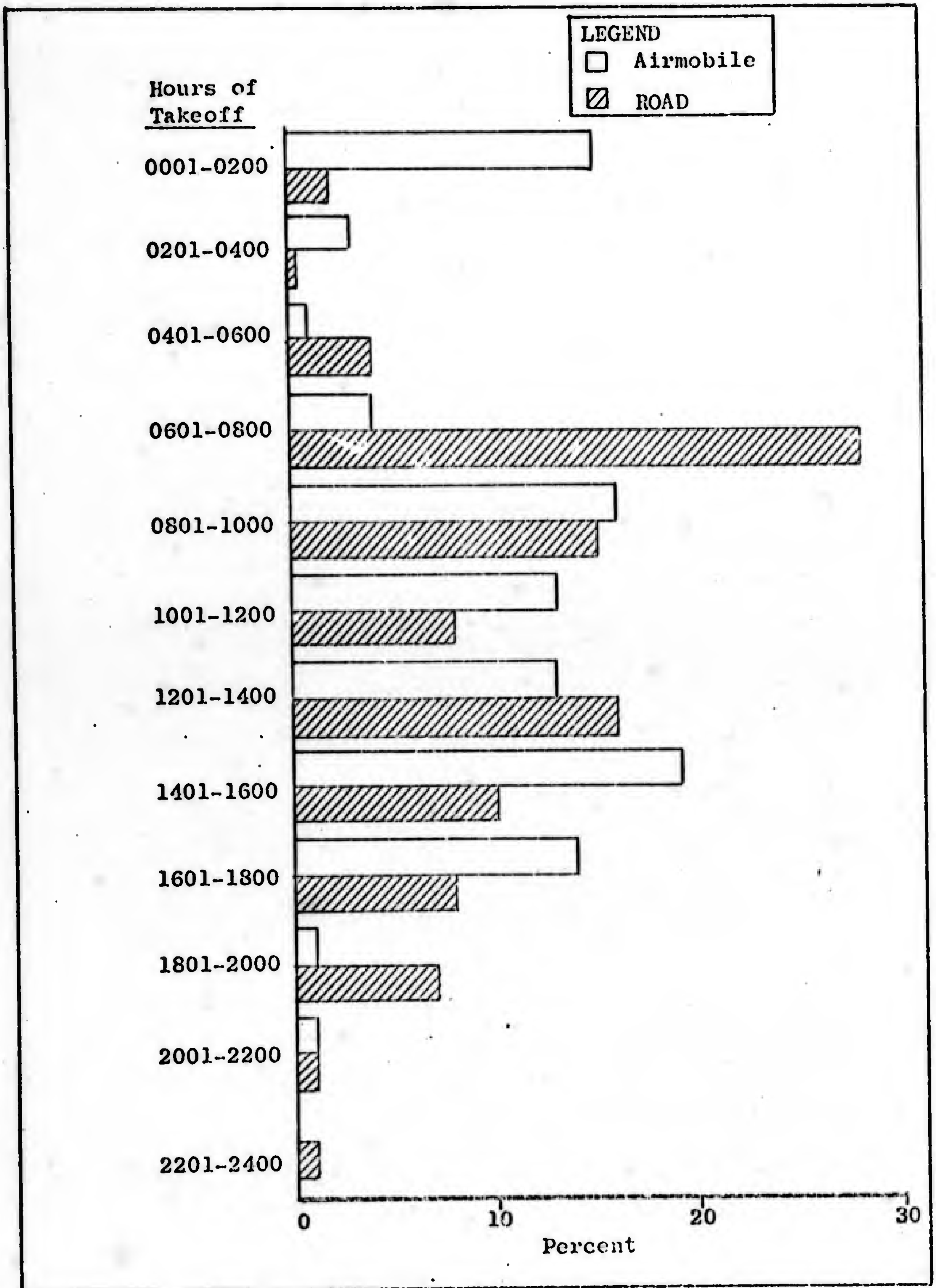


Figure 7-5. Distribution of UH-1D/H Takeoffs

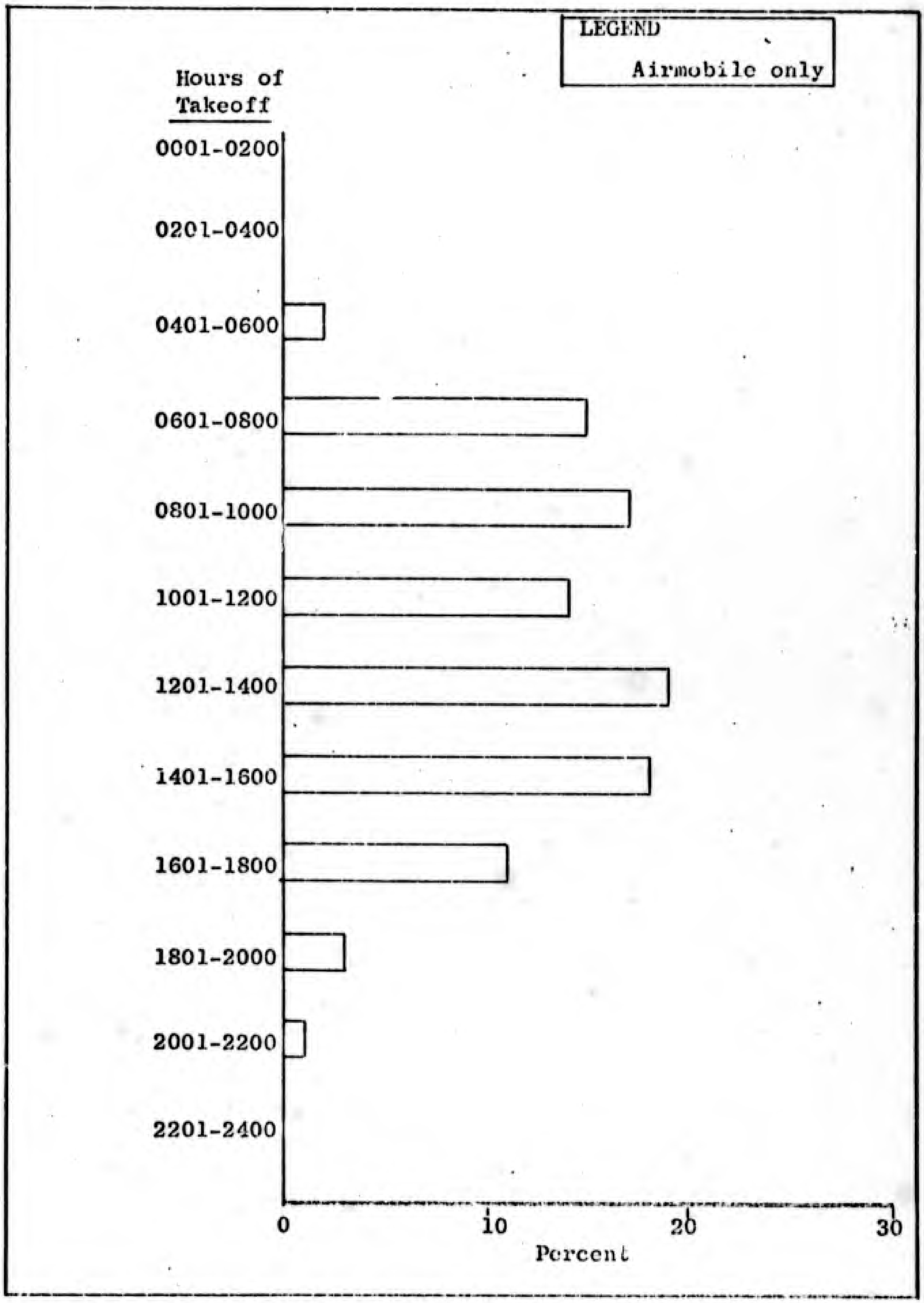


Figure 7-6. Distribution of CH-47 Takeoff

The data from the ROAD Division for the UH-1B/C aircraft were insufficient to allow preparation of a takeoff distribution. Thus, Figure 7-4 contains only a distribution for the UH-1B/C aircraft of the Airmobile Division. As with the OH-13 aircraft, the UH-1B aircraft of the Airmobile Division take off between the hours of 0600 and 2000 hours. Its takeoff distribution has a small peak during the midmorning and another peak during the midafternoon. There is a slight lull in the number of takeoffs at midday.

The UH-1D/H aircraft presented in Figure 7-5 tend to perform some flying during the night, but not with the frequency of the OV-1 aircraft. The explanation for these night takeoffs appears to be the use of the UH-1D aircraft for purposes of evacuation. The peculiarly high percentage of takeoffs in the Airmobile Division during the first two-hour interval of the day results from the use of the UH-1D to perform perimeter security control. Here, as we have seen with other aircraft, the Airmobile Division has a greater percentage of its takeoffs during the afternoon or late morning hours, while the ROAD Division has many of its takeoffs during the early morning or morning hours.

The distribution of takeoffs for the CH-47 is presented in Figure 7-6. The range of takeoffs are from 0600 hours to 2200 hours. Most of the flights take off between 0600 hours and 1800 hours. The distribution of aircraft takeoffs is approximately equal over this range.

DAILY UTILIZATION

The hours flown per flying day for such aircraft are presented in Figures 7-7 through 7-12. These hours are the total hours for all missions on each day flown. The discussion of missions flown per day is covered in Chapter 8. Since data were insufficient to prepare a distribution for the Airmobile Division, the results in Figure 7-7 are only for the OV-1 aircraft of the ROAD Division. The average number of hours flown per flying day for OV-1 aircraft of the ROAD Division is 3.4.

The distributions describing the hours flown per flying day by the OH-13 aircraft of both the ROAD and Airmobile Divisions appear in Figure 7-8. The OH-13 aircraft of the Airmobile Division fly fewer hours per day than the aircraft of the ROAD Division. This is reflected in the average hours flown per flying day which for the Airmobile Division is only 2.8 hours, and for the ROAD Division is 3.4.

The distributions of the UH-1B/C aircraft of the Airmobile and ROAD Divisions are approximately the same as seen in Figure 7-9. The average hours flown per flying day for both Divisions is also approximately the same. The average for the Airmobile Division is 2.9, while that of the ROAD Division is 3.1.

The daily utilization of the UH-1D by both Divisions is also very similar. Here, as with the UH-1B, there is only 2/10ths of an hour difference between the average hours flown in the two Divisions. The Airmobile Division average is 3.8; the ROAD Division average is 4.0. Though the means are very close, the actual hours are not closely distributed. The peak of the distribution for the UH-1D aircraft in the ROAD Division

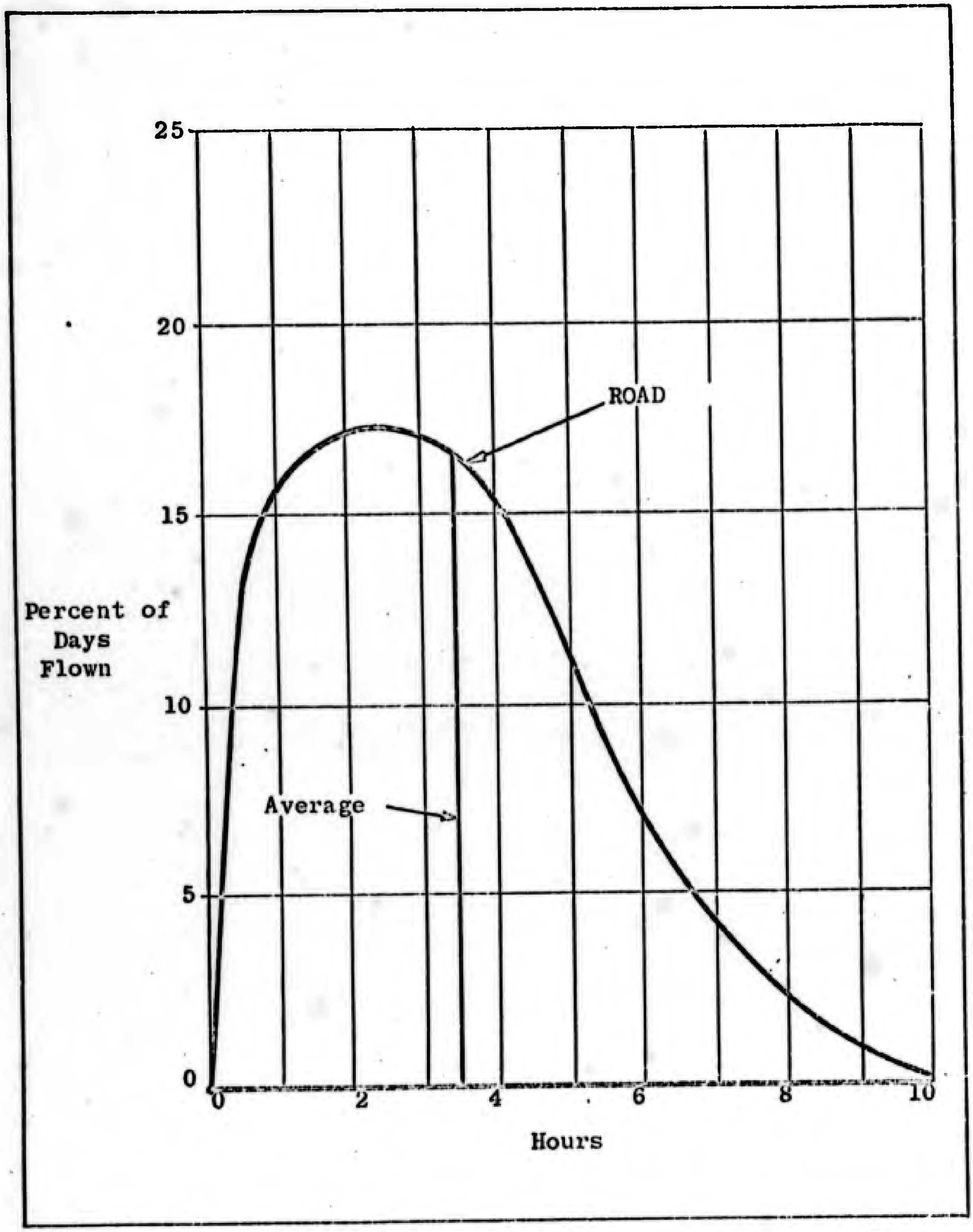


Figure 7-7. Hours Flown Per Flying Day - OV-1

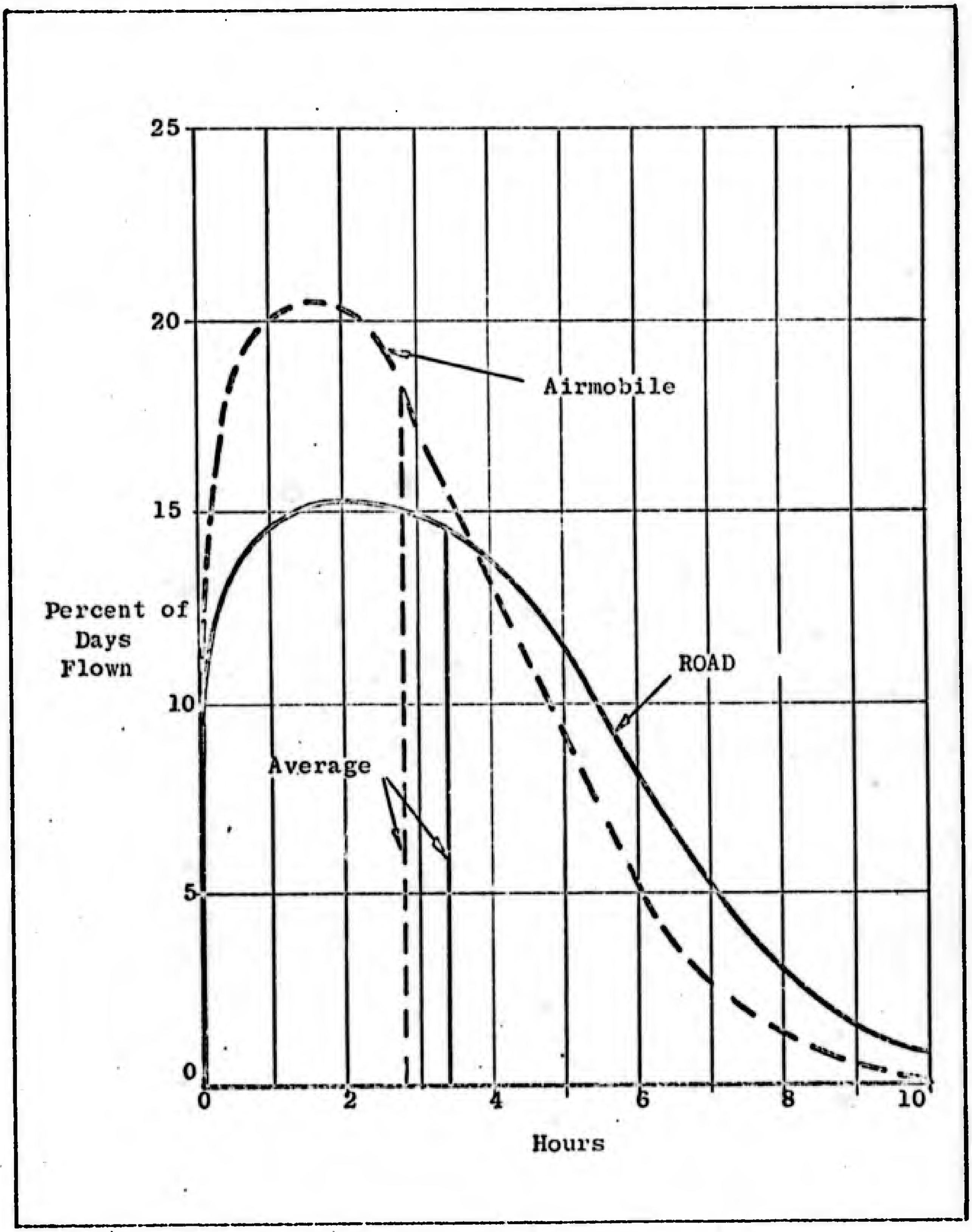


Figure 7-8. Hours Flown Per Flying Day - OH-13

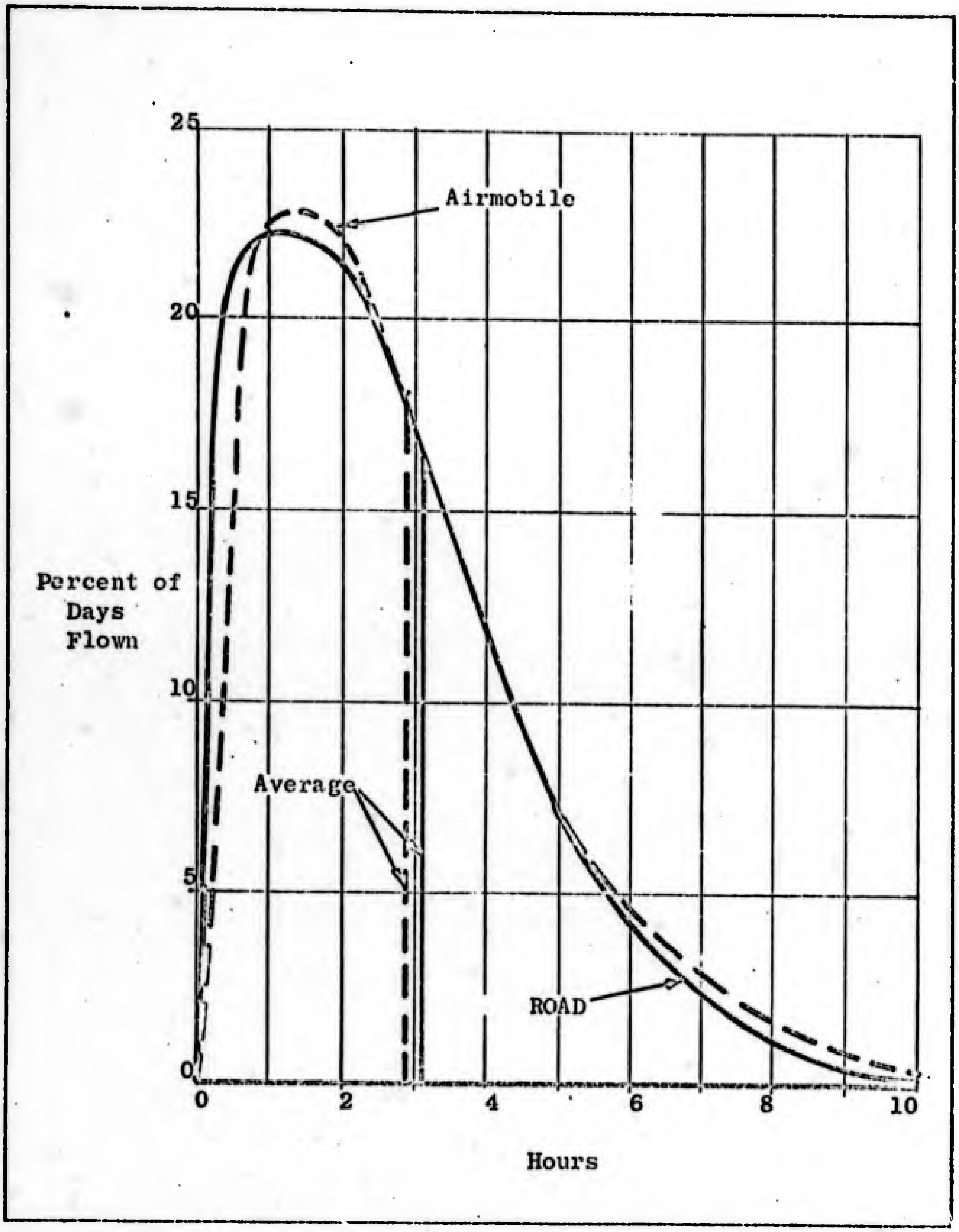


Figure 7-9. Hours Flown Per Flying Day - UH-1B/C

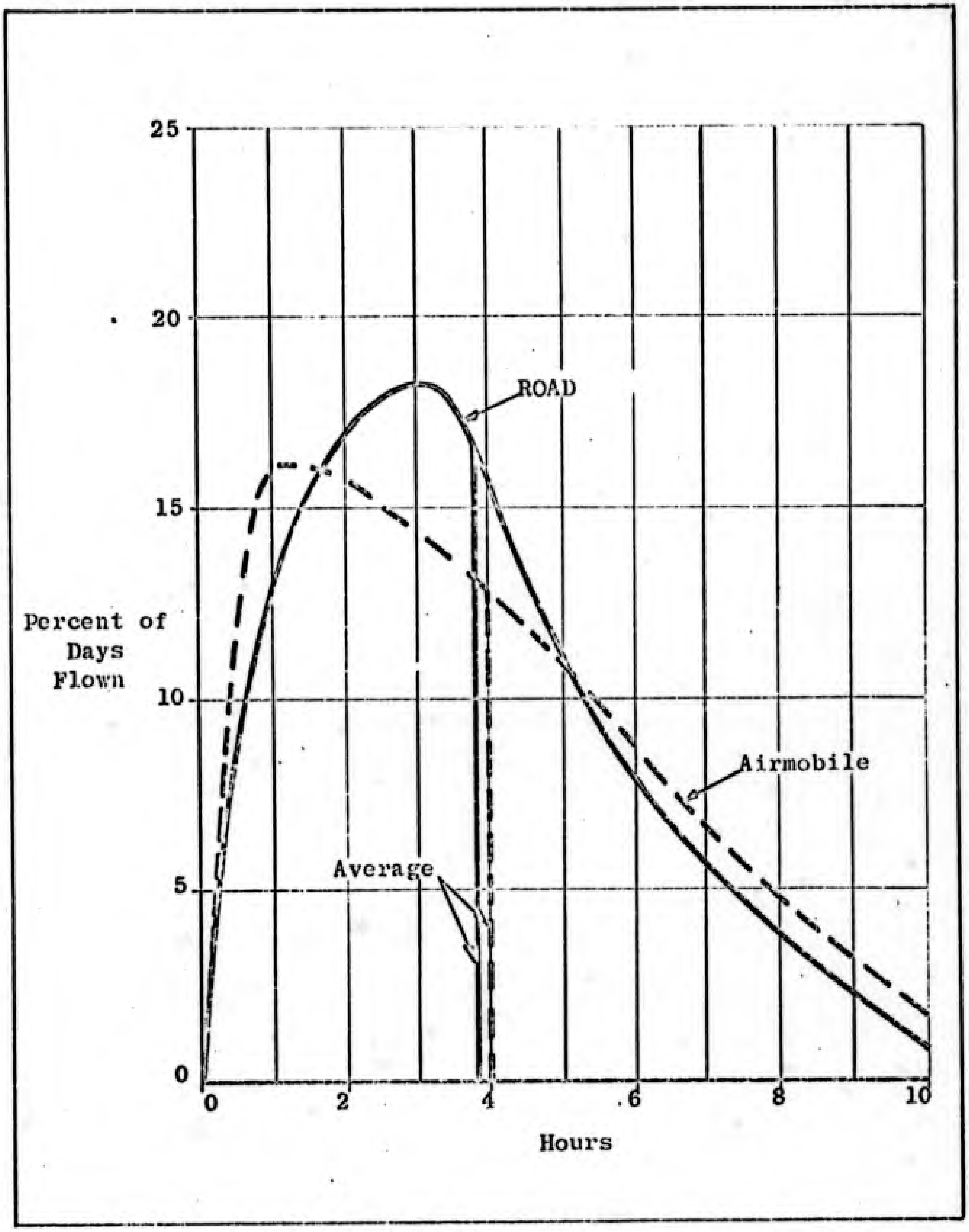


Figure 7-10. Hours Flown Per Flying Day - UH-1D/H

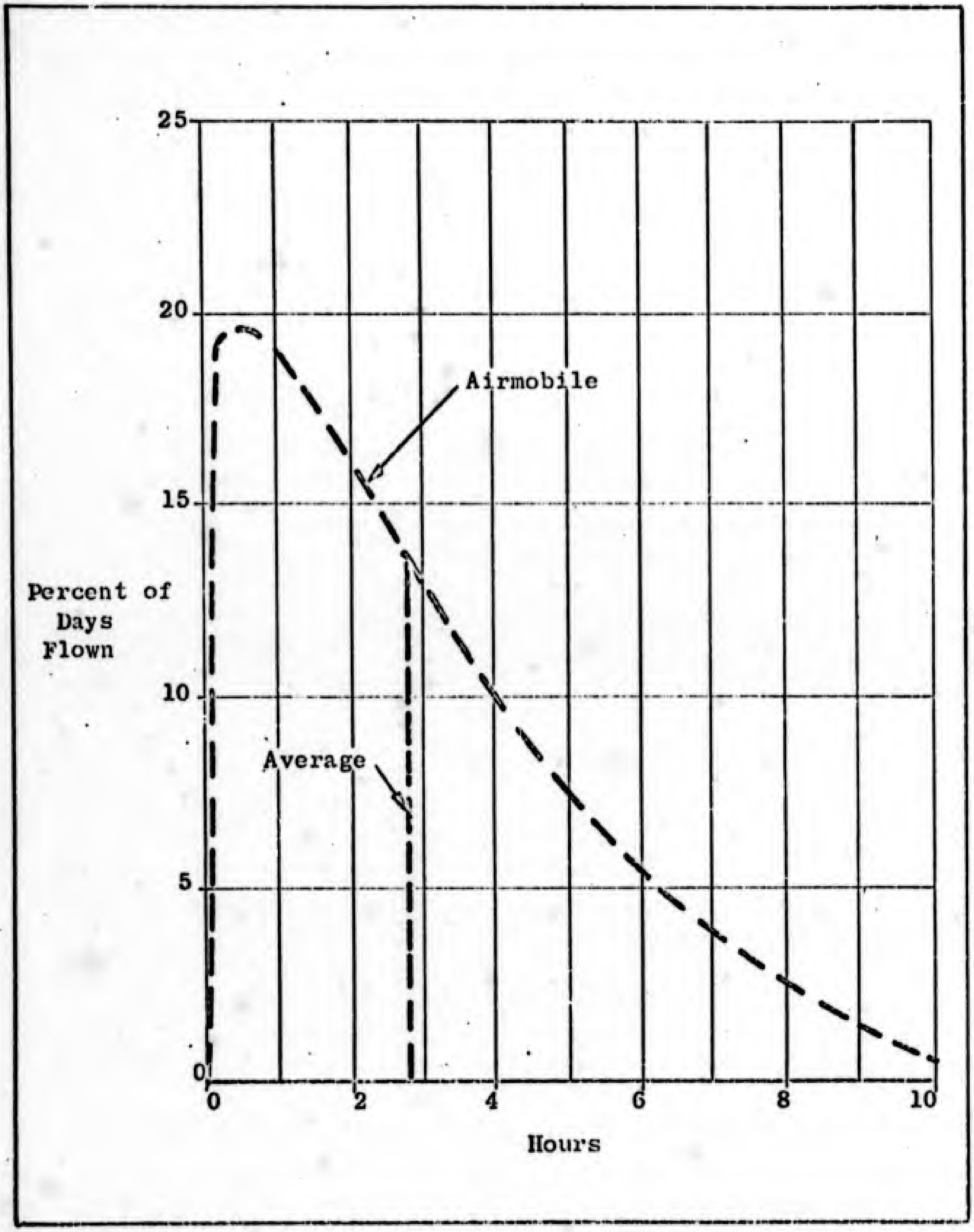


Figure 7-11. Hours Flown Per Flying Day - CH-47A

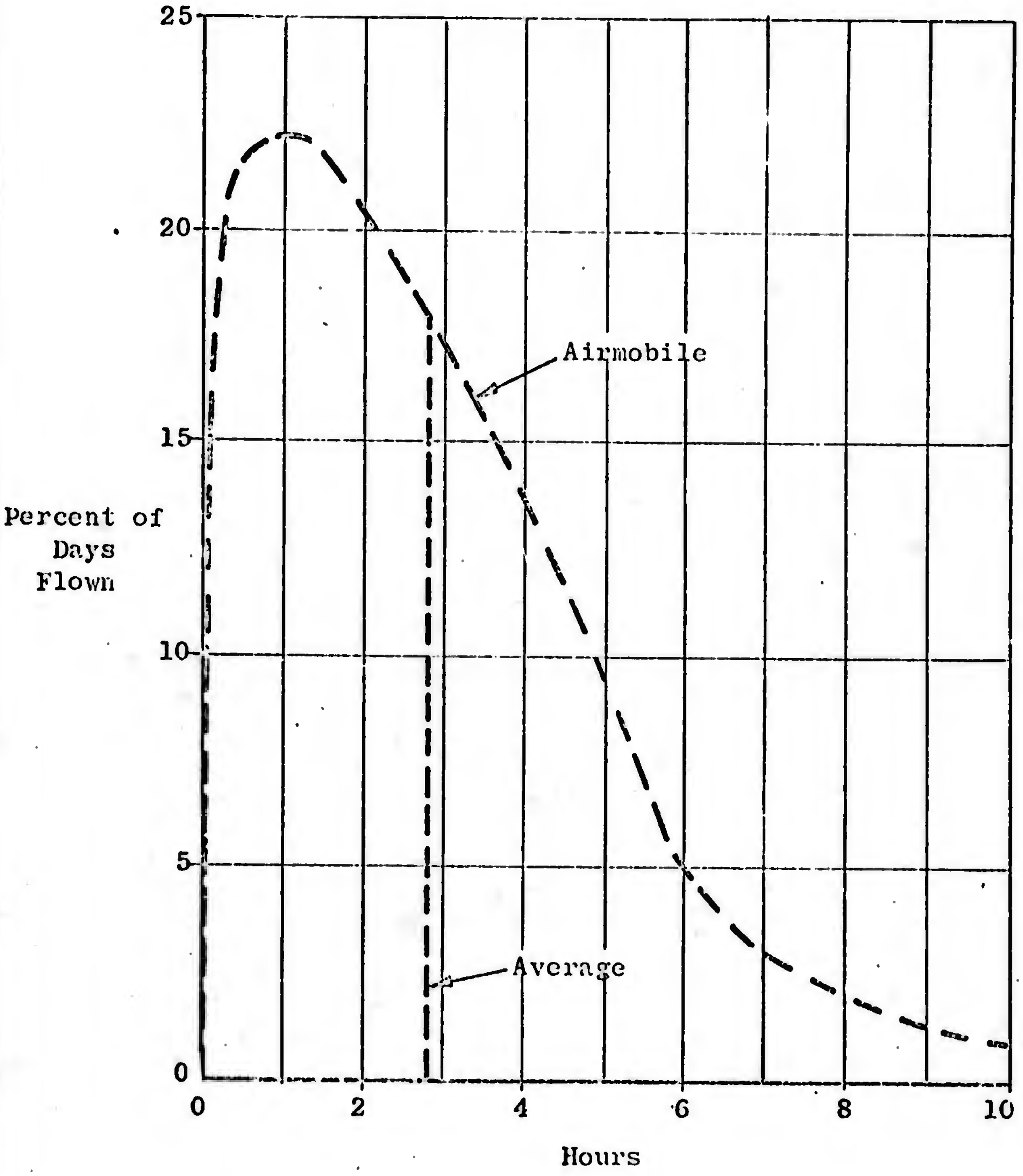


Figure 7-12. Hours Flown Per Flying Day - CH-54

is to the left of the Airmobile Division. Moreover, a greater number of hours flown per flying day were observed to fall in the 0 to 5 hour range for the ROAD Division than for the Airmobile Division. In contrast, the number of hours flown per flying day between the 5 and 10 hour range was weighted for the Airmobile Division more than for the ROAD Division. These two conditions balance each other out and account for the relatively close average flying hours.

The distributions for the CH-47 and CH-54 appearing in Figures 7-11 and 7-12 respectively are very similar. In fact, the average number of hours flown per flying day for both of these aircraft is the same at 2.8 hours.

In general, for all aircraft of both Divisions, the percent of occurrences of 5 or more hours flown per flying day ranges from 10 to 30 percent. The OH-13 and UH-1 aircraft fly more hours per day than the other aircraft.

MONTHLY UTILIZATION

The average monthly utilization rates for all aircraft of both Divisions are contained in Figure 7-13. With the exception of the UH-1B aircraft, the ROAD Division aircraft have higher monthly utilization rates than those of the Airmobile Division. The OV-1 aircraft of the ROAD Division fly 13 more hours per month more than those of the Airmobile Division. However, both Divisions fly their OV-1 aircraft less than the DA Standard requirement.

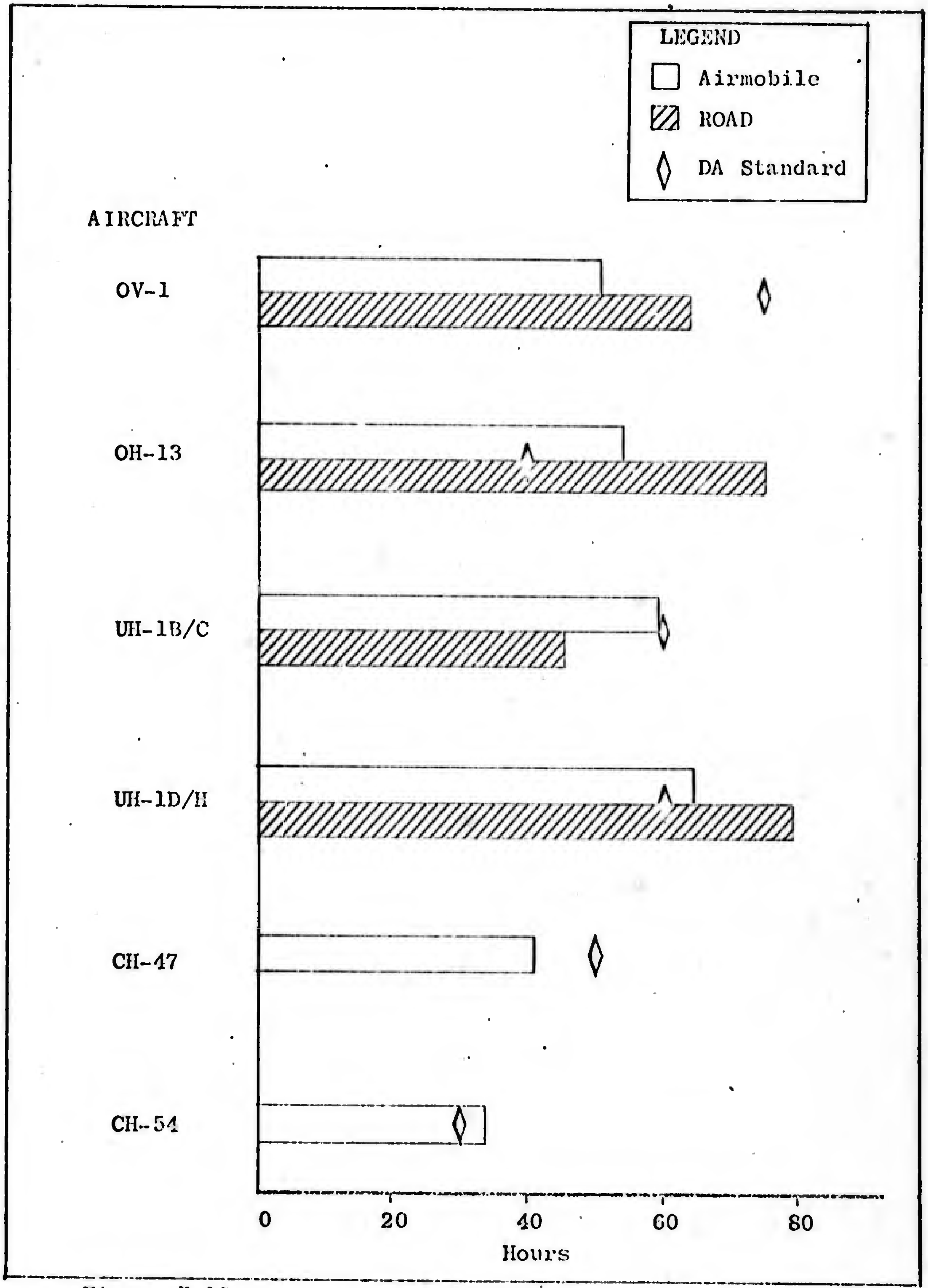


Figure 7-13. Average Monthly Utilization Rates
(October 1966 - September 1967)

The OH-13 aircraft of the ROAD Division fly 21 hours per month more than those of the Airmobile Division. Additionally, both Divisions exceed the DA Standards. In the case of the ROAD Division, the actual utilization rate is nearly twice that of the DA Standard.

The UH-1B is the only aircraft for which the Airmobile Division flies more hours per month than the ROAD Division. Here, the Airmobile Division merely meets the DA Standard and exceeds the monthly average of the ROAD Division by 14 hours.

Both the ROAD Division and Airmobile Division UH-1D aircraft exceed the DA standard. Moreover, the aircraft of the ROAD Division exceed those of the Airmobile Division by 15 hours per month.

The CH-47 aircraft do not meet the DA Standard, missing it by nine hours. On the other hand, the CH-54 aircraft exceed the DA Standard by some 4 percent with a constant utilization rate of 34 hours.

Using the utilization probability factors presented in Figure 7-1, and the daily utilization factors presented in Figures 7-7 through 7-12, a comparative analysis was made with the monthly utilization rates appearing in Figure 7-13. The results showed that the monthly rates derived for the Airmobile Division using the utilization probabilities and daily utilization factors were within 1 percent to 5 percent of the monthly rates as calculated by the 1352 Monthly Report. For the ROAD Division, the utilization probability/daily utilization estimation agreed with the monthly utilization rate to within 3 percent to 13 percent. Considering the varied sources used in deriving the utilization probabilities with the daily utilization factors and the monthly utilization rates, such variation is well within the limits of acceptance.

CHAPTER 8

MISSION PATTERNS

CHAPTER 8

MISSION PATTERNS

MISSIONS PER DAY

Aircraft utilization in terms of Operational Readiness, as discussed in Chapter 7, constitutes the first phase of this analysis. The second phase investigates aircraft missions. The first mission parameter is the number of missions flown per day. The distributions presenting the results of the number of missions flown per day appear in Figures 8-1 through 8-5. Data were available and analyzed for all aircraft, excluding the CH-54.

As seen in Figure 8-1, at least a fraction of 1 percent of the days studied were observed to have 6 missions flown per day for all aircraft in both Divisions. With the exception of the OV-1 of the Airmobile Division, the percentage distribution of days by number of missions flown decreased with the increasing number of missions flown daily. For the OV-1, the category of days on which only one mission was flown had a smaller percentage than the categories of 2 and 3 missions flown per day. The ROAD Division flew a greater percentage of their OV-1 aircraft in a 1 and 2 missions per day category than those in the Airmobile Division. Curiously, both Divisions fly the same percentage of days in the 3 missions per day category. In contrast to the 1 and 2 missions per day category, the Airmobile Division flies a greater percentage of 4, 5, and 6 mission days than the OV-1 aircraft of the ROAD Division.

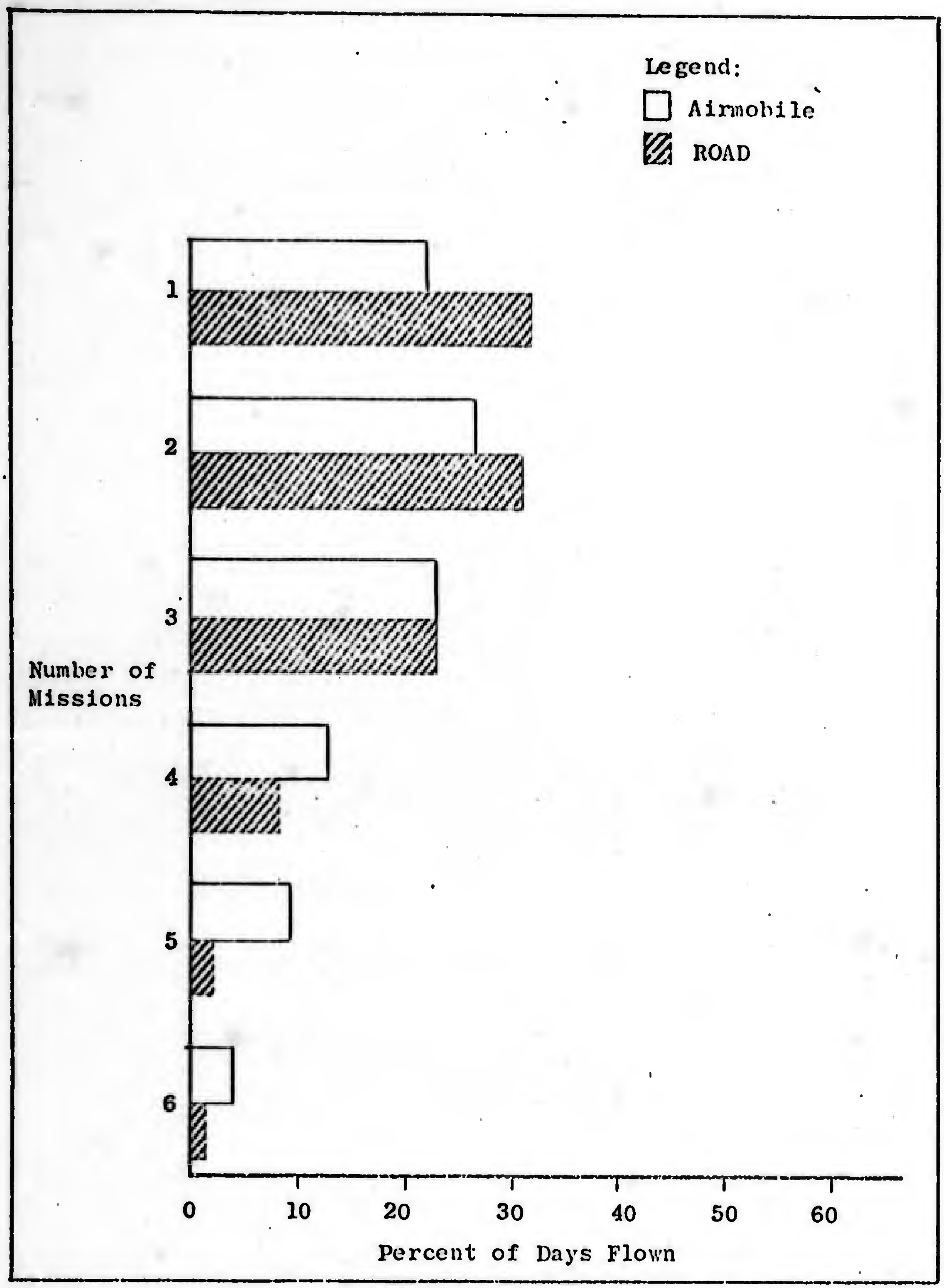


Figure 8-1. Number of OV-1 Missions Flown Per Day

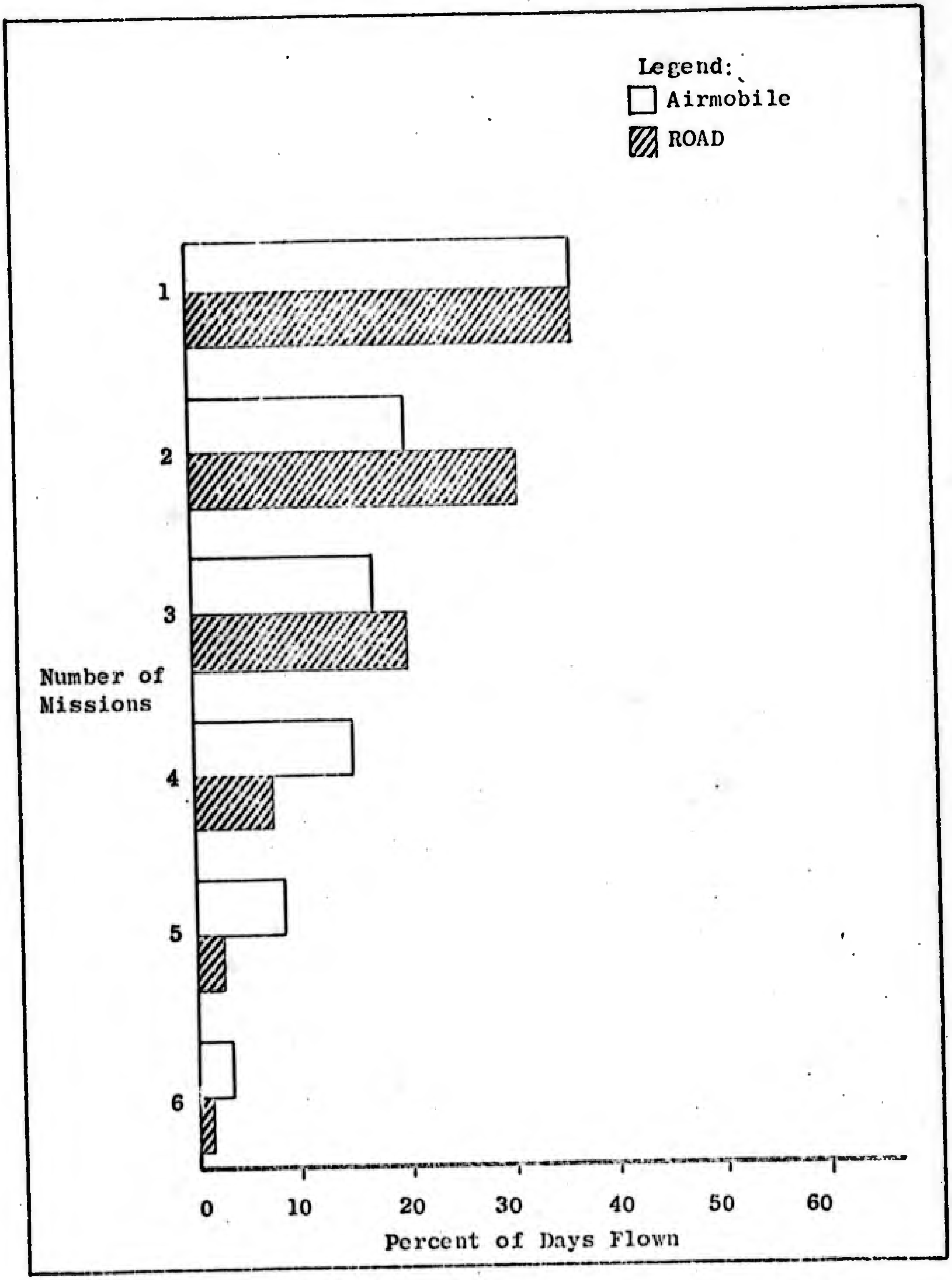


Figure 8-2. Number of OH-13 Missions Flown Per day

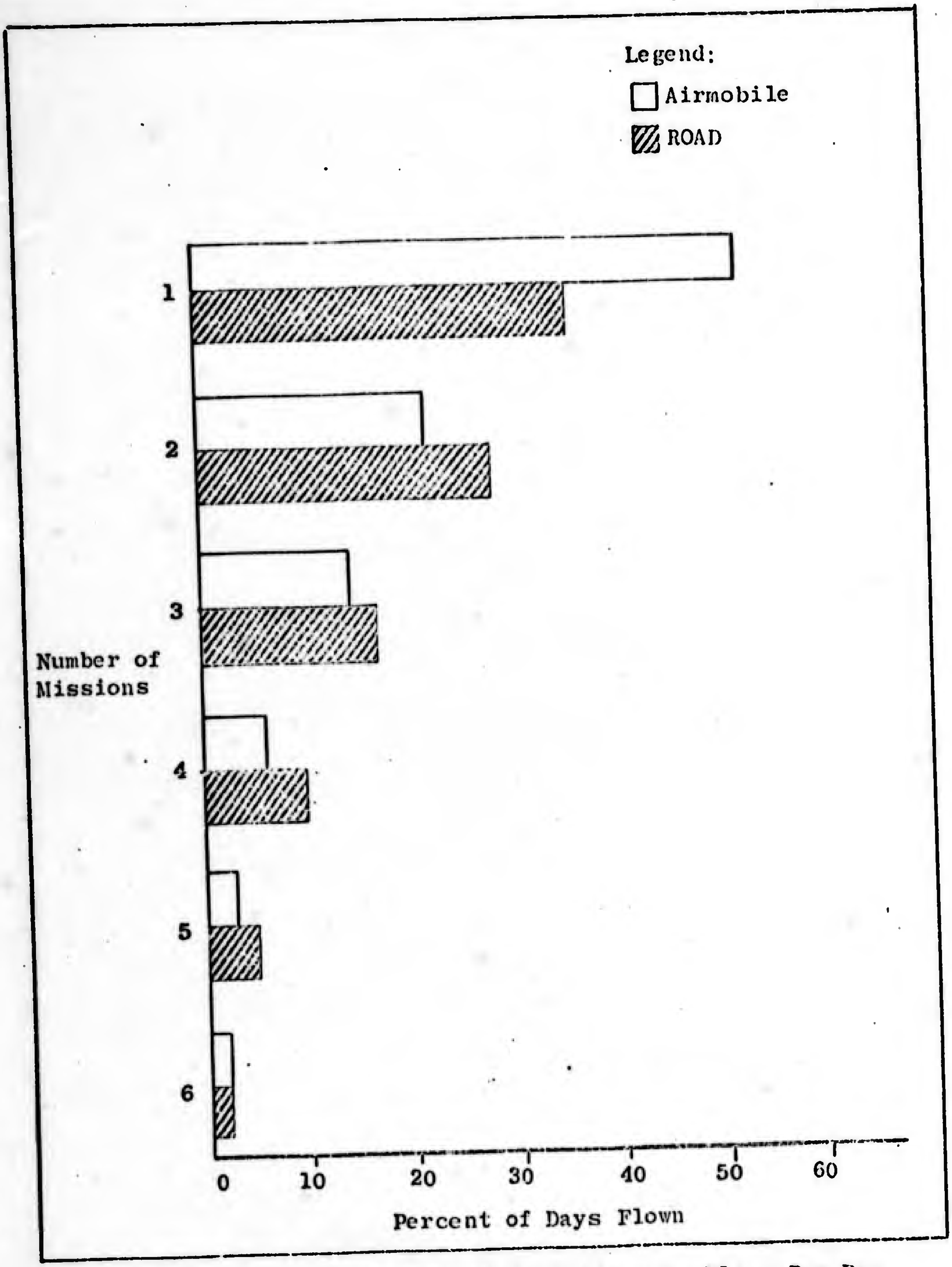


Figure 8-3. Number of UH-1B/C Missions Flown Per Day

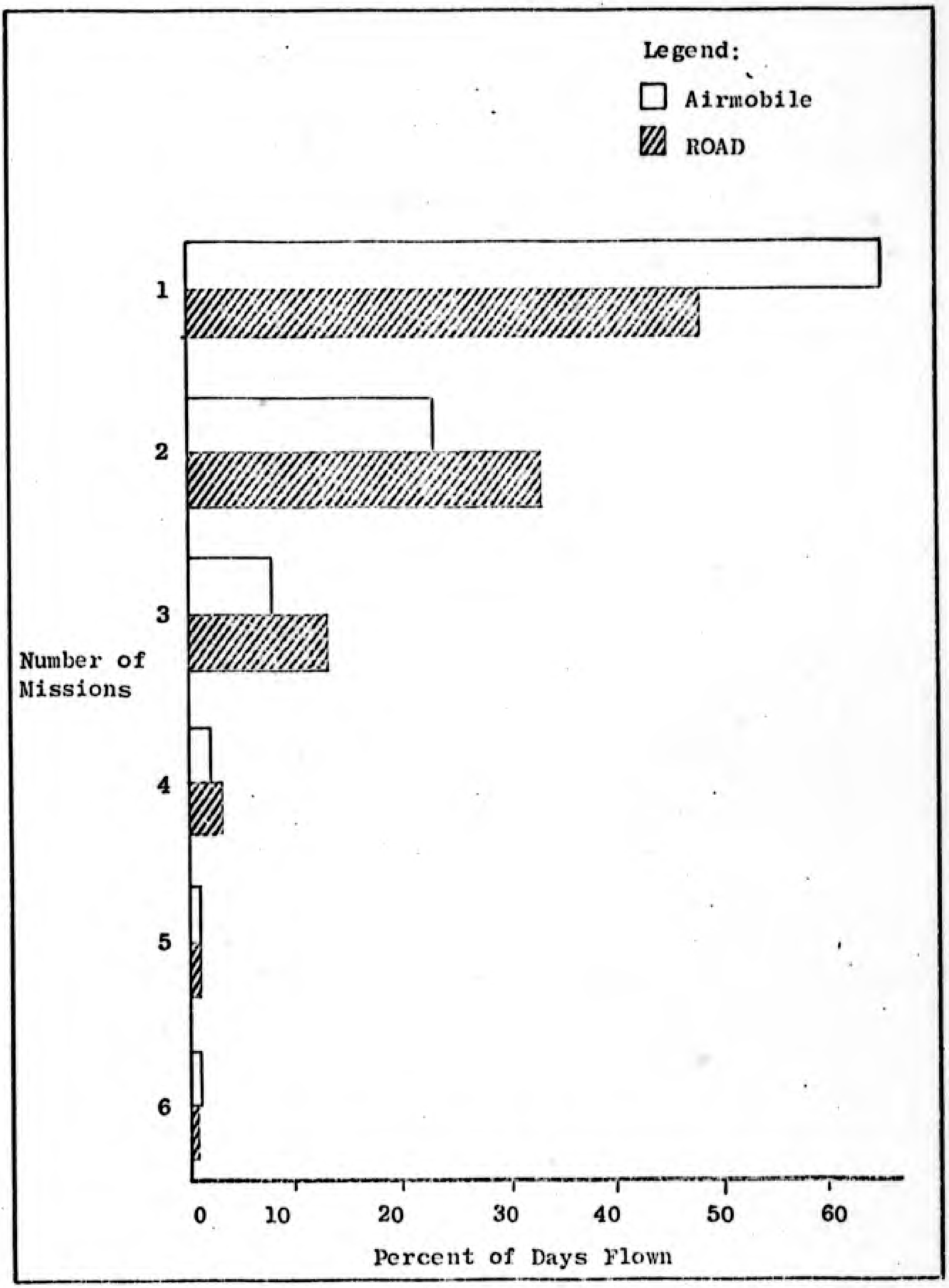


Figure 8-4. Number of UH-1D/H Missions Flown Per Day

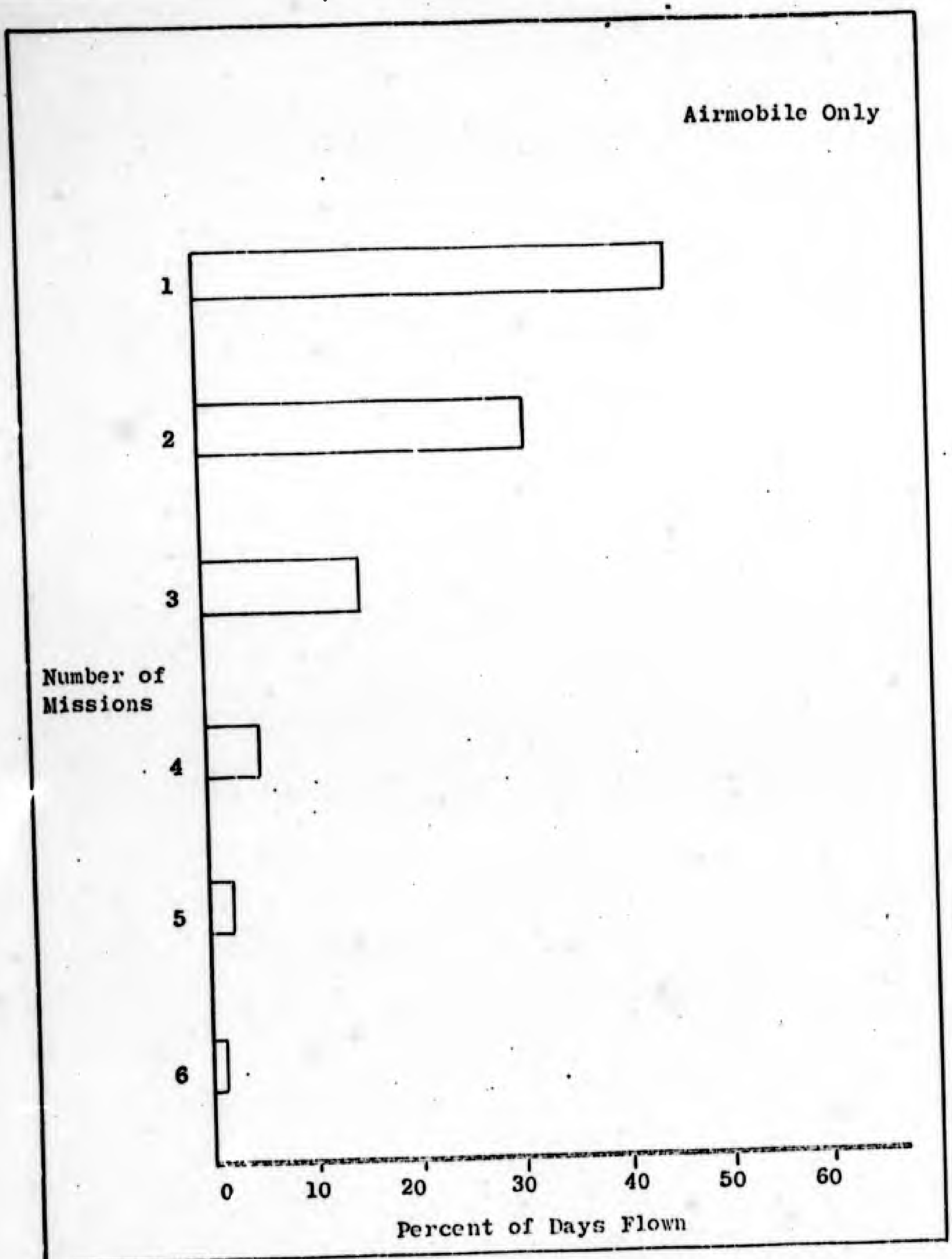


Figure 8-5. Number of CH-47 Missions Flown Per Day

Consistent with the results of the distributions presented in Figure 8-1, the average number of missions flown per day by the aircraft of the Airmobile Division are greater than those of the ROAD Division. The aircraft of the Airmobile Division average was 2.7 missions per day, while the average for the ROAD Division was 2.2 missions per day.

As shown in Figure 8-2, both the Airmobile and ROAD Divisions fly approximately the same percentage of the 1 mission per day category (36 percent). As was observed with the OV-1, the OH-13 aircraft of the ROAD Division fly a greater percentage of the 2 and 3 mission days than the OH-13s of the Airmobile Division. In contrast to the high percentage of 1 and 2 missions per day flown by the OH-13 of the ROAD Division, the OH-13 aircraft of the Airmobile Division fly a greater percentage of 4, 5, and 6 missions per day than these aircraft in the ROAD Division. On the average, the OH-13 aircraft of the Airmobile Division fly a greater number of missions per day than the OH-13 aircraft of the ROAD Division. These averages are 2.5 and 2.1 missions per day respectively.

The distributions for the UH-1B and UH-1D aircraft are shown in Figures 8-3 and 8-4. The patterns of these aircraft are very similar. The Airmobile Division UH-1B and UH-1D aircraft fly at least 16 percent more 1 mission days than these aircraft of the ROAD Division. Similarly, both the UH-1B and the UH-1D aircraft of the ROAD Division fly greater percentages of 2 through 6 mission days than these aircraft of the Airmobile Division. Thus, both series of UH-1 aircraft have a greater probability of performing more than 1 mission per day in the ROAD Division than in the Airmobile Division.

In both Divisions, the UH-1D aircraft fly a greater percentage of low missions per day than the UH-1B aircraft. For the UH-1D, in 95 to 97 percent of the days observed, no more than three missions per day were flown. For the UH-1B aircraft, only 82 to 88 percent of the days observed had a maximum of three missions per day flown. The average for the UH-1B aircraft of the Airmobile Division is 1.9 missions per day, while for the -D model, the average is 1.5 missions per day. For those aircraft in the ROAD Division, the average for the -B model is 2.3 while the average for the -D model is 1.7. This emphasizes the fact that fewer missions per day were flown by the -D series of UH-1 aircraft. Furthermore, it can be noted from the averages presented that the UH-1 aircraft of the ROAD Division fly a greater number of missions than those of the Airmobile Division, i.e., four-tenths of a mission more for the UH-1D aircraft and six-tenths of a mission more for the UH-1B aircraft.

The CH-47 aircraft missions are presented in Figure 8-5. The average number of missions flown per day by the CH-47 aircraft of the Airmobile Division is 1.9. At least 70 percent of the days observed had no more than 2 missions flown.

A comparison of Figures 8-1 through 8-5 indicates some general observations which are applicable to both the Airmobile and ROAD Divisions. The OV-1 and OH-13 aircraft tend to follow a pattern which is typical of observation aircraft. As expected in this mission pattern, aircraft fly many missions per day. In contrast, the utility aircraft (UH-1) of both Divisions essentially follow a pattern of few missions per day. This would be expected since most utility aircraft would be involved in tactical missions of which few are planned for any one day. Additionally, as would be expected, the larger aircraft fly fewer missions per day.

The observation aircraft (OV-1 and OH-13) fly between 2.1 and 2.7 missions per day, while the UH-1 aircraft fly between 1.5 and 2.3 missions per day. Finally, the CH-47 aircraft fly 1.9 missions per day. None of the aircraft studied fly more than an average of three missions per day. The total range of averages investigated is 1.5 missions to 2.7 missions per day.

MISSION TYPE

All missions studied were categorized into three groups. The Combat Assault missions comprise the first group. These are missions performed in an assault role to deliver friendly troops or supplies into the immediate combat operations area where a hostile force is engaged. Missions included in this category are:

a. Trooplift and pickup at a landing zone
b. Aeromedical evacuation
c. Close air support
d. Suppressive and defensive fire in a landing zone or against enemy troops and installations
e. Aircraft escort
f. Aircraft recovery of troops in an assault area
g. Reconnaissance and observation surveillance, directly connected with a combat operation.

The second group of missions includes those of a Direct Combat Support character. Such a mission is indicated by support rendered a friendly force immediately before, during or immediately following a combat operation. The type of missions grouped into this category include:

a. Combat resupply operation
b. Forward air control
c. Artillery adjustment
d. Non-assault aircraft recovery
e. Flare drop
f. Airborne command post
g. Command and control escort
h. Trooplift to a loading zone or assembly area
i. Resupply to outlying areas
j. Non-assault aeromedical evacuation or assembly area
k. Armed reconnaissance observation and surveillance not directly connected with combat operations
l. Air cover and defoliation.

The final group of missions is that of Other Combat Support. These missions are categorized by support of friendly forces not connected with an immediate combat operation, but which must be accomplished at altitudes which make the aircraft vulnerable to ground support or hazards of weather or terrain. These missions include the following:

a. Personnel transport
b. Search and rescue
c. Aircraft recovery
d. Aeromedical evacuation
e. Carrier duty
f. Photo and visual reconnaissance
g. Flare drop
h. All other flights, except Combat Assault and Direct Combat Support flights.

The distributions of missions by type are presented in Figures 8-6 through 8-8 for all aircraft, excluding the CH-54 for the Airmobile Division for which there were insufficient data. For both Divisions, 96 to 99 percent of the OV-1 missions fall into the Direct Combat Support group. This high percentage of Direct Combat Support missions for the OV-1 is a result of its use for reconnaissance, observation and surveillance missions not directly connected with a combat operation. As indicated in Figure 8-6, the OV-1 aircraft fly a small percentage of Combat Assault and Other Combat Support missions. For the Airmobile Division, these percentages are small and of little consequence. For the ROAD Division, the Combat Assault group accounts for nearly 4 percent of the OV-1 missions. This is a result of the use of this aircraft by the ROAD Division for reconnaissance, surveillance and observation missions directly connected with combat missions.

Also presented in Figure 8-6 are the mission distributions for the OH-13 aircraft of both Divisions. From the pie charts presented in this Figure, it is apparent that the Airmobile and ROAD Divisions are utilizing their OH-13 aircraft differently. Apparently, the OH-13 aircraft of the Airmobile Division are more involved with immediate combat operations than those of the ROAD Division. Two-thirds of the missions of the OH-13 aircraft in the Airmobile Division are for Combat Assault as opposed to one-third for the ROAD Division. In contrast, 61 percent of the OH-13 missions of the ROAD Division are in the Direct Combat Support group, while only 31 percent of the OH-13 missions of the Airmobile Division fall into this group.

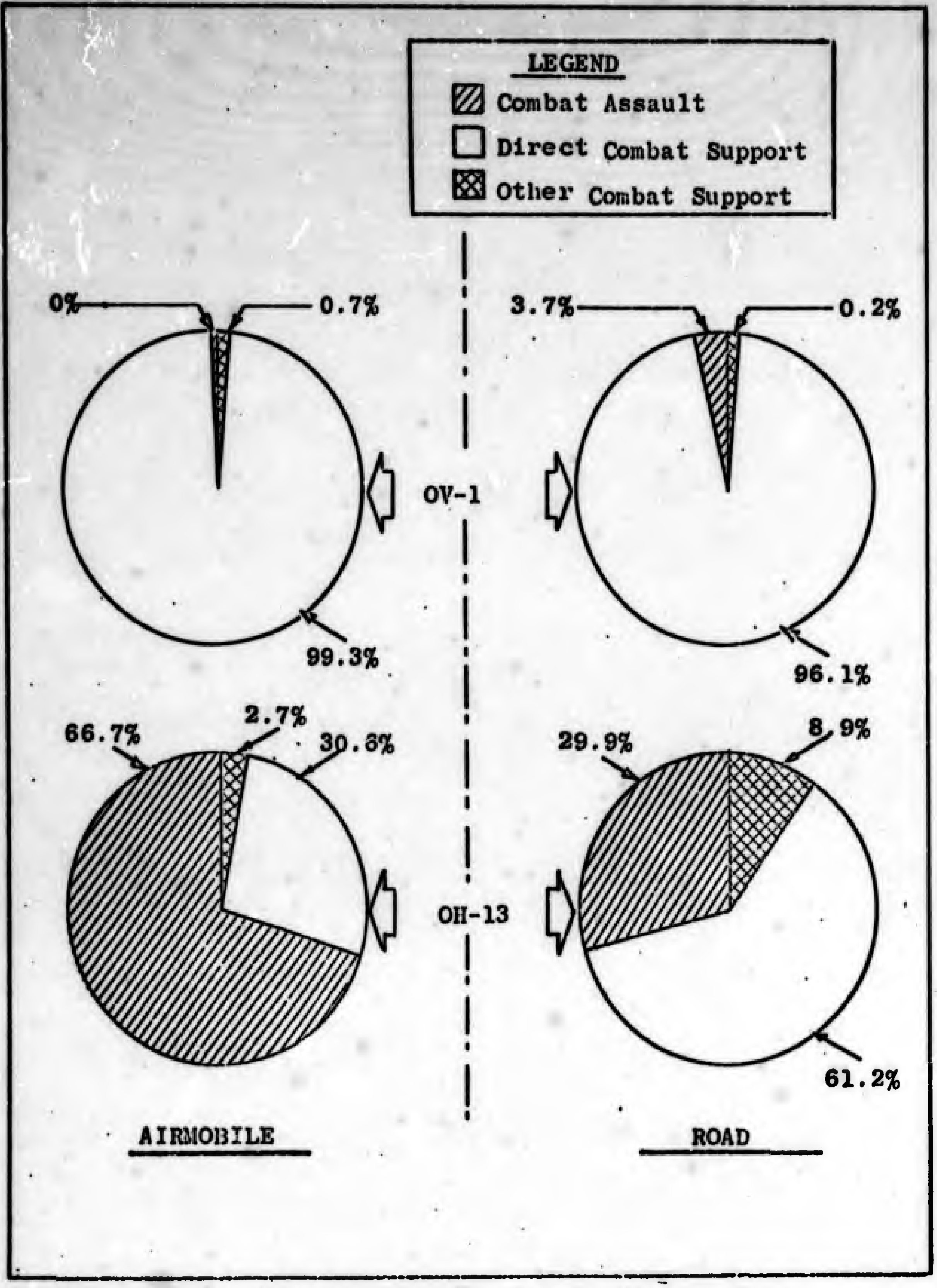


Figure 8-6. Mission Distribution by Mission Type

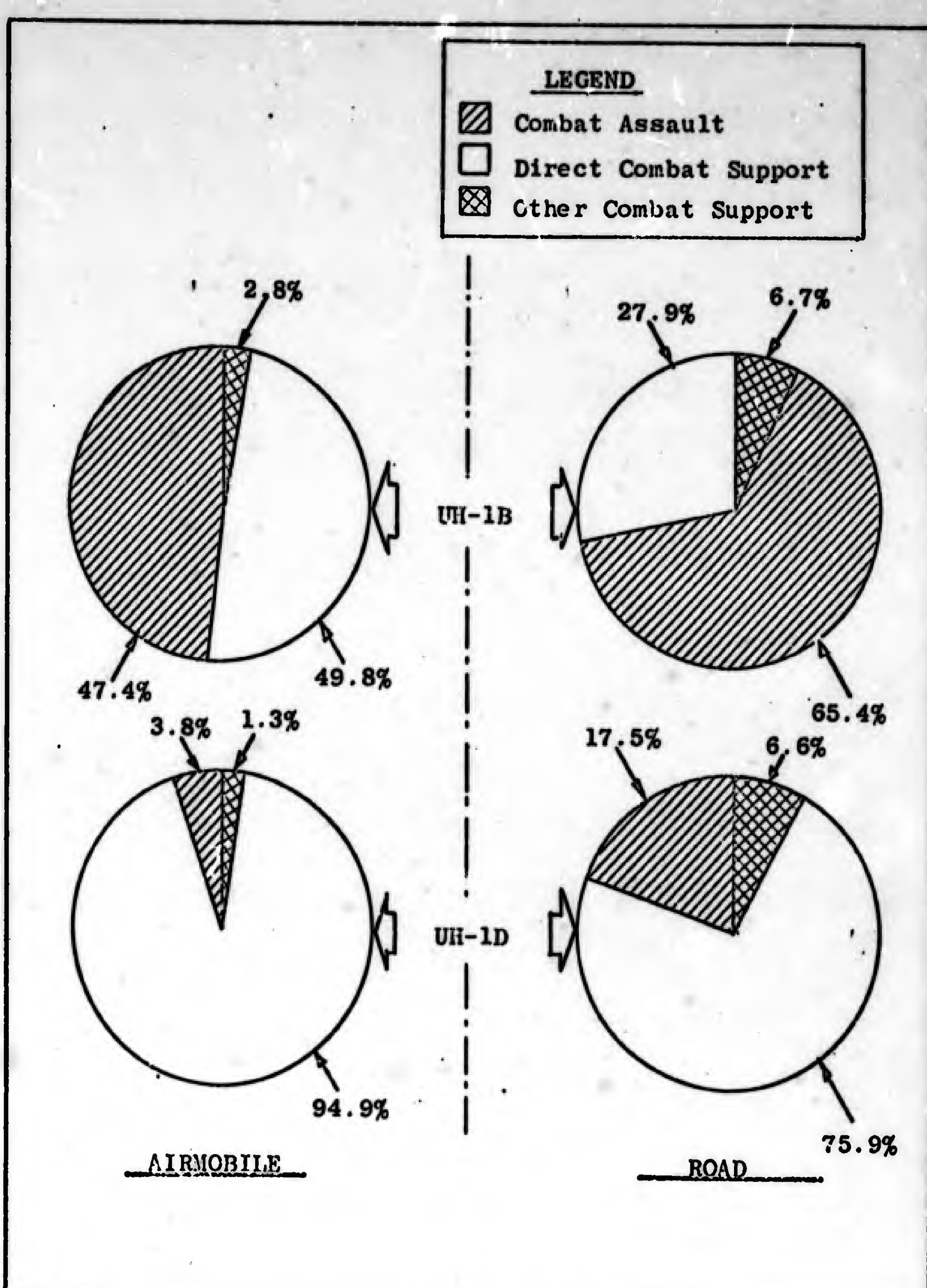


Figure 8-7. Mission Distribution by Mission Type

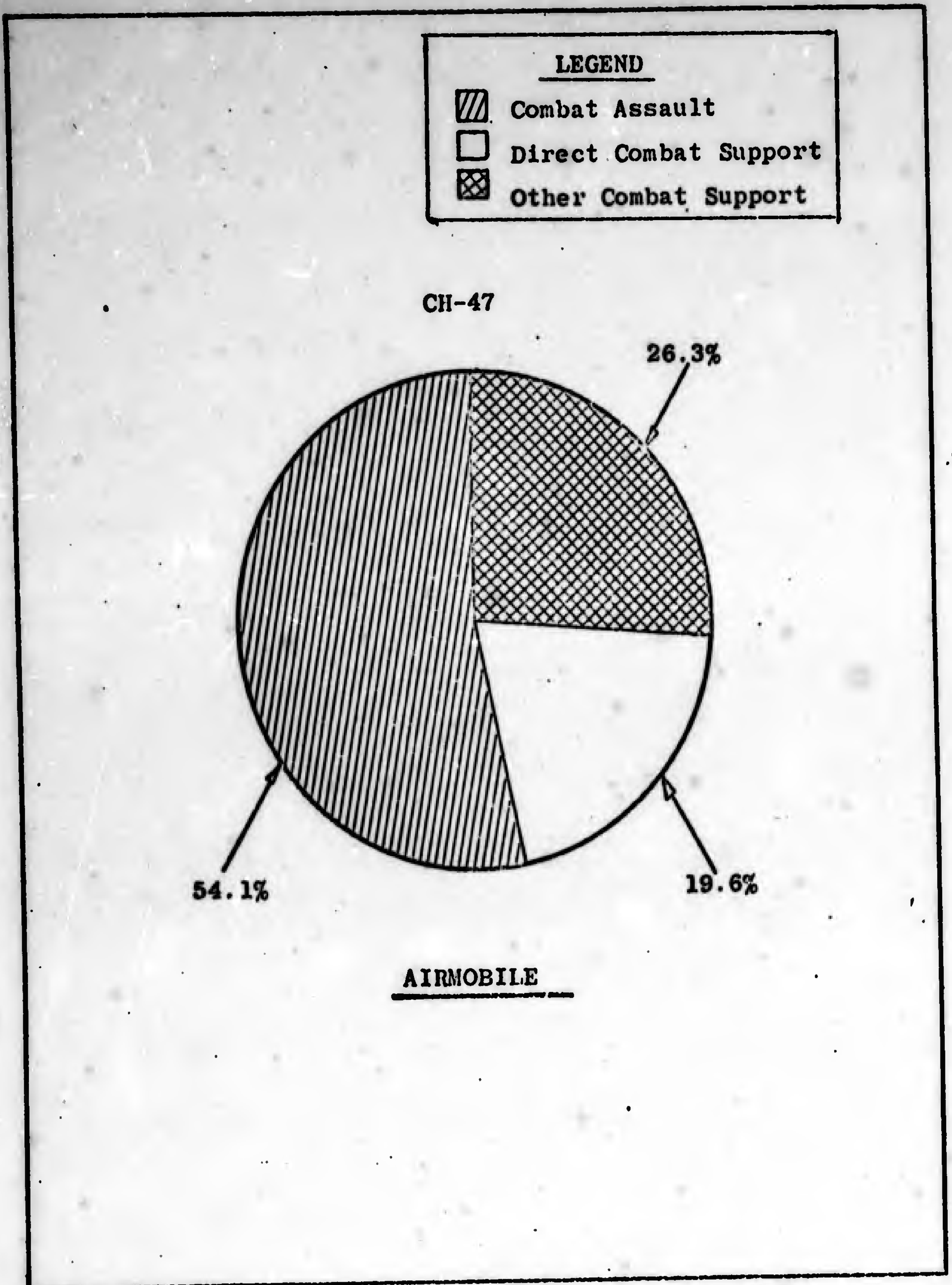


Figure 8-8. Mission Distribution by Mission Type

[redacted]

From these results, it can be seen that the Airmobile Division is utilizing its OH-13 aircraft in Combat Assault missions to complement the Direct Combat Support missions of the OV-1 aircraft discussed above. The ROAD Division is utilizing its OH-13 aircraft in Direct Combat Support missions as it is utilizing its OV-1 aircraft. Most of the missions of the OH-13 of the ROAD Division are for artillery adjustment. In addition to the first two types of missions flown, the OH-13 aircraft of both Divisions fly numerous Other Combat Support missions. For the Airmobile Division, this accounts for approximately 3 percent of the missions, while for the ROAD Division, these Other Combat Support missions account for nearly 9 percent.

The distributions of missions by type for the UH-1B and UH-1D aircraft are shown in Figure 8-7. For the UH-1B aircraft of the Airmobile Division, the distribution of mission by type is approximately equal for Combat Assault and Direct Combat Support. The percentages for these two categories are 47.4 percent and 49.8 percent respectively. The remaining 2.8 percent of the missions of the UH-1B aircraft in the Airmobile Division fall into the Other Combat Support group. The missions for the UH-1B aircraft of the ROAD Division are distributed between Direct Combat Support and Combat Assault with a ratio of 1:2. The missions flown on UH-1B aircraft of the ROAD Division (65.4 percent) are for Combat Assault, while 27.9 percent are for Direct Combat Support. This is substantially different than the distribution for the Airmobile Division. The ROAD Division flies a greater number of Combat Assault

[redacted]

missions with its UH-1B aircraft. The Other Combat Assault mission group accounts for approximately 7 percent of the missions. This is more than twice the percentage of Airmobile UH-1B missions in this category.

The UH-1D aircraft of the Airmobile Division primarily fly Direct Combat Support missions. These missions account for 94.9 percent of the observed UH-1D missions. The UH-1D aircraft of the ROAD Division also fly a high percentage of Direct Combat Support missions (76.9 percent). These aircraft of the ROAD Division fly approximately 4 times as many of each of the other two mission groups as the UH-1D aircraft in the Airmobile Division. The ROAD Division UH-1D aircraft fly 17.5 percent Combat Assault missions, while the Airmobile Division UH-1Ds fly 3.8 percent of their missions in this category. The Other Combat Support mission category accounts for 6.6 percent of the UH-1D missions of the ROAD Division and 1.3 percent of the UH-1D missions in the Airmobile Division.

The mission distribution by type of mission for CH-47 aircraft of the Airmobile Division is presented in Figure 8-8. Approximately, 54 percent of the missions flown by the CH-47 aircraft are for Combat Assault due to its use for trooplifts and evacuations during combat operations. Direct Combat Support missions account for approximately 20 percent of all missions flown by the CH-47. Finally, 26.3 percent of the CH-47 aircraft missions are for Other Combat Support missions. This is the largest percentage recorded for this mission group for all aircraft studied. Mission distributions by type for each of the Divisions were prepared by properly weighting each of the individual distributions developed for each type and model of aircraft. The results indicate that the types of missions performed by both Divisions are similar. The Airmobile Division aircraft flew 33.6 percent of all missions for Combat Assault. The aircraft of the ROAD Division percentage for Combat Assault missions was 35.6. The performance of both Divisions was also very similar for the Direct Combat Support missions, i.e., 61.5 and 58.0 percent respectively. The percentages for the Other Combat Support mission group were 4.9 for the Airmobile Division and 6.4 for the ROAD Division. Thus, as demonstrated by the similarity of the distributions of missions by type for both Divisions, the aviation requirements of these Divisions in combat operations are the same.

MISSION HOURS

The final parameter necessary for describing the complete mission picture of utilized aircraft is the number of hours flown per mission. This parameter is described by the Hours Flown Per Mission Distributions presented in Figures 8-9 through 8-13. The distribution of hours flown per OV-1 mission for both Divisions is presented in Figure 8-9. The Airmobile Division distribution is to the left of that of the ROAD Division for missions taking more than 1-1/2 hours. This indicates that the ROAD Division flies more missions with its OV-1 aircraft than the Airmobile Division. A comparison of the average hours flown per mission by the OV-1 aircraft of both Divisions shows that the ROAD Division OV-1s fly an average of six-tenths of an hour more per mission than

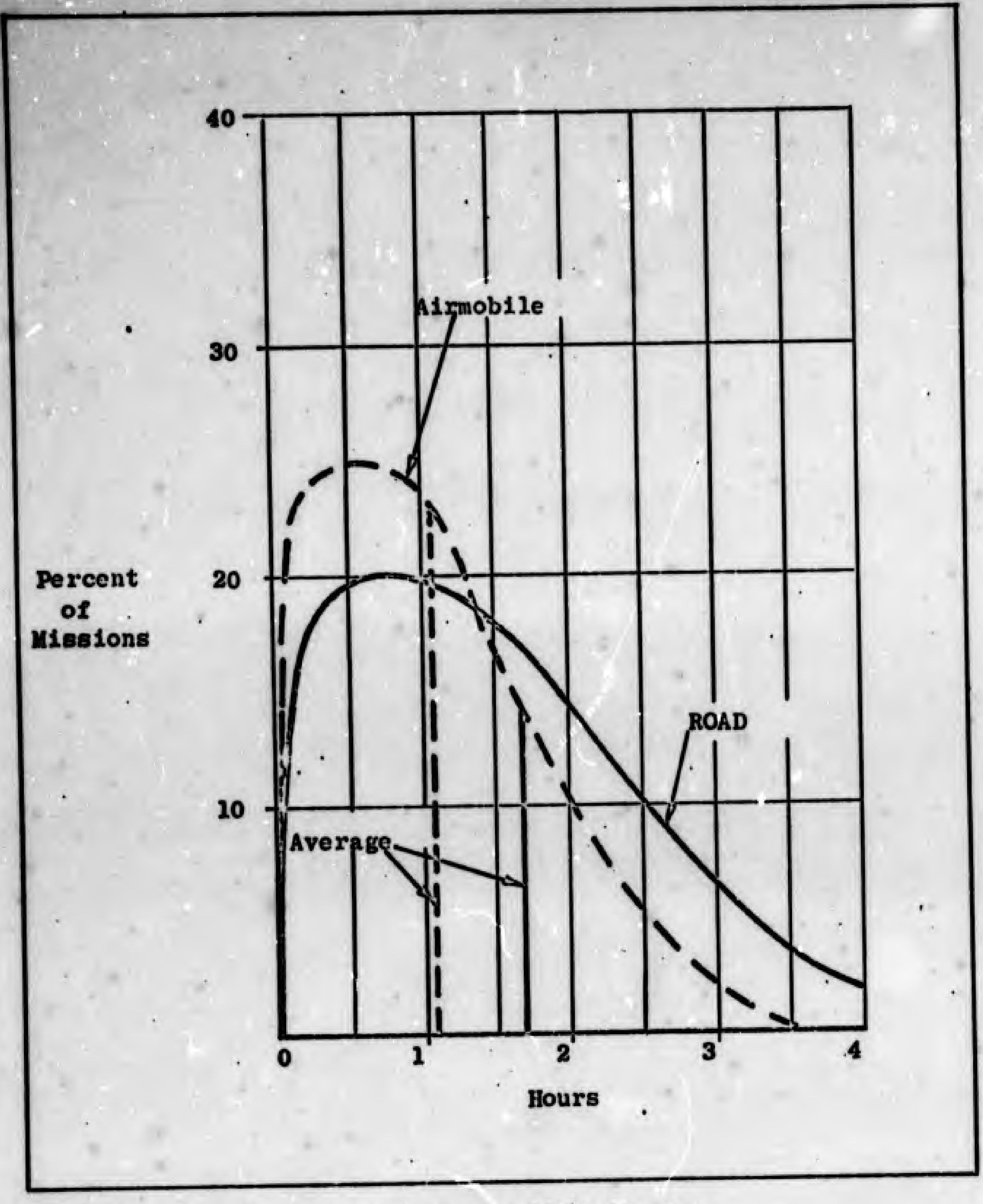


Figure 8-9. Hours Flown per OV-1 Mission

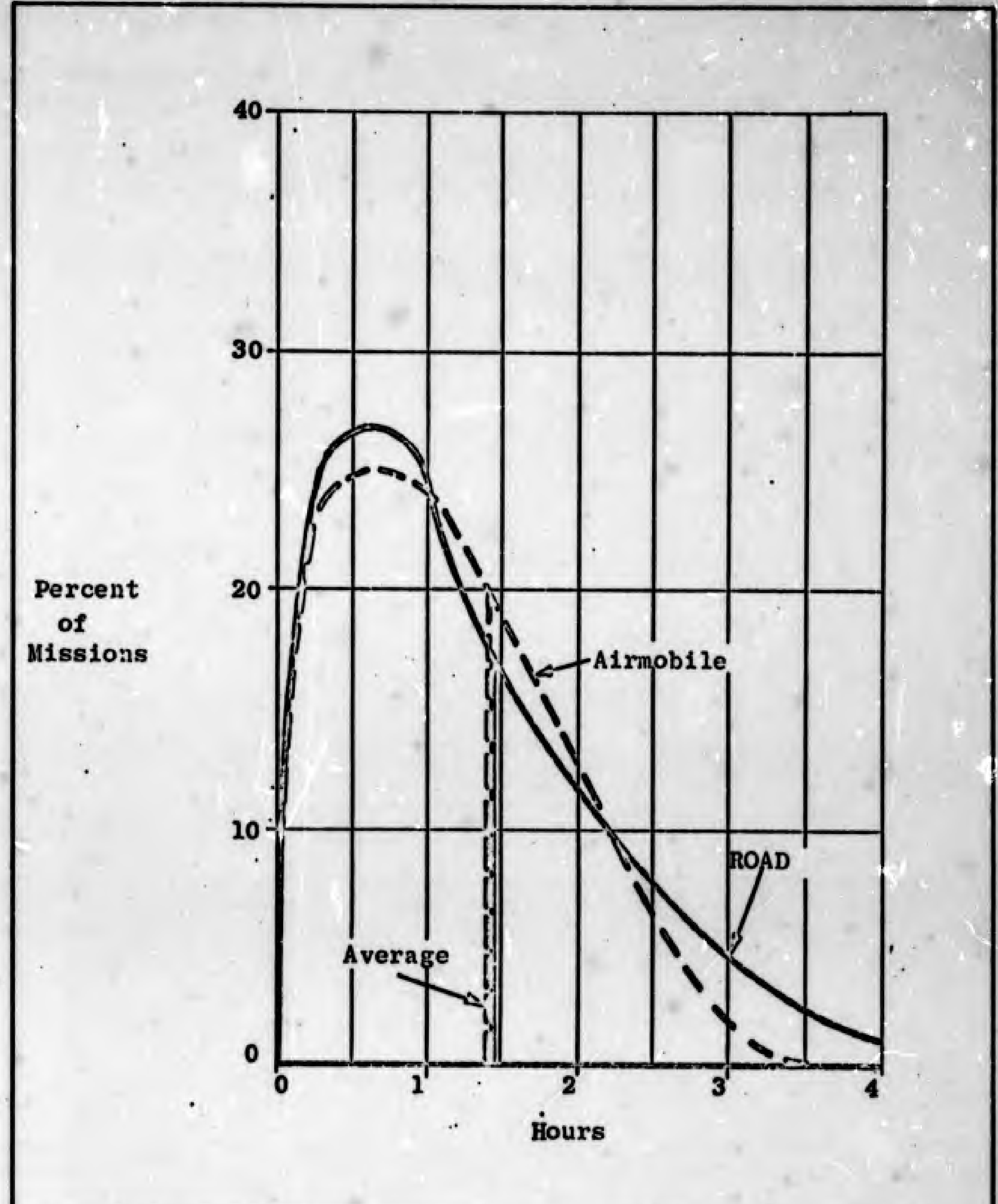


Figure 8-10. Hours Flown per OH-13 Mission

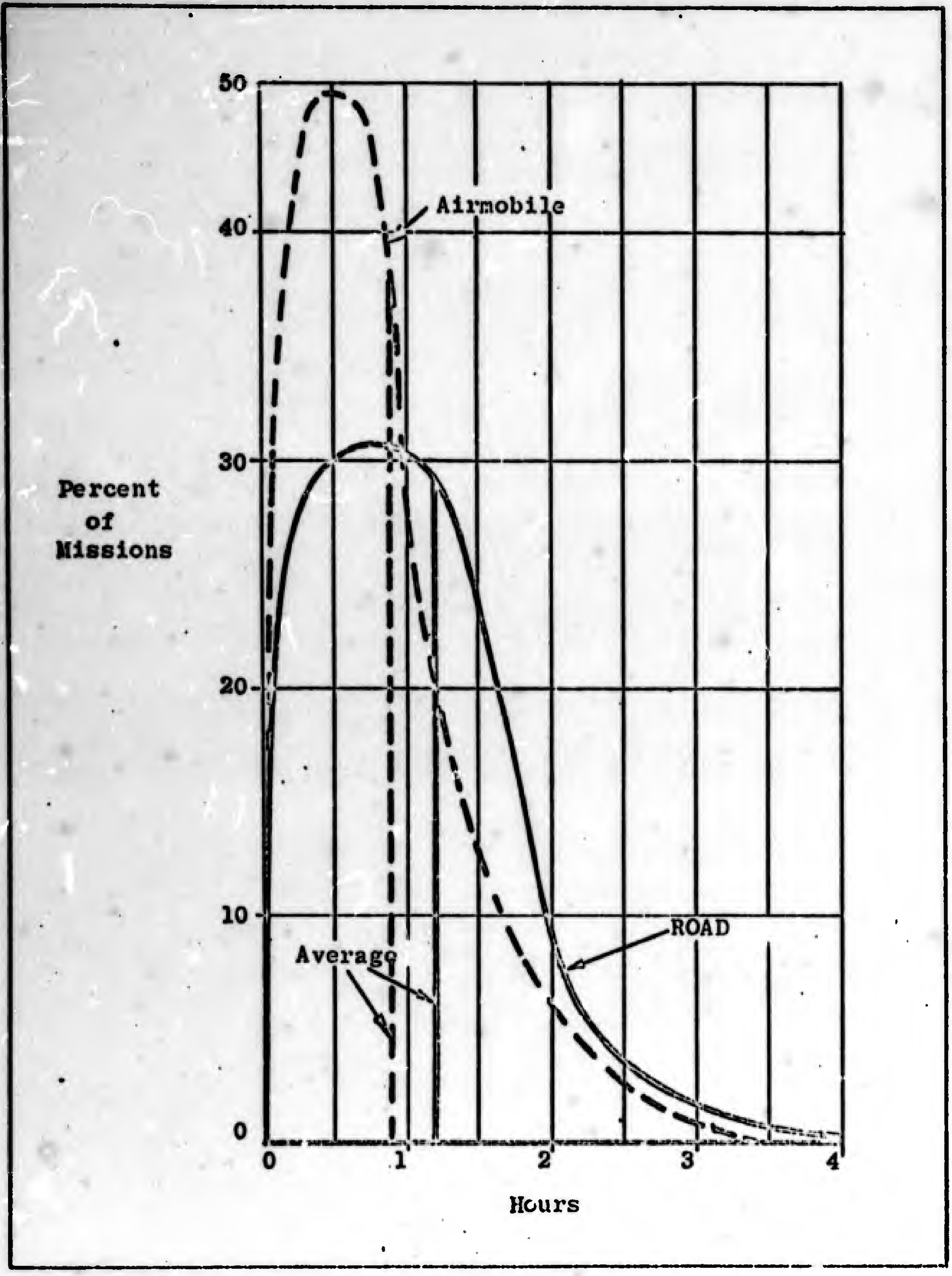


Figure 8-11. Hours Flown per UH-1B/C Mission

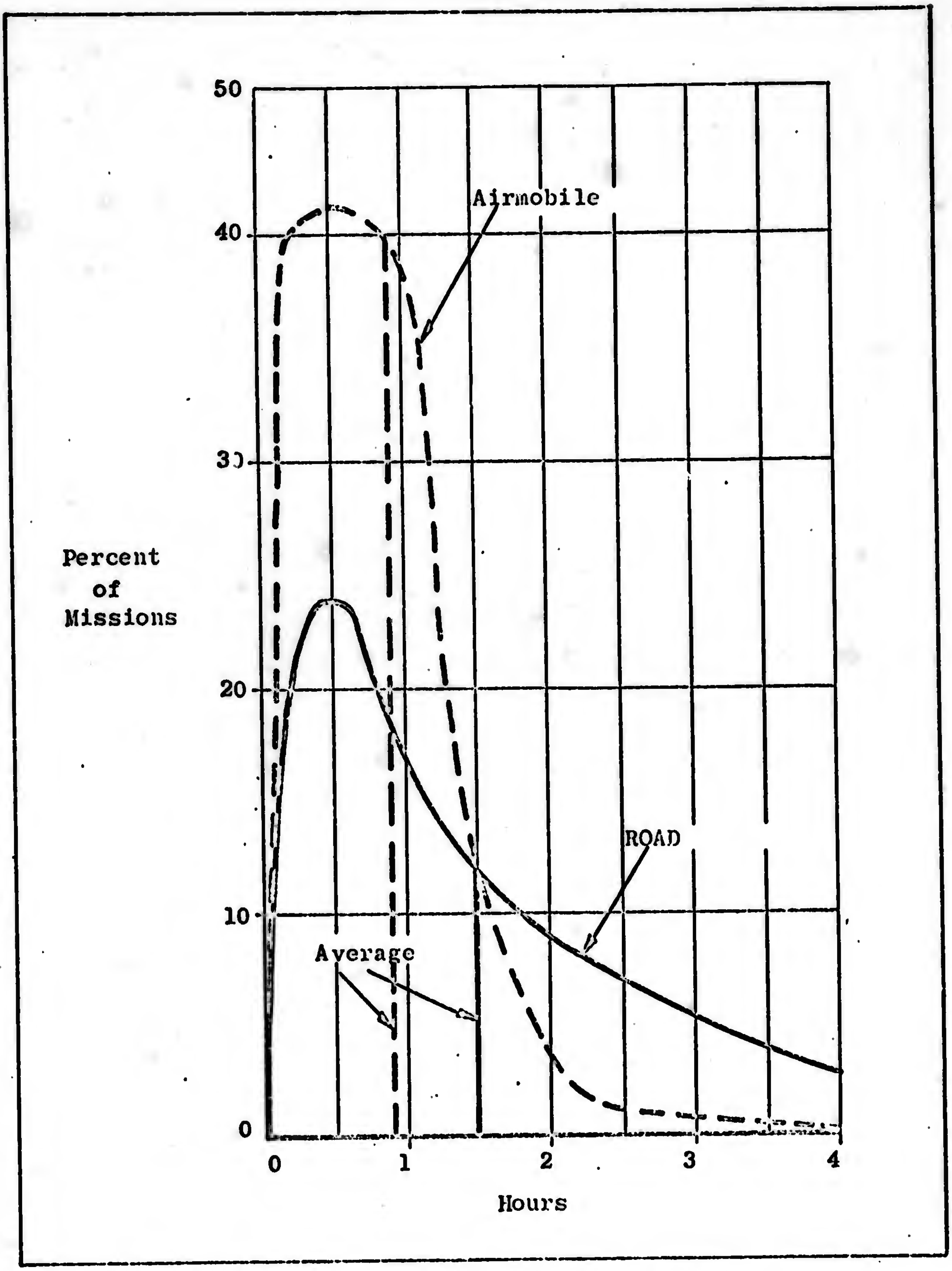


Figure 8-12. Hours Flown per UH-1D/H Mission

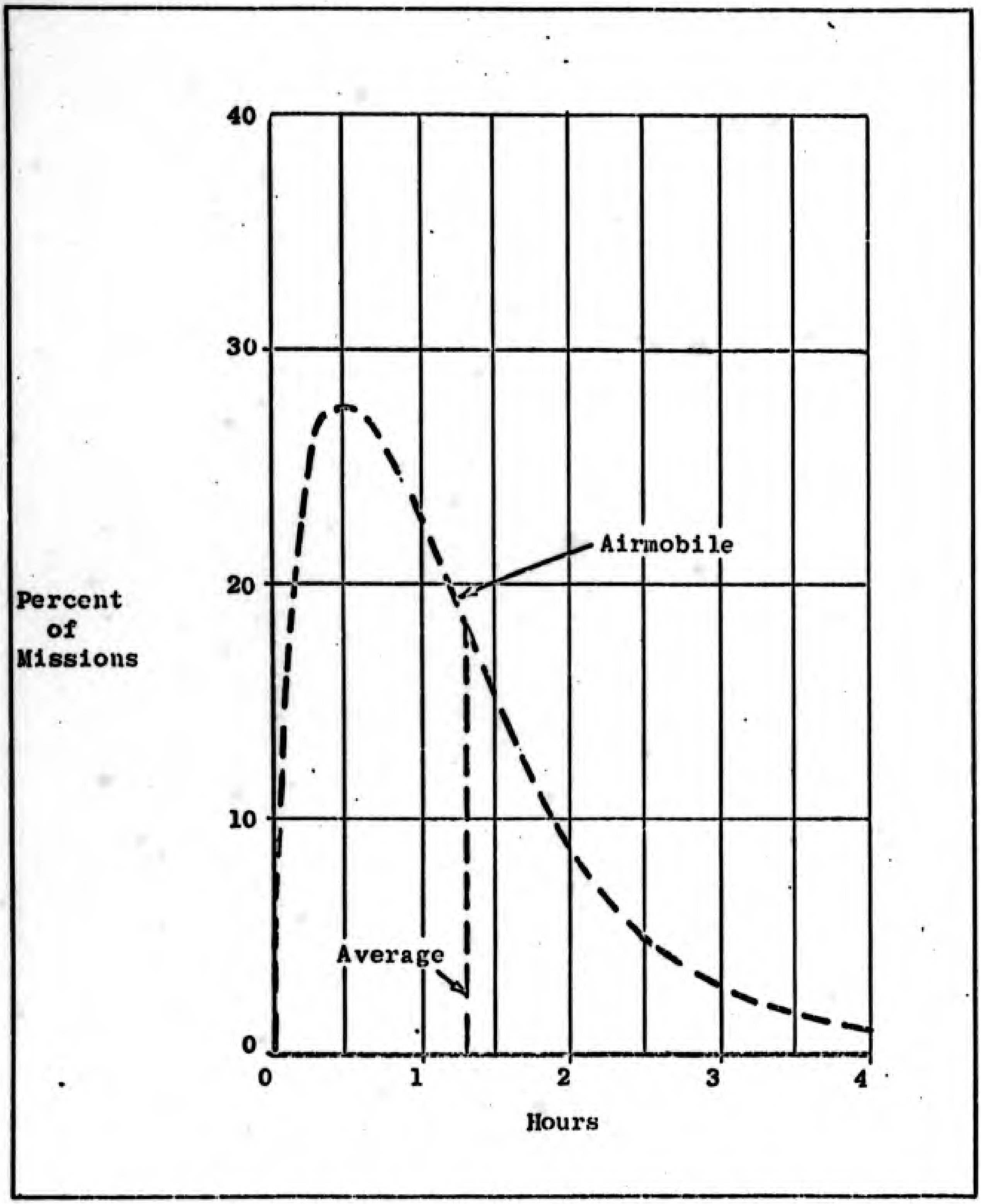


Figure 8-13. Hours Flown per CH-47 Mission

the Airmobile Division OV-1s. The average hours flown per mission for the OV-1 aircraft of the ROAD Division is 1.7 hours, while the average for the Airmobile Division is 1.1 hours.

As seen in Figure 8-10, the distributions of hours flown per OH-13 mission of both Divisions are very similar. The variations in the curves of the Divisions presented in Figure 8-10 compensate for each other with the result that the average hours flown per OH-13 mission for both Divisions are equal at 1.4 hours per mission.

The averages of hours flown per UH-1B/C mission by the Airmobile and ROAD Divisions are 0.9 hours and 1.2 hours respectively. Though these averages are only three-tenths of an hour apart, the distributions for these two Divisions are quite different as shown in Figure 8-11. The distribution of the ROAD Division is rather small and wide with no reading for one hour per mission exceeding 30 percent. In contrast, the distribution of the UH-1B aircraft of the Airmobile Division is rather narrow with a peak at 43 percent for the half-hour missions. Here again, the aircraft of the ROAD Division fly longer missions than those of the Airmobile Division.

The distribution of hours flown per UH-1D/H mission is shown in Figure 8-12. Here, as seen with the UH-1B/C aircraft, the distributions for both Divisions differ greatly. Though the high peak for both Division distributions are at the half-hour mission mark, the distribution of the Airmobile Division is much narrower than the ROAD Division. Forty-one percent of the Airmobile UH-1D missions were one-half hour in length, while only 24 percent of the ROAD Division missions were this long. The differences in the two distributions are further emphasized by the six-tenths of an hour difference in the averages. The average hours flown per mission for the UH-1D aircraft of the Airmobile Division is 0.9, while the average for the ROAD Division is 1.5. It should be noted that the average hours flown per mission for both the UH-1B and UH-1D aircraft of the Airmobile Division is 0.9 hours.

The average hours flown by the CH-47 aircraft of the Airmobile Division is 1.3. The distribution for this aircraft is shown in Figure 8-13. The peak of this distribution (28 percent) is at the half-hour mark per mission.

In summary, the aircraft of the ROAD Division fly more hours per mission than the aircraft of the Airmobile Division. A comparison of the average number of hours flown per mission for all aircraft within both Divisions indicates that the average mission of the ROAD Division is three-tenths of an hour (approximately 20 minutes) longer than the average mission flown by the Airmobile Division. The averages of the Airmobile and ROAD Division aircraft are 1.1 and 1.4 hours per mission respectively.

CHAPTER 9

PERSONNEL REQUIREMENTS

CHAPTER 9

PERSONNEL REQUIREMENTS

INTRODUCTION

This Chapter presents an analysis of personnel in the Airmobile and conventional ROAD Divisions under actual combat conditions, based on the operations of the 1st Cavalry Division (Airmobile) and the 1st Infantry Division (ROAD) in Vietnam; additional certain data relative to overall aviation support personnel relationships applicable to all Army Aviation in Vietnam are given.1/ The Chapter compares the following:

1. Maintenance personnel, on the basis of skill, MOS grade, experience and maintenance equivalency requirements.
2. Personnel utilization for direct and indirect productive time, and time lost from work.
3. Distribution of supply, maintenance and administrative overhead personnel.

As in the other Chapters of this Report, observations focus on mid-1966 through mid-1967, with data obtained from both Army records and on-site observations. Certain portions of the data presented herein were used, with COR concurrence, in APJ Report 483-2 (See Reference 3.).

1/ In this and succeeding chapters, the words "repairman" and "mechanic" are used interchangeably and this point is noted to avoid any terminological ambiguity.

Before proceeding to the detailed analysis, it is of interest to summarize certain overall observations.

1. During the period studied, the overall effectiveness of Army maintenance effort in Vietnam continued to increase. Thus, the number of maintenance personnel per aircraft declined from a March 1966 value of 5.0 to a June 1966 value of 4.7; at the same time, the number of flying hours per aircraft increased from approximately 55 flying hours per aircraft per month to 62.
2. With respect to the individual Divisions, the following observations may be made:

   a. Maintenance skills are considered equal in both Divisions. Similarly, trained personnel and grades are received as replacements for personnel returning to CONUS. There is no differential in the filling of quotas for replacements for either Division from the CONUS source.
   b. The grade structures for the maintenance units in both Divisions are very close in percentage of grade, with the ROAD Division having a slight advantage in the wrench-turning grades.
   c. In the supply field, the units in the Airmobile Division have more than twice the number of personnel than the comparable unit in the ROAD Division.
   d. The maintenance personnel are comparable in capabilities and experience. However, the maintenance unit in the 15th Transportation Battalion (Airmobile) has a space and requirement for a production control NCO

of grade E8 which requires a higher degree of knowledge and experience than the E7 requirements in the ROAD Division.

e. It was found, in all cases, that the records and reports for uniform establishment of the utilization of manpower and skills were not available. These data are essential for relating the status of the unit to its ability to meet its requirements.

OVERALL PERSONNEL-TO-AIRCRAFT RATIO

Personnel skills and parts are the primary resources of maintenance. Total personnel requirements are established by the total number and distribution of aircraft, and the combat environment. The number of aircraft affect the number of personnel required through their implications in terms of maintenance actions connected with the possession of aircraft. At low levels of utilization (well below those experienced in Vietnam), the maintenance requirements arising from possession dominate personnel requirements. As utilization increases, the relationship between the number of hours flown by the fleet and the total manpower becomes more nearly linear. The effect of the distribution of aircraft in large and small units has been covered in previous APJ studies.

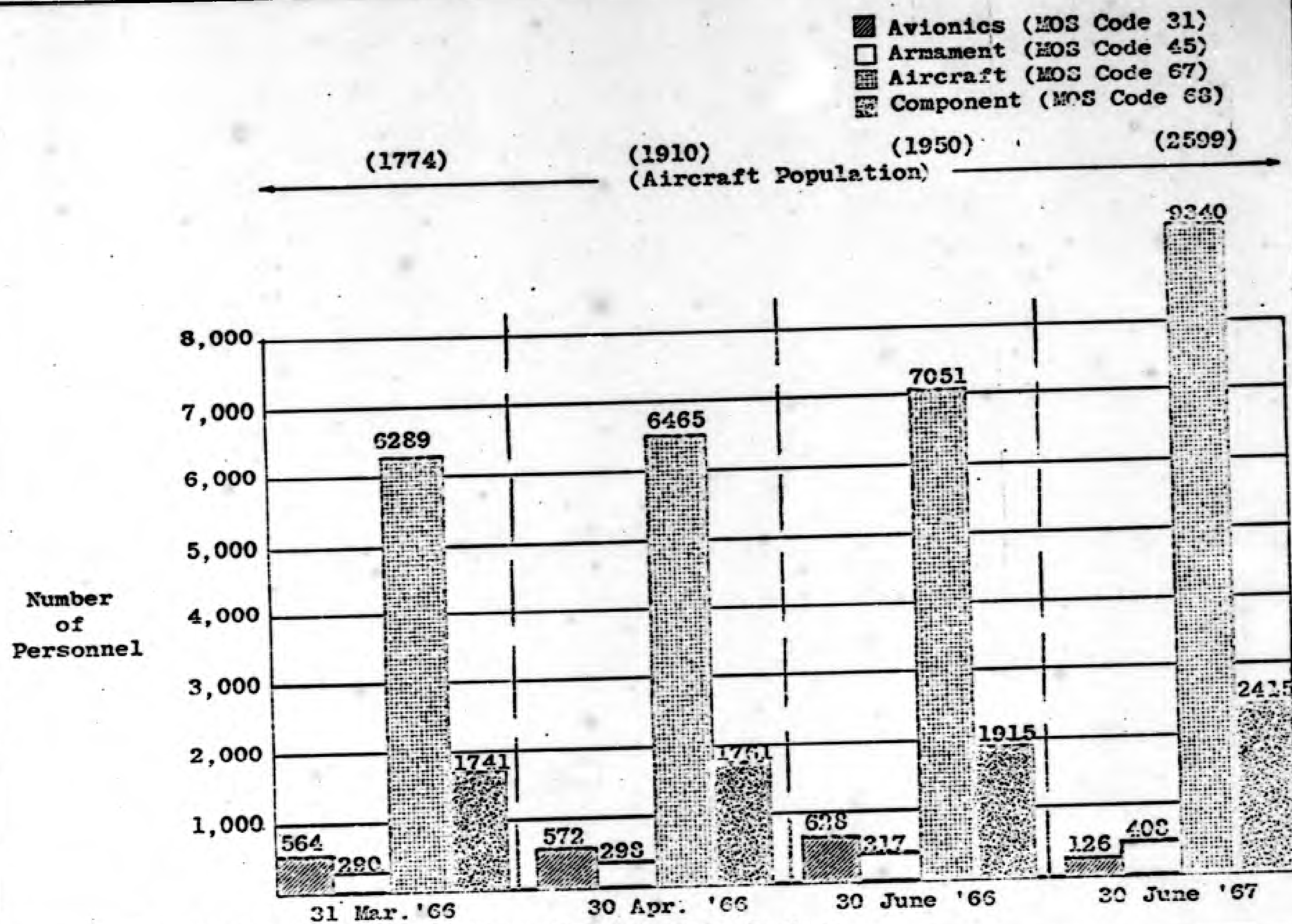
The effect of the natural and combat environment is very pronounced. Although the aircraft is essentially omnienvironmental when it is airborne, it spends sufficient time on the ground to be affected by the surface environment. Thus, manpower requirements are affected by geographical location, and the combat environment places further demands on the soldier's time which severely diminish his availability for "wrench turning".

Manpower Skill Distribution

The distribution of manpower skills is a function not only of the above factors, but of the mix of fixed and rotary wing aircraft, and also the amount of aircraft armament and avionics that must be supported. Two additional factors that affect the number of maintenance personnel are the requirements for aircraft crews and component repair. While the level of utilization and conditions of flight service in peacetime are such that crewmen may be assigned maintenance tasks, this is only partially true in Vietnam. The crew chief who must fly in combat, acting as a door gunner, is scarcely in a position to carry out the full scope of maintenance actions which he would otherwise perform in peacetime. Men assigned to component repair operate in the specialized areas of engine, power train, and accessories. Certain of the component repairmen, however, are primarily engaged in inspection and replacement work and not in repair, as such.

The relative distribution of personnel skills is given in Figure 9-1 which presents for four time periods (between March 1966 and June 1967), the total number of personnel and the distribution of skills authorized for aircraft maintenance support in Vietnam.

Except for avionics personnel, it will be seen that the progressive increases in the aircraft population and the number of



Source: "Enlisted Aviation L-45 Report" USARV Data Center

Figure 9-1. Aircraft Maintenance Repairmen Authorizations Vietnam 1966 - 1967 maintenance personnel are accompanied by a relatively stable distribution of personnel assigned to the major categories. The emphasis on black-box replacement, with return to CONUS for overhaul, and the low avionics maintenance per flying hour requirement account for the lack of proportionality in the trend of avionics personnel requirements.

The overall statistics display a continuing improvement in manpower utilization measured both in terms of maintenance men per aircraft and maintenance men per flying hours supported. Thus, the number of maintenance men per aircraft at the end of the first quarter of 1966 was 5.0 and by the end of the second quarter, it was 5.1. However, after a year (end of second quarter 1967) a much larger population of 2599 aircraft utilized at a higher average rate, was supported with a lower number of maintenance men per aircraft. The underlying causes are beyond the scope of this study. However, reference may be had to APJ Report 483-102 (Reference 4) which provides an intensive analysis of conventional, airmobile, and detachment support concepts. The following table provides key results in this area:

Date	No. of A/C	Average Monthly F/H per A/C	Maintenance Personnel per A/C
3/31/66	1815	55.1	5.0
6/30/66	2000	57.0	5.1
6/30/67	2599	62.2	4.7

MAINTENANCE PERSONNEL

Skills and Experience

The maintenance skills of mechanics are closely related to the training, experience, intelligence and interest of the individual. These personnel were found to be comparable in both the Direct Support unit of the 1st Infantry Division (ROAD) and the Direct Support units of the 1st Cavalry Division (Airmobile). Since all the personnel were trained in the same schools in CONUS and had approximately the same amount of experience, this constituted the basis for considering them on an equal basis.

The only possible difference in skill or training requirements might be in the capability required for A Company of the 15th Transportation Battalion in the Airmobile Division which supports the CH-47 since this helicopter utilizes a more complex hydraulic power train and control system than other types of aircraft.

The Direct Support units in both Divisions had sheetmetal structural repair MOS and capabilities, but they lacked enough personnel to take care of the required sheetmetal and battle damage repair. Both Divisions were dependent upon civilian contract personnel as backup support in this phase of their maintenance. This shortage of sheetmetal repairmen extends throughout all units in Vietnam and the Theater is largely dependent upon the extensive battle damage and sheetmetal repair being accomplished by civilian contract personnel and contracts with Air Vietnam.

In both Divisions, the mechanics in the lower grade structure are usually recent maintenance school graduates. Most of the higher grade mechanics are career soldiers with strong backgrounds of professional schooling and experience, and many of them are on their second tour of duty in Vietnam.

Full advantage was taken by both Divisions of the quotas received from the USARV Army Aircraft Mobile Training Program (AAMTAP) schools by the unit Commanders. The AAMTAP courses required from two to four weeks time, but the additional training they received was well worth this loss of the mechanic's time. This greatly reduced the on-the-job training time required for the school-trained, but inexperienced mechanic. Personal observations and interviews by APJ personnel in Vietnam provide the basis for these conclusions.

Grades

Figure 9-2 presents the comparative grade structure of maintenance personnel for the Airmobile and ROAD Divisions. In the Airmobile Division, the grade rate of E8 in production control requires higher qualifications than is required for the maintenance company in the 1st Infantry Division (ROAD). The production control sergeant is not authorized in the ROAD Division. The highest rank for maintenance personnel in the ROAD Division is E7 for the aircraft maintenance supervisor and the forward support platoon headquarters sergeant. As noted previously, the capabilities of personnel of the same ranks and responsibilities are considered comparable in both units.

Grade	E-3	E-4	E-5	E-6	E-7	E-8	Total
Airmobile TOE 55-407T	25	78	81	26	4	1	215
Plus							
Avionics Repair Section (TOE 55-406T*)	-	.75	2.25	1.5	-	-	4.5
Percentage by Grade	11.4	35.9	37.9	12.5	1.8	.5	100.0
ROAD MTOE 55-89G	9	70	48	13	2	-	142
Percentage by Grade	6.3	49.3	33.8	9.2	1.4	-	100.0

*A total of eighteen repairmen are prorated over the four DS Companies.

Figure 9-2. Maintenance Personnel by Grades - Airmobile and ROAD Divisions (Direct Support Companies)

In the Grade of E3, the Airmobile Direct Support Companies had 11.4 percent of their maintenance personnel in this grade against 6.3 percent in the ROAD Division Direct Support Company. The Airmobile Division had 35.9 percent in E4s in comparison with 49.3 percent in the ROAD Division. They also had 37.9 percent in Grade E5 comparable to 33.8 percent in the ROAD Division. In Grade E6, the Airmobile Division had 12.5 percent and the ROAD Division had 9.2 percent. In Grade E7, the Airmobile Division had 1.8 percent comparable to 1.4 percent in the ROAD Division.

The maintenance personnel,as noted above, are comprised of a higher percentage of E3, E6 and E7 grades in the Airmobile Direct Support units. Additionally, the Airmobile units are authorized an E8 in production control, although none is authorized for the ROAD Division.

E Company of the 701st Maintenance Battalion (ROAD), which is now organized under MTOE 55-89G, has higher percentages of E4 and E5 Grades, in comparison with TOE-89E under which it was previously organized with a higher percentage of E3 and E4 Grades. This increase of percentages in the higher grades under MTOE 55-89G indicates a higher skill level because the spaces for higher grades will thus be filled with more qualified personnel. This places the ROAD Division and the Airmobile Division on a comparable basis, with the ROAD Division having a slight advantage in the lower grades of the "wrench-turning" skills.

Maintenance Equivalent Requirements

The bases of this comparison are the population of aircraft by type, model and series, and the units supporting the owning organizations as of July 1967. These figures, it should be noted, are in a constant state of flux due to enemy action, accident, loss and replacement actions.

In the 1st Infantry Division (ROAD), there are seven organizations owning aircraft, in addition to the two aircraft owned by E Company of the 701st Maintenance Battalion for maintenance, supply pickup, and float aircraft.

In the Airmobile Division, the four companies of the 15th TC Battalion support aircraft similar to those supported by the ROAD Division except for the CH-47, O-1 and U-6 aircraft. A Company supported six units, B Company supported 9 units, C Company supported 15 units and D Company supported 10 units.

Figure 9-3 presents the distribution of aircraft by TMS for the Direct Support companies of both Divisions, as of July 1967.

As seen in this Figure, in July 1967, the four Direct Support companies of the Airmobile Division supported 454 aircraft of various types, models, and series. This figure fluctuated from day to day, but the overall norm is approximately 466 aircraft on hand, including the maintenance float aircraft.

To determine a comparative standard, a method of maintenance equivalent evaluation was developed to show workloads generated based

Direct Support Companies	TMS	No.of A/C	Total Aircraft
ROAD			
E Co. 701st Maint. Bn.	OV-1	3	
	OH-13	44	
	UH-1B	28	
	UH-1D	24	
Total (ROAD)			99
Airmobile			
A Co. 15th TC	O-1	4	
	U-6	1	
	OV-1	3	
	CH-47	57	
Total			65
B Co. 15th TC	OH-13	28	
	UH-1B	10	
	UH-1C	12	
	UH-1D	73	
	UH-1H	12	
Total			135
C Co. 15th TC	OH-13	12	
	UH-1B	33	
	UH-1C	20	
	UH-1D	62	
Total			127
D Co. 15th TC	OH-13	52	
	UH-1B	18	
	UH-1C	18	
	UH-1D	34	
	UH-1H	5	
Total			127
Grand Total (Airmobile)			454

Figure 9-3. Distribution of Aircraft Supported by Direct Support Companies -- Airmobile and ROAD Divisions (as of July 1967)

on a common denominator. For this study, it was broken down for each TMS and type of maintenance.

The man-hour per flying hour rate by type of maintenance (Organizational, Direct Support and General Support) was developed from APJ data bank sample studies. Using these rates, the ratios were applied to the maintenance equivalents of each TMS to provide a value for each type of maintenance. These stratifications of maintenance equivalents, based on Vietnam experience, are shown in Figure 9-4.

Because of the high density and maintenance requirements of the UH-1D, it was used as the basic unit, as seen in this Figure. In order to present a clear picture of the workload distribution, these factors cover the three types of maintenance distribution.

The following Figures(9-5 and 9-6) show a further breakout of aircraft assignments and maintenance equivalents required for the 1st Infantry Division (ROAD) and the 1st Cavalry Division (Airmobile). As can be seen in Figure 9-5, the maintenance equivalents for supply personnel in E, Company of the 701st Maintenance Battalion (ROAD) are approximately one and one-half times greater than those required for the supply personnel in the Direct Support Companies of the 15th TC Battalion (Airmobile). This is due to the fact that the supply personnel in the ROAD Division account for 9 percent of the total personnel, while in the Direct Support companies of the Airmobile Division, the supply personnel account for 13 percent. This results in a ratio of approximately 1.5:1 supply personnel in the Airmobile DS units to the ROAD Direct Support unit.

TMS	ROAD AND AIRMOBILE DIVISIONS				DS BREAKOUT		
					ROAD		Airmobile
	Total	Org	GS	DS	DS Co.	Back Up DS Co.	DS Cos.
OV-1**	0.30	0.38	0.07	0.35	0.35	-	0.35
OH-13	0.68	0.28	0.12	0.28	0.26	0.02	0.28
UH-1B/C	0.76	0.42	0.02	0.32	0.26	0.06	0.32
UH-1D	1.00*	0.58	0.06	0.36	0.30	0.06	0.36
CH-47	2.99	2.31	0.05	0.63	-	-	0.63

* 223.5 Man-Hours per month is basis for unity
** Excludes Avionics

Figure 9-4. Maintenance Equivalents for Types of Aircraft Supported

	ROAD Division	Airmobile Division				
	E Company 701st M. Bn.	A Company 15th TC Bn.	B Company 15th TC Bn.	C Company 15th TC Bn.	D Company 15th TC Bn.	Total 15th TC Bn.
Total No. of Aircraft	99	65	135	127	127	454
Total ME	26.97	37.96	45.48	42.64	40.12	166.20
Total Supply Personnel	18	43	43	43	43	172
ME per Supply Personnel	1.50	0.88	1.06	0.99	0.93	0.97

Figure 9-5. Aircraft Assignments and Related Maintenance Equivalents, for <u>Supply</u> Personnel (as of July 1967)

	ROAD Division	Airmobile Division				
	E Company 701st M. Bn.	A Company 15th TC Bn.	B Company 15th TC Bn.	C Company 15th TC Bn.	D Company 15th TC Bn.	Total 15th TC Bn.
Total No. of Aircraft	99	65	135	127	127	454
Total ME	26.97	37.96	45.48	42.64	40.12	166.20
Total Dir.Lab. Personnel	129	166	200	187	178	731
ME Per Maint. Personnel	0.21	0.23	0.23	0.23	0.23	0.23

Figure 9-6. Aircraft Assignments and Related Maintenance Equivalents, for Maintenance Personnel (as of July 1967)

For the ROAD Division, as can be seen from Figure 9-6, E Company of the 701st Maintenance Battalion has 26.97 maintenance equivalents for a total of 129 direct labor personnel. For the Airmobile Division, the findings were as follows:

1. A Company of the 15th Transportation Battalion had a total of 37.96 maintenance equivalents and 166 direct labor personnel.
2. B Company had a total of 38.48 maintenance equivalents and 200 direct labor personnel.
3. C Company had a total of 42.64 maintenance equivalents and 187 direct labor personnel.
4. D Company had a total of 40.12 maintenance equivalents and 176 direct labor personnel.

As shown in Figure 9-6, the maintenance equivalents supported per maintenance man are very close in both Divisions with 0.21 maintenance equivalents per maintenance personnel in the ROAD Company and 0.23 in the Airmobile companies. The man-hours per maintenance personnel for the Airmobile Division average approximately 8 percent higher than the ROAD Division.

Inasmuch as the APJ simulation concept involves analytical relationships in the fine structure of the performance of individual organizations, it is desirable to present for reference purposes the detailed charts supporting the conclusions reached in Figure 9-6.[1] (See Figures 9-7 through 9-11).

1/ See also analyses and results in APJ 483-2 (Reference 3).

	OV-1	OH-13	UH-1B	UH-1D	Total	Share of Maint. Personnel Dir Labor	Share of Maint. Personnel Total
1st Bde						7.5	8.2
No A/C	-	6	-	-	6		
ME Req'd	-	1.56	-	-	1.56		
2nd Bde						7.5	8.2
No A/C	-	6	-	-	6		
ME Req'd	-	1.56	-	-	1.56		
3rd Bde						6.2	6.8
No A/C	-	5	-	-	5		
ME Req'd	-	1.30	-	-	1.30		
A Co 1st Avn Bn						34.1	37.6
No A/C	-	-	9	16	25		
ME Req'd	-	-	2.34	4.80	7.14		
B Co 1st Avn Bn						26.4	29.1
No A/C	3	8	-	8	19		
ME Req'd	1.05*	2.08	-	2.40	5.53		
D Co 4th Cav						32.3	35.6
No A/C	-	9	17	-	26		
ME Req'd	-	2.34	4.42	-	6.76		
Div Artillery						12.4	13.7
No A/C	-	10	-	-	10		
ME Req'd	-	2.60	-	-	2.60		
E Co 701st						2.6	2.8
No A/C	-	-	2	-	2		
ME Req'd	-	-	.52	-	.52		
Totals	3	44	28	24	99	129.0	142.0
Total ME Req'd	1.05*	11.44	7.28	7.20	26.97		

*Excludes Avionics

Figure 9-7. Aircraft Assignments, Related Maintenance Equivalents and Number of Maintenance Personnel Supported by E Co., 701st Bn, ROAD Division (July 1967)

	0-1	U-6	OV-1	CH-47	Total	Share of Maint. Personnel Dir Labor	Share of Maint. Personnel Total
11th Gen Sup						5.5	6.5
No A/C	-	1	3	-	4		
ME Req'd	-	.20	1.05*	-	1.25		
Co A 228th						49.6	58.6
No A/C	-	-	-	18	18		
ME Req'd	-	-	-	11.34	11.34		
Co B 228th						44.1	52.1
No A/C	-	-	-	16	16		
ME Req'd	-	-	-	10.08	10.08		
Co C 228th						44.1	52.1
No A/C	-	-	-	16	16		
ME Req'd	-	-	-	10.08	10.08		
Btry E 82nd						3.5	4.3
No A/C	4	-	-	-	4		
ME Req'd	.80	-	-	-	.80		
1st Avn Det						5.5	6.5
No A/C	-	-	-	2	2		
ME Req'd	-	-	-	1.26	1.26		
Co A 15th TC						13.9	16.4
No A/C	-	-	-	5	5		
ME Req'd	-	-	-	3.15	3.15		
Totals	4	1	3	57	65	166.2	196.5
Total ME Req'd	.80	.20	1.05*	35.91	37.96		

*Excludes Avionics

Figure 9-8. Aircraft Assignments, Related Maintenance Equivalents and Number of Maintenance Personnel Supported by 1st Cav Div A Co., 15th Bn, Airmobile (July 1967)

	OH-13	UH-1B	UH-1C	UH-1D	UH-1H	Total	Share of Maint. Personnel Dir Labor	Share of Maint. Personnel Total
11th Gen Sup							25.8	30.4
No A/C	9	3	3	4	-	19		
ME Req'd	2.52	.96	.96	1.44	-	5.88		
HHC 229th							5.1	6.0
No A/C	3	1	-	-	-	4		
ME Req'd	.84	.32	-	-	-	1.16		
Co A 229th							26.8	31.7
No A/C	-	-	-	17	-	17		
ME Req'd	-	-	-	6.12		6.12		
Co B 229th							30.0	35.4
No A/C	-	-	-	19	-	19		
ME Req'd	-	-	-	6.84		6.84		
Co C 229th							30.0	35.4
No A/C	-	-	-	19		19		
ME Req'd	-	-	-	6.84		6.84		
Co D 229th							4.6	5.4
No A/C	-	5	6	-	-	11		
ME Req'd	-	1.60	1.92	-	-	3.52		
Co B 15th Med							36.3	42.8
No A/C	-	-	1	2	-	3		
ME Req'd	-	-	.32	.72	-	1.04		
Hq 15th Med Bn							36.3	42.8
No A/C	-	-	-	11	12	23		
ME Req'd	-	-	-	3.96	4.32	8.28		
Btry E 82nd							25.5	29.9
No A/C	16	1	2	1	-	20		
ME Req'd	4.48	.32	.64	.36	-	5.80		
Totals	28	10	12	73	12	135	199.5	235.2
Total ME Req'd	7.84	3.20	3.84	26.28	4.32	45.48		

Figure 9-9. Aircraft Assignments, Related Maintenance Equivalents and Number of Maintenance Personnel Supported by 1st Cav Div B Co., 15th Bn, Airmobile (July 1967)

	OH-13	UH-1B	UH-1C	UH-1D	Total	Share of Maint. Personnel: Dir Labor	Share of Maint. Personnel: Total
HHC 3rd Bde						17.7	20.8
No A/C	8	-	-	5	13		
ME Req'd	2.24	-	-	1.80	4.04		
HHC 227th						5.1	6.0
No A/C	3	1	-	-	4		
ME Req'd	.84	.32	-	-	1.16		
Co A 227th						26.8	31.6
No A/C	-	-	-	17	17		
ME Req'd	-	-	-	6.12	6.12		
Co B 227th						28.4	33.5
No A/C	-	-	-	18	18		
ME Req'd	-	-	-	6.48	6.48		
Co C 227th						28.4	33.5
No A/C	-	-	-	18	18		
ME Req'd	-	-	-	6.48	6.48		
Co D 227th	-	-	-			15.4	18.1
No A/C	-	3	8	-	11		
ME Req'd		.96	2.56		3.52		
HH 2/20th						4.2	5.0
No A/C	-	-	3	-	3		
ME Req'd	-	-	.96	-	.96		
A Btry 2/20						16.8	19.9
No A/C	-	9	3	-	12		
ME Req'd	-	2.88	.96		3.84		
B Btry 2/20						16.8	19.9
No A/C	-	8	4	-	12		
ME Req'd	-	2.56	1.28	-	3.84		
C Btry 2/20						16.8	19.9
No A/C	-	10	2	-	12		
ME Req'd	-	3.20	.64	-	3.84		

Figure 9-10. Aircraft Assignments, Related Maintenance Equivalents and Number of Maintenance Personnel Supported by 1st Cav Div C Co., 15th Bn Airmobile (July 1967) (continued)

	OH-13	UH-1B	UH-1C	UH-1D	Total	Share of Maint. Personnel	
						Dir Labor	Total
HHC 15th TC						1.6	1.9
No A/C	-	-	-	1	1		
ME Req'd	-	-	-	.36			
Co A 15th TC						1.6	1.9
No A/C	-	-	-	1	1		
ME Req'd	-	-	-	.36	.36		
Co C 15th TC						5.5	6.6
No A/C	1	2		1	4		
ME Req'd	.28	.64		.36	1.28		
Bank Sup						1.6	1.9
No A/C	-	-	-	1	1		
ME Req'd	-	-	-	.36	.36		
Totals	12	33	20	62	127	(220.5)	186.7
TOTAL ME Req'd	3.36	10.56	6.40	22.32	42.64		

Figure 9-10. Aircraft Assignments, Related Maintenance Equivalents and Number of Maintenance Personnel Supported by 1st Cav Div C co., 15th Bn Airmobile (July 1967)(concluded)

	OH-13	UH-1B	UH-1C	UH-1D	UH-1H	Total	Share of Maint. Personnel	
							Dir Labor	Total
HHC 1st Bde							17.7	20.9
No A/C	8	-	-	5	-	13		
ME Req'd	2.24	-	-	1.80	-	4.04		
HHC 2nd Bde							16.1	19.0
No A/C	8	-	-	4	-	12		
ME Req'd	2.24	-	-	1.44	-	3.68		
Co C 228th							3.7	4.4
No A/C	3	-	-	-	-	3		
ME Req'd	.84	-	-	-	-	.84		
Co D 15th TC							8.2	9.7
No A/C	3	-	1	2	-	6		
ME Req'd	.84	-	.32	.72	-	1.88		
HHT/1st/9th							10.7	12.6
No A/C	-	1	1	5	-	7		
ME Req'd	-	.32	.32	1.80	-	2.44		
Tr A 9th							40.3	47.6
No A/C	10	7	4	6	2	29		
ME Req'd	2.80	2.24	1.28	2.16	.72	9.20		
Tr B 9th							40.3	47.6
No A/C	10	5	6	6	2	29		
ME Req'd	2.80	1.60	1.92	2.16	.72	9.20		
Tr C 9th							38.7	45.8
No A/C	10	5	6	6	1	28		
ME Req'd	2.80	1.60	1.92	2.16	.36	8.84		
Totals	52	18	18	34	5	127	(175.7)	(207.6)
Total ME Req'd	14.56	5.76	5.76	12.24	1.80	40.12		

Figure 9-11. Aircraft Assignments, Related Maintenance Equivalents, and Number of Maintenance Personnel Supported by 1st Cav Div D Co., 15th Bn Airmobile (July 1967)

CONTACT TEAMS

Contact teams were used both in the 1st Infantry Division and the Airmobile Division DSU. They usually consisted of a warrant officer, a non-commissioned office (E6), and sufficient mechanics of lower grades to fulfill the required missions. Engines, transmissions and other major components were prepared as quick change assemblies at the home base and flown with the contact team to the requiring unit. When possible, the aircraft were airlifted to the home base for repair or replacement of major components.

DISTRIBUTION OF PERSONNEL RESOURCES

In view of local fluctuations among units and across time, it was concluded that a TO&E analysis of relative personnel distribution would most appropriately describe the average distribution of personnel resources available to the Airmobile and ROAD Divisions. These results are given in Figure 9-12.

It will be seen that while the proportion of administrative and overhead personnel were very closely comparable, a difference is apparent in the allocation of resources of supply and maintenance, with the Airmobile Division having a slightly higher percentage of its resources devoted to supply.

DS Co.	Supply		Maintenance		Administrative and Overhead		Total	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
E Co., 701st. Maint. Bn. (ROAD)	18	9.0	142	70.0	42	21.0	202	100.0
15th Trans. Bn. (Airmobile)	39	13.0	215	65.0	73	22.0	331	100.0

Figure 9-12. Comparative Distribution of Personnel - Airmobile versus ROAD Divisions

CHAPTER 10

MAINTENANCE AND SUPPLY

CHAPTER 10

MAINTENANCE AND SUPPLY

ROAD MAINTENANCE CONCEPTS

As described in the companion APJ Report 500-1 (Reference 1), there are major differences between the ROAD and Airmobile maintenance concepts.

The ROAD concept provides for four levels of maintenance: Organizational, Direct Support, General Support, and Depot level, with Direct Support and General Support considered as Field maintenance.

Organizational maintenance primarily comprises scheduled inspections and minor component adjustments, repairs, and removal and replacement. Because Organizational maintenance is strongly keyed to "on-flight-line" activity, Organizational levels are not authorized to remove and replace most major aircraft components. A certain amount of Organizational maintenance work comprises special inspections, usually with assistance provided by Direct Support units. Such inspections may be the consequence of combat operations or special requirements as determined by the National Maintenance Point.

ROAD Direct Support activity is primarily the removal and replacement of major components, major airframe repairs with a heavy emphasis on sheetmetal work, and inspection assistance to Organizational level units. In Vietnam, field recovery of aircraft (although strictly speaking, not maintenance work against individual aircraft) is a significant function.

The ROAD General Support concept relates to airframe repairs beyond the capability of the DS level, including major modifications. Component test inspection work is charged to General Support, although the extent to which this work has been performed varies widely from time to time and unit to unit. Depot level maintenance is not performed in Vietnam.

The requirement for inspections at all levels is a major one: At Organizational level, daily inspections are performed each day the aircraft is flown and every 72 hours if the aircraft is not utilized. Intermediate inspections are accomplished every 25 hours of flying, with a periodic inspection at the end of every 100 hours of flying.

Although maintenance management emphasizes the separation of the inspection function as such from the concommitant maintenance work, this distinction is rarely observed in maintenance records. Instead, the maintenance man tends to lump not only the inspection, but the corrective action which had to be taken as a consequence of the inspection, under a single heading. Therefore, the distinction between inspection and maintenance as reflected in the records is essentially elastic and depends on individual training and unit command emphasis.

AIRMOBILE MAINTENANCE CONCEPTS

The Airmobile maintenance concept went through a considerable evolution as detailed in APJ Report 500-1 (Reference 1). The initial Howze Board concept of moving maintenance forward was replaced during the 11th

Air Assault tests by its opposite, i.e., the limitation of maintenance at "A" level (corresponding to an Organizational level) to work which could be accomplished in four hours or less. Work which was evacuated and could not then be accomplished in 72 hours or less at "B" level was further evacuated to "C" level (corresponding to the analog of General Support).

Upon moving to Vietnam, the Airmobile Division continued, during the period studied, to emphasize policies providing responsive maintenance with a retention of maintenance unit mobility. Extensive use of Direct Support level (co-located on the same Divisional Base area) and informal adherence to a time limit rule, produce a distribution of effort between Organizational and Direct Support that differs from that experienced by the ROAD units. The Airmobile Division also received considerable support during the period studied from both General Support units and the Floating Aircraft Maintenance Facility (FAMF).

These differences in the structure of maintenance produce the patterns which are discussed below by type, model and series of aircraft. The time period covered by the data is the last part of 1966 through the middle of 1967. The data were obtained from TAERS records and observations of APJ staff in the Theater. The depth of data at Organizational level on the OH-13S and UH-1D comprise over 10,000 aircraft hours. Sample sizes on the UH-1B and OV-1 are smaller, but are of sufficient size that the variance of the mean is reduced to low and stable levels. In general, sample sizes for the 1st Cavalry Division are smaller than for the 1st Infantry Division and some variability may be expected for the OH-13S because the period observed corresponded to a time when considerable modifications were made. The sample size for CH-47 at Organizational level covers over 8,000 hours and more than 600 control numbers. At Direct Support level, sample sizes for the 1st Infantry unit cover approximately 3,500 events and for the Airmobile Division, approximately 13,000 events.

ORGANIZATIONAL MAINTENANCE

This section discusses the performance of maintenance functions at Organizational level. Four categories of analyses are given with side-by-side comparisons of the 1st Infantry and 1st Cavalry Divisions, where data are available and aircraft are held by both units. Thus, the CH-47 is not assigned to the 1st Infantry, and therefore appears in the 1st Cavalry only.

The first analysis of Organizational maintenance functions covers the distribution of maintenance events. In TM 38-750, "The Army Equipment Record System"(TAERS) provision is made for reporting at least five relevant categories: inspection, modification, crash damage, combat damage, and general maintenance. It is interesting and important to note that, with very few exceptions, only the categories of inspection and general maintenance are reported.

Because it was deemed important to determine whether the effect of maintenance organization was such that not only could there be a difference between maintenance events, but in the allocation of maintenance man-hours, a comparable analysis was made for these hours. Finally, maintenance man-hours per event were computed to indicate the intensity of maintenance effort.

The three essentially independent views of the maintenance process provide comparisons among the allocation of effort in terms of jobs undertaken and man-hours allocated and also the intensity with which maintenance manpower was devoted to the job at hand.

The fourth category breaks down maintenance functions into aircraft subsystem and other significant maintenance categorization. It was in this area that a major problem was encountered, arising from differing interpretations on the part of personnel filling out the forms as to the proper allocation of maintenance work. In many cases, where more than one maintenance function is performed, there is a strong tendency to use the category of "other". In other instances however, the maintenance is associated with the primary system being worked on. The latter procedure is far preferable to the first in which the category of "other" dominates all observations. The impact of this factor on the different aircraft varies considerably. In all instances, with the exception of the OH-13S, the category of "other" distorts but does not invalidate the analyses.

Figure 10-1 presents the distribution of Organizational maintenance effort in terms of maintenance events, man-hours and man-hours per event for the OH-13S. It is seen that the 1st Cavalry Division allocated more of its events to the category of inspections, but when maintenance work was performed, the intensity of maintenance was greater. An example is shown in Figure 10-1 in which the man-hours per event in total are approximately equal, (4.5 versus 4.4), but the distribution of effort is such that they spent 70 percent more time on the inspection category of work than on general maintenance.

As noted above, the category of "other" dominates Figure 10-2 which gives the percentage distribution of Organizational general maintenance functions per event. No conclusion can be drawn from these data for the 1st Infantry Division. However, the 1st Cavalry Division data are sufficiently resolved to give the relative allocation of effort against the major subsystems. It is not surprising that the power plant, airframe and dynamics account for the major portion of work. The electrical system maintenance effort on the OH-13S can be attributed to gun-firing problems in the operating environment.

Figure 10-3 provides maintenance events, man-hours and man-hours per event for the UH-1B. The pattern of maintenance event distribution follows that previously noted, i.e., major emphasis on inspection as contrasted with general maintenance. Where maintenance man-hours per event are considered, the Division's performance of Organizational work in relatively small

	1st Infantry Division %	1st Cavalry Division %
A. Maintenance Events		
Inspection	75.1	84.3
General Maintenance	24.9	15.7
B. Maintenance Man-Hours		
Inspection	91.4	89.5
General Maintenance	8.6	10.5
C. Maintenance Man-Hours Per Event		
Inspection	3.5	2.7
General Maintenance	1.0	1.7

Figure 10-1. OH-13S Percent Distribution of Organizational Maintenance Level

Subsystems	1st Infantry Division %	1st Cavalry Division %
Power Plant	6.1	18.1
Airframe	5.1	12.5
Instruments	1.8	6.9
Electrical	1.6	20.8
Hub/Rotor Blades	1.3	19.4
Avionics	.5	2.8
Transmission	.4	1.4
Fuel System	.3	-
Hydraulics	.3	2.8
Others	82.6	15.3

Data Source: DA Forms 2408-3

Figure 10-2. OH-13S Percent Distribution of Organizational General Maintenance Events jobs, as discussed above, is confirmed. If the rather large amount of work and labor devoted to modification on a per job basis is disregarded (note that modifications comprise only .4 percent of the 1st Infantry Division maintenance events) then the total figures are more closely comparable.

Figure 10-4 describes the distribution of Organizational general maintenance events for the UH-1B/C. Although for the 1st Infantry Division the category of "other" is more than twice as large as it is for the 1st Cavalry, its impact is almost entirely in the airframe, hydraulic and electrical categories. Observations suggest these are the categories which tend to be lumped into the "other" category. The patterns appear to be closely comparable across organizations. Within aircraft, the major consumer of man-hours and of maintenance events is the airframe, followed by the power plant and dynamic system.

Figures 10-5 and 10-6 present the distribution of Organizational maintenance for the UH-1D. The 1st Cavalry had a higher percentage of inspection events than the 1st Infantry (87.1 percent versus 74.1 percent) and had a correspondingly higher percentage of man-hour expenditure (93.3 percent versus 86.9 percent). However, as can be seen in Figure 10-5, the man-hours per inspection event were lower for the 1st Cavalry (4.4 percent) than the 1st Infantry (5.9 percent). The 1st Cavalry reported no modification or crash damage maintenance. The man-hours expended in the 1st Infantry for each combat damage event was high (36 M/H), although the percentage of events was low (0.1 percent).

	1st Infantry Division %	1st Cavalry Division %
A. Maintenance Events		
Inspection	79.9	90.2
Modification	.4	.1
General Maintenance	19.7	9.7
B. Maintenance Man-Hours		
Inspection	85.1	94.9
Modification	.5	.1
General Maintenance	14.4	5.0
C. Maintenance Man-Hours Per Event		
Inspection	3.5	2.7
Modification	4.5	.1
General Maintenance	2.4	1.2

Figure 10-3. UH-1B/C Percent Distribution of Organizational Maintenance Level

Subsystems	1st Infantry Division %	1st Cavalry Division %
Power Plant	14.7	14.2
Airframe	25.3	31.1
Instruments	4.2	4.7
Electrical	4.0	8.4
Hub/Rotor Blades	14.7	17.9
Transmission	.6	2.1
Fuel System	-	1.1
Hydraulics	3.7	6.3
Others	32.8	14.2

Data Source: DA Forms 2408-3

Figure 10-4. UH-1B/C Percent Distribution of Organizational General Maintenance Events

	1st Infantry Division %	1st Cavalry Division %
A. Maintenance Events		
Inspection	74.1	87.1
Modification	.1	-
Combat Damage	.1	-
General Maintenance	25.7	12.9
B. Maintenance Man-Hours		
Inspection	86.9	93.3
Modification	.1	-
Combat Damage	.3	-
General Maintenance	12.7	6.7
C. Maintenance Man-Hours Per Event		
Inspection	5.9	4.4
Modification	5.2	-
Combat Damage	36.0	-
General Maintenance	2.3	2.2

Data Source: DA Forms 2408-3

Figure 10-5. UH-1D Percent Distribution of Organizational Maintenance Level

Subsystems	1st Infantry Division %	1st Cavalry Division %
Power Plant	31.7	14.1
Airframe	19.3	29.7
Instruments	4.6	2.9
Electrical	5.3	8.8
Hub/Rotor Blades	19.4	20.6
Avionics	.4	2.6
Transmission	1.0	2.3
Hydraulics	8.7	11.2
Others	9.4	7.8

Data Source: DA Forms 2408-3

Figure 10-6. UH-1D Percent Distribution of Organizational General Maintenance Events

Figure 10-7 provides data comparable to that noted above for the CH-47. Analyses of the CH-47 performance must consider the fact that both military and contractor technical teams participated in its support. The maintenance pattern of approximately 75:25 of inspection to general maintenance, in terms of events, must be viewed in the light of the fact that maintenance man-hours, and the intensity of maintenance strongly favor inspections. The distribution of general maintenance event is given in Figure 10-8. The concentration of effort on airframe and hydraulics is apparent.

Figures 10-9 and 10-10 provide data on the 1st Infantry Division, OV-1 aircraft only, (1st Cavalry data were unavailable). The 75:25 ratio of inspection to general maintenance, in terms of events, is the same as the CH-47 explained above. Airframe received the greatest general maintenance attention, with electrical (due to the type of aircraft) next. The low percentage of propeller events is noteworthy considering the complexity of this unit which costs approximately as much as the entire OV-1 aircraft.

DIRECT SUPPORT MAINTENANCE

This section discusses the performance of maintenance functions at Direct Support level.

A comparison of aircraft maintenance performance by the 1st Infantry Division (ROAD) and 1st Cavalry Division (Airmobile) must

	1st Cavalry Division 1/ %
A. Maintenance Events	
Inspection	75.5
Modification	.1
General Maintenance	24.4
B. Maintenance Man-Hours	
Inspection	92.7
Modification	.1
General Maintenance	7.2
C. Maintenance Man-Hours Per Event	
Inspection	15.2
Modification	4.5
General Maintenance	3.7

1/ 1st Infantry Division - not applicable

Figure 10-7. CH-47A Percent Distribution of Organizational Maintenance Level

Subsystems	1st Cavalry Division 1/ %
Power Plant	9.2
Airframe	22.5
Instruments	9.7
Electrical	8.3
Hub/Rotor Blades	7.5
Avionics	.9
Transmission	3.8
Fuel System	.5
Hydraulics	22.5
Sheetmetal	.2
Armament	.1
Test	1.2
Others	13.6

1/1st Infantry Division - not applicable
Data Source: DA Forms 2408-3

Figure 10-8. CH-47A Percent Distribution of Organizational General Maintenance Events

	1st Infantry Division 1/ %
A. Maintenance Events	
Inspection	75.2
General Maintenance	24.8
B. Maintenance Man-Hours	
Inspection	86.7
General Maintenance	13.3
C. Maintenance Man-Hours Per Event	
Inspection	4.5
General Maintenance	2.1

1/ 1st Cavalry Data Not Available

Figure 10-9. OV-1 Percent Distribution of Organizational Maintenance Level

Subsystems	1st Infantry Division 1/ %
Power Plant	5.7
Airframe	34.3
Electrical	13.5
Propeller	3.9
Hydraulics	7.0
Others	35.6

1/ 1st Cavalry Data Not Available

Data Source: DA Forms 2408-3

Figure 10-10. OV-1 Percent Distribution of Organizational General Maintenance Events consider certain fundamental environmental and operational differences inherent in the two unit types. For example, the 1st Infantry Division, by and large, operates from lower level altitudes in South Vietnam as compared to the 1st Cavalry Division and this may well account for the relatively high amount of rotor hub and rotor blade maintenance noted for the 1st Cavalry Division. As another example, the 1st Infantry Division utilizes a Direct Support Company in backup to their organic aircraft maintenance company, e.g., aircraft engines maintained by the 605th DSU in support of "E" Co., 701st Maint. Bn., 1st Infantry Division.

Certain differences in data reporting also exist to the level of maintenance performance and reporting. An example is the reporting by the 1st Infantry Division of periodics performed at Organizational level. The 1st Cavalry Division performs periodics at Direct Support level. As a result, the 1st Cavalry Division reflects a higher percentage of inspections (35.8 percent) at Direct Support level than does the 1st Infantry Division (19.7 percent).

Crash damage and combat damage together comprise approximately 10 percent of Direct Support maintenance for both units. This compares with approximately 3 percent for USARV total, which includes these units.

Modifications comprise less than 2 percent of reportable maintenance at Direct Support level. However, care must be exercised in the use of reported military labor since civilian teams have performed substantial modifications which may not have been reported.

Figures 10-11 and 10-12 present, respectively, the OH-13S distribution of Direct Support maintenance effort in terms of all maintenance events and, for general maintenance, specifically by functional categories. The 1st Cavalry reported a higher percentage (35.8 percent) of inspection events than the 1st Infantry, 18.2 percent; the 1st Infantry reported over 80 percent of events as "general maintenance" compared to the 1st Cavalry Division's 49 percent. Comparable distribution percentages exist within general maintenance with the exception of the 1st Cavalry wherein transmission events comprised 25.4 percent of general maintenance, while the 1st Infantry reported only 5.5 percent. This may be due to combat and crash damage events which were reported by the 1st Cavalry, but not the 1st Infantry.

Figure 10-13 presents data on the UH-1B, with inspection events again reported more often by the 1st Cavalry (35.8 percent) than the 1st Infantry (14.1 percent). Both reported considerable combat damage events. Two major differences within general maintenance are apparent in Figure 10-14. The 1st Cavalry reported 25.7 percent of their events for hub and rotor blades, while the 1st Infantry had only 4.6 percent. However, the 1st Infantry reported twice the percentage of the 1st Cavalry for power plant events (24.8 percent to 12.4 percent).

The 1st Cavalry experience with the UH-1C, which was not in the 1st Infantry during the period studied, was similar to their

[redacted]

Maintenance Events	1st Infantry Division %	1st Cavalry Division %
Inspection	18.2	35.8
Modification	-	.7
Crash Damage	1.6	7.1
Combat Damage	-	7.3
General Maintenance	80.2	49.1

Data Source: DA Forms 2408-3

Figure 10-11. OH-13S Percent Distribution of Direct Support Maintenance Events

Subsystems	1st Infantry Division %	1st Cavalry Division %
Power Plant	13.5	9.6
Airframe	20.8	19.8
Instruments	.6	1.2
Electrical	5.1	2.2
Hub/Rotor Blades	23.5	23.4
Avionics	8.9	2.3
Transmission	5.5	25.4
Fuel System	1.2	.5
Hydraulics	2.2	1.6
Sheetmetal	.6	1.8
Calibrate, Test, Fabricate	4.5	.3
Others	13.6	11.9

Data Source: DA Forms 2408-3

Figure 10-12. OH-13S Percent Distribution of Direct Support General Maintenance Events

Maintenance Events	1st Infantry Division %	1st Cavalry Division %
Inspection	14.1	35.8
Modification	1.4	2.9
Crash Damage	1.1	1.3
Combat Damage	24.3	18.4
General Maintenance	59.1	41.6

Data Source: DA Forms 2408-3

Figure 10-13. UH-1B Percent Distribution of Direct Support Maintenance Events

Subsystems	1st Infantry Division %	1st Cavalry Division %
Power Plant	24.8	12.4
Airframe	26.3	29.6
Instruments	.8	1.5
Electrical	4.1	4.8
Hub/Rotor Blades	4.6	25.7
Avionics	3.0	6.6
Transmission	5.3	4.9
Fuel System	1.1	.5
Hydraulics	.5	2.4
Sheetmetal	6.5	5.4
Calibrate, Test, Fabricate	.3	.5
Armament	1.8	.4
Others	20.9	5.3

Data Source: DA Forms 2408-3

Figure 10-14. UH-1B Percent Distribution of Direct Support General Maintenance Events

UH-1B experience, reference Figure 10-16. Possible problems arising from the introduction of the "540 Rotor System" of the UH-1C are apparent from Figure 10-15, with inspection events only 26.8 percent of all maintenance, while the percentage of general maintenance increased over the UH-1B (64.8 percent to 41.6 percent).

Data in Figure 10-17 pertaining to the UH-1D are comparable with combat damage comprising over 10 percent of all events. However, differences again exist within general maintenance (Figure 10-18). The 1st Infantry again reported higher engine maintenance (23.9 percent) compared with 1st Cavalry (13.9 percent), and the reverse, for hub and rotor blades, (7.4 percent for the 1st Infantry versus 23.8 percent for the 1st Cavalry). This phenomenon compares exactly to the UH-1B, reference Figure 10-14.

Figure 10-19 provides data on the 1st Cavalry CH-47, with inspections equalling general maintenance. Figure 10-20 reveals a low percentage of events for transmissions (10.9 percent), while hub and rotor blades accounted for 43.6 percent.

In Figure 10-21, the 1st Cavalry OV-1 shows general maintenance with 69 percent of the events. As can be seen in Figure 10-22, the 1st Cavalry power plant accounts for 40.2 percent of the events versus the 1st Infantry's 13.2 percent. This is directly opposite to the situation with the UH-1B and UH-1D, (reference Figures 10-14 and 10-18), wherein the 1st Infantry had twice the power plant events as the 1st Cavalry. The higher percentage of propeller events

Maintenance Events	1st Cavalry Division %
Inspection	26.8
Modification	1.5
Crash Damage	-
Combat Damage	6.9
General Maintenance	64.8

Data Source: DA Forms 2408-3

Figure 10-15. UH-1C Percent Distribution of Direct Support Maintenance Events

Subsystems	1st Cavalry Division %
Power Plant	11.0
Airframe	25.3
Instruments	2.3
Electrical	2.0
Hub/Rotor Blades	30.7
Avionics	2.3
Transmission	.7
Hydraulics	1.3
Sheetmetal	2.7
Calibrate, Test, Fabricate	1.0
Armament	.3
Others	20.4

Data Source: DA Forms 2408-3

Figure 10-16. UH-1C Percent Distribution of Direct Support General Maintenance Events

Maintenance Events	1st Infantry Division %	1st Cavalry Division %
Inspection	19.9	28.4
Modification	3.7	1.2
Crash Damage	.1	1.2
Combat Damage	10.7	10.9
General Maintenance	65.6	58.3

Data Source: DA Forms 2408-3

Figure 10-17. UH-1D Percent Distribution of Direct Support Maintenance Events

Subsystems	1st Infantry Division %	1st Cavalry Division %
Power Plant	23.9	13.9
Airframe	35.3	34.9
Instruments	1.0	1.4
Electrical	4.9	2.9
Hub/Rotor Blades	7.4	23.8
Avionics	5.3	2.7
Transmission	5.6	5.9
Fuel System	.4	1.2
Hydraulics	1.0	2.9
Sheetmetal	4.9	2.2
Calibrate, Test, Fabricate	.2	.3
Armament	.1	-
Others	10.0	7.9

Data Source: DA Forms 2408-3

Figure 10-18. UH-1D Percent Distribution of Direct Support General Maintenance Events

Maintenance Events	1st Cavalry Division %
Inspection	46.5
Modification	1.7
Crash Damage	.5
Combat Damage	2.9
General Maintenance	48.4

Data Source: DA Forms 2408-3

Figure 10-19. CH-47A Percent Distribution of Direct Support Maintenance Events

Subsystems	1st Cavalry Division %
Power Plant	18.1
Airframe	6.1
Transmission	10.9
Hub/Rotor Blades	43.6
Hydraulics	2.5
Electrical	2.3
Instruments	.6
Sheetmetal	6.4
Avionics	3.3
Fuel System	.7
Others	5.5

Data Source: DA Forms 2408-3

Figure 10-20. CH-47A Percent Distribution of Direct Support General Maintenance Events

Maintenance Events	1st Infantry Division %	1st Cavalry Division %
Inspection	27.1	29.0
Modification	.5	-
Crash Damage	3.9	-
Combat Damage	2.6	2.0
General Maintenance	65.9	69.0

Data Source: DA Forms 2408-3

Figure 10-21. OV-1 Percent Distribution of Direct Support Maintenance Events

Subsystems	1st Infantry Division %	1st Cavalry Division %
Power Plant	13.2	40.2
Airframe	6.6	16.9
Instruments	5.3	.9
Electrical	15.2	.9
Propeller	6.0	15.2
Avionics	4.0	.9
Transmission	2.0	-
Hydraulics	20.0	3.6
Sheetmetal	10.6	.9
Calibrate, Test, Fabricate	2.0	9.8
Others	15.1	10.7

Data Source: DA Forms 2408-3

Figure 10-22. OV-1 Percent Distribution of Direct Support General Maintenance Events

(1st Cavalry 15.2 percent versus 1st Infantry 6.0 percent) and calibrate, test and fabricate events (1st Cavalry 9.8 percent versus 1st Infantry 2.0 percent) perhaps indicate an operational difference existing between the two Divisions.

Maintenance Overflow

The structure of DS maintenance in ROAD (as exemplified by the 1st Infantry Division) differed from Airmobile Division through the provision of an organic backup DS unit. A study of a small sample of data from the backup unit is indicative of the pattern of backup and overflow work.

Overall maintenance events comprised approximately 65 percent aircraft repair and 35 percent component repair. Man-hour distribution, however, was 92 percent aircraft and only 8 percent components. This relationship suggests that component work was limited to the "inspect" and "adjust" category. An analysis of the aviation maintenance events follows:

	% of Events	% of Man-Hours
Modifications	25.7	39.2
Crash Damage	22.8	19.2
Combat Damage	5.8	1.0
General Maintenance	45.7	40.6

It will be seen that the pattern of maintenance is substantially different for the 605th (backup DS) from that of the E Company (DS). Thus, inspections comprise a negligible portion of their time with emphasis on modifications and crash and combat damage work.

The pattern of overflow maintenance workloading includes sheetmetal, fabrication and airframe work (to a total of approximately 30 percent), dynamic components and power train to approximately 50 percent. This suggests that the backup DS unit takes on many of the functions that, in other organizations, are passed to General Support.

The following table illustrates the percentage distribution of work orders by functional categories performed on the aircraft:

Sheetmetal	5.0%
Rotor Hub and Blades	45.0%
Transmission	5.0%
Airframe	15.0%
Armament	10.0%
Fabrication	10.0%
Instruments	5.0%
Power Plant	5.0%

PARTS CONSUMPTION

Parts costs per flying hour are heavily determined, not only by the physical and combat environment, but also by the chronological age of the aircraft studied. Earlier APJ studies for AVCOM have provided empirical demonstrations of the fact that aircraft proceed through the first years of their life history essentially "in step" and hence, reach major inspection intervals, major part replacements and other cost significant events at approximately the same time. Therefore, parts costs per flying hour will fluctuate depending on whether or not the group of aircraft studied have such major events occurring within the observation interval.

Parts costs per flying hour are also determined by the extent to which components are removed for modifications, i.e., even older aircraft experience "pulses" of parts consumption as a consequence of retrofit programs, modification work orders, and the like. Finally, pricing policy, i.e., the decision to cost parts at acquisition or rebuild or overhaul affects stated costs in accordance with the formula used by the Department of Army.

The subject area of parts cost, therefore, requires a careful scrutiny of the data by skilled analysts and the willingness to conclude that certain information is not representative and hence cannot be properly reported on. Additionally, the nature of the Army's Equipment Record System is such that it is all too easy to "lose" (in the report) small expendable items, common hardware, and the like.

In this study, the nature of the data are such, at Organizational level, that it was not possible to state reliably the pattern of parts consumption and this is extrapolated using APJ Report 385-1, (Reference 5).

Approximately $14 million worth of parts consumption data on six aircraft were priced. This was accomplished through the interchange with AVCOM of an APJ tape containing consumption data by Federal Stock Number. (AVCOM matched the prime and substitute Federal Stock Numbers on the APJ tape with the AVCOM Master Records to obtain the pricing information used in this Report and this cooperation is gratefully acknowledged.)

Recoverability Code Analysis

Parts consumption, reported on DA Form 2407 "Maintenance Request" provide valuable indicators of logistical support requirements. For the purposes of this Report, parts used in aircraft maintenance were identified by aircraft type, model and series under two major categories - "Dollar Value" and "Number of Items". Each category was further subdivided by Recoverability Codes, indicating whether unserviceable items were repaired, returned to CONUS for rework or salvage, or were expendable. If expendable, maintenance may have been accomplished on such items to the extent maintenance instructions and parts were available to the maintenance level authorized to remove, repair and replace the item.

The following codes apply to Figure 10-23:

Code	Explanation
R	Applies to repair parts and assemblies which are economically reparable at DSU and GSU activities and normally are furnished by supply on an exchange basis.
T	Applies to high dollar value recoverable repair parts which are subject to special handling and are issued on an exchange basis. Such repair parts normally are repaired or overhauled at Depot maintenance activities.
U	Applies to repair parts specifically selected for salvage by reclamation units because of precious metal content, critical materials, high dollar value reusable casings or castings.
E	Applies to expendable parts.

TMS	Number of Items - %							
	1st Infantry Division				1st Cavalry Division			
	R	E	U	T	R	E	U	T
OH-13	9.1	79.0	7.2	4.7	8.3	74.8	4.4	12.5
UH-1B	7.8	87.2	0	5.0	15.6	61.7	1.3	21.4
UH-1C	*	*	*	*	7.9	87.1	1.5	3.5
UH-1D	5.0	88.5	0	6.5	13.4	68.4	.6	17.6
CH-47	*	*	*	*	6.2	26.9	0	66.9
OV-1C	15.9	76.1	0	8.0	**5.0	**89.2	0	**5.8

TMS	Dollar Value - %							
	1st Infantry Division				1st Cavalry Division			
	R	E	U	T	R	E	U	T
OH-13	27.4	15.4	.9	56.3	4.7	9.2	.4	86.0
UH-1B	10.1	3.4	0	86.5	9.0	2.7	.1	88.2
UH-1C	*	*	*	*	29.8	3.4	.4	66.7
UH-1D	2.9	2.4	0	94.7	6.0	3.6	0	90.4
CH-47	*	*	*	*	.2	2.7	0	97.1
OV-1C	5.8	13.5	0	80.7	**10.6	**10.5	0	**78.9

* Not Applicable
**OV-1B

Code: R-Reparable at DS/GS T - Reparable at Depot (Hi-Value)
U-Salvage E - Expendable

Figure 10-23. Aircraft Parts Expenditure By Percent Dollar Value and Percent Number of Items - Direct Support Level

The results of the analysis of approximately 3,500 maintenance actions in the 1st Infantry Division and over 13,000 maintenance actions in the 1st Cavalry are set forth as research results (Figure 10-23). Despite the sample size, there is considerable variability between the units for the same aircraft. The chief difference occurs in the case of the OH-13, in which both number and dollar value of "T" coded items are low in comparison with the other aircraft. Additionally, the UH-1C was in the process of introduction during the period studied and cannot be regarded as representative.

Finally, because of the extensive continuing modification during the period studied, the work performed on the CH-47 is reflected in the high dollar value and high proportion of "T" coded items.

The overall relationships and rationale of aircraft parts consumption is given in Figure 10-24. This Figure is a test of the frequently stated dictum that "85 percent of the dollar value is embodied in approximately 15 percent of the parts". This relationship (with the anomaly of the CH-47) is shown to be remarkably stable. Thus, if we take all of the results given, we note that in no case did the "T" coded items represent more than 20 percent of item removals; rather they averaged approximately 9 percent. The percentage of dollar value represented by the "T" coded items ranged from 58 percent to 97 percent and averaged approximately 83 percent. The graph shows that 1st Cavalry and 1st Infantry Division experience with regard to the consumption of "T" coded items interpenetrated, but with the 1st Cavalry Division representing a larger percentage of items than their counterpart in the 1st Infantry.

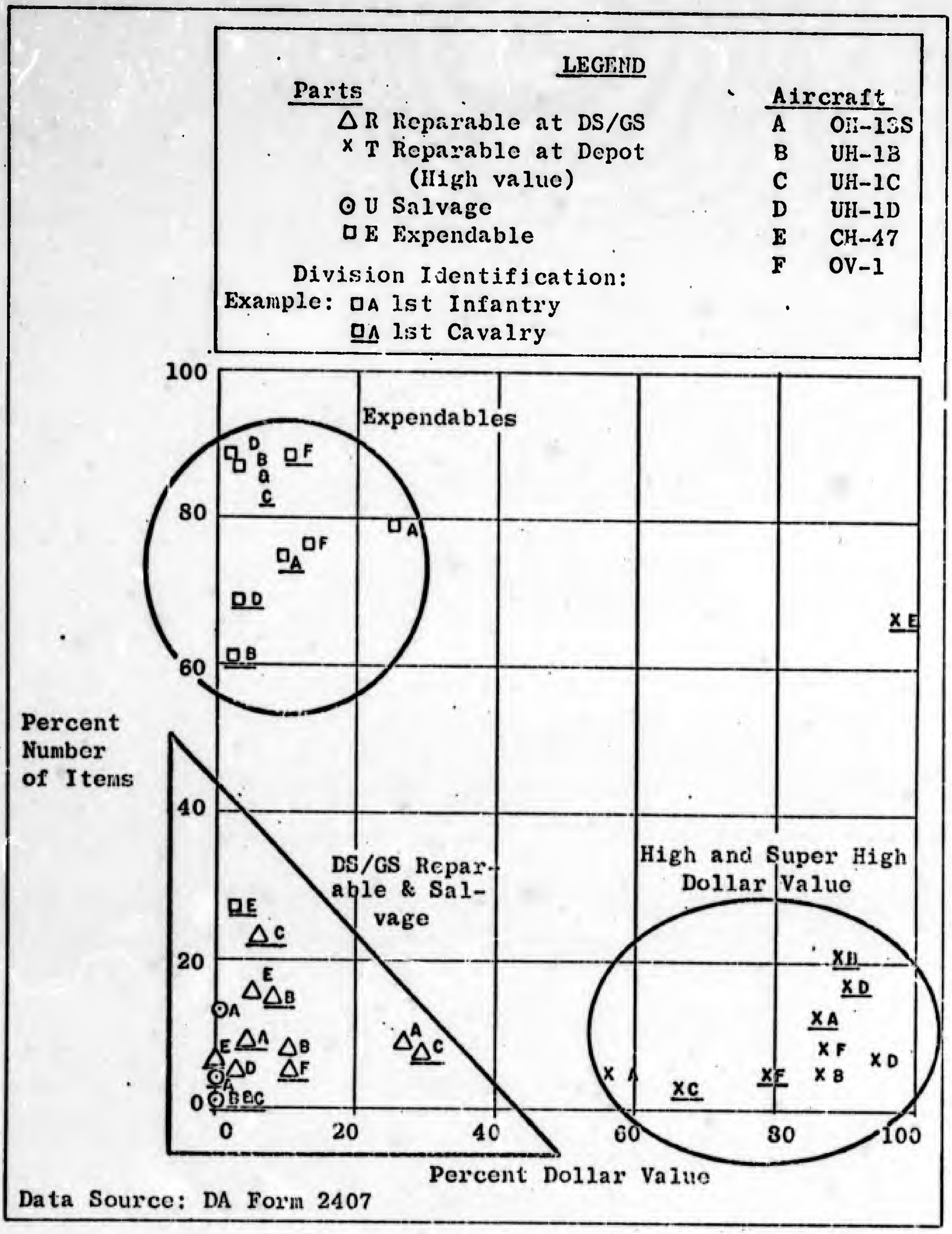


Figure 10-24. Aircraft Parts Consumption Percent Number of Items Versus Percent Dollar Value

The data also permit an analysis to be made of Expendables relationships. Here, we see that expendable consumption ranges between approximately 2 and 26 percent in dollar value and between approximately 60 and 90 percent in number of items. It can be seen that the inverse of the preceding dictum also appears to be true, i.e., expendables comprising about 8 percent of the dollar value constitute approximately 80 percent of the number of items.

Clustered in the lower quadrant, occupying a triangular area, and accounting for approximately 22 percent of the number of items and 30 percent of the cost, are the "R" and "U" items. There are very few "U" coded items and the centroid of the distribution of "R" coded "Reparable/DS/GS" is approximately 10 percent of the dollar value and 10 percent of the number of items. It should be borne in mind, of course, that the distribution in this case is highly variable (well exemplified by the points) and reflects command emphasis, work organization, skills, interests, and the particular problems encountered by the given maintenance organization under study. Each of these factors plays a part in increasing the variability. On mathematical grounds, it should also be noted that the exhaustion of the degrees of freedom in any three categories determines the value of the fourth category.

If we further consider the parts consumption pattern for the CH-47 during the period studied, in the light of the overall relationships disclosed, we find that the analyst is justified in regarding the data presented for the CH-47 as conditional, subject to further review with the accumulation of additional data.

Parts Costs Per Flying Hour

Parts costs per flying hour in this Report are calculated at "cost of issue". As discussed in the introductory remarks to this section, it is essential to consider the precise stage in the aircraft life history represented by the data, as well as the effects of environment and maintenance practice.

Inasmuch as the data were insufficient to perform an analysis of Organizational parts consumption, these data are estimated, based on the ratio established in APJ Report 385-1 (Reference 5) between Organizational and DS parts consumption (Figure 10-25). The empirical measurements at Direct Support level are also set forth in this Figure.

Aircraft	1st Infantry Division		1st Cavalry Division	
	Org.	D.S.	Org.	D.S.
OH-13	$ 2.39	$ 15.55	$ 4.85	$ 31.59
UH-1D	18.16	80.30	16.98	75.10
OV-1	23.84	196.88	12.81	105.80

Figure 10-25. Aircraft Maintenance Parts Cost per Flying Hour

In general, parts consumption in the 1st Infantry Division correspond closely to that reported in APJ 385-1, (Reference 5) while the figures for the 1st Cavalry are consistent only in the case of the UH-1D. The 1st Infantry's OH-13 part consumption closely matches APJ 385-1 while the parts consumption noted for the 1st Cavalry is approximately double. The situation is reversed for the OV-1, in which the 1st Cavalry consumption per flying hour is substantially lower than that for the 1st Infantry. (Here, the extremely small population must be taken into account as a source of variability. Additionally, during the period studied, crash and combat damage required the turn-in of all 1st Cavalry OV-1 aircraft, with the corresponding issue of new aircraft whose parts consumption during the period of time observed was naturally lower.)

It is concluded, from this phase of study, that the area of parts consumption per flying hour requires continued investigation related to the factors noted above.

MAINTENANCE MAN-HOURS PER FLYING HOUR

Maintenance man-hours per flying hour measure the intensity of effort devoted to keeping aircraft in flying condition. It is a function, of course, not only of the intensity of effort but of the level of flying hours, of maintenance organization, and of the management tradeoff involved in the "repair" vs. "replace" philosophy. Previous APJ studies have shown that maintenance man-hours per flying hour are of themselves dependent on the absolute number of flying hours attained. However, both the 1st Cavalry Division and the 1st Infantry Division are operating their aircraft at levels well beyond the nonlinear inflection point. Operating at flying hour levels of 50 to 100 flying hours per individual aircraft per month results in the substantial elimination of nonlinearities due to this factor. The remaining differences then relate to the age of the individual aircraft, the extent to which supply was substituted for maintenance, and the factors of organizational philosophy and operation.

The preceding discussion relating to parts consumption established that there was no major difference discernible in the statistics between the philosophy of "repair" vs "replace" in the respective missions. Organization, however, is shown to play a considerable role in Figure 10-26.

	ORG M/H per F/H		DS M/H per F/H		Total	
	Inf.	Cav.	Inf.	Cav.	Inf.**	Cav.
OH-13S	1.14	1.39	1.08	1.62	2.22	3.01
UH-1B	2.07	1.65	1.07	2.01	3.14	4.79
UH-1D	2.03	2.87	1.01	2.11	3.04	4.98
CH-47	N/A	11.47	N/A	6.25	N/A	17.72
OV-1	1.83	*1.54	2.14	*1.43	3.97	*2.97

*Data Source APJ 469-305 (Reference 6)
**Excludes backup DS performance by the 605th
N/A - Not Applicable

Figure 10-26. Man-Hours per Flying Hour
1st Infantry Division and
1st Cavalry Division

The data set forth in this Figure are based on about 11,500 maintenance events at Organizational level and approximately 4,000 events at Direct Support level for the 1st Infantry. Approximately 10,000 events are covered at Organizational and 13,000 events at Direct Support for the 1st Cavalry.

In general, the 1st Infantry man-hours per flying hour at Organizational level are closely equal to (and in one case slightly higher than) the 1st Cavalry, while at Direct Support level, the man-hours per flying hour are consistently lower. This difference is, at least in part, accounted for by the fact that substantial parts of backup maintenance (discussed above) were performed by the 605th DS in support of the E Company of the 701 DS. This must be contrasted with the relatively low utilization of the 701st GS by the 1st Cavalry during the period studied.

Thus, the total maintenance man-hours per flying hour for the 1st Infantry are artifically deflated by the absence of backup work performed by the 605th. Additionally, differences arise from the impact of the "maintenance back" practice within the Airmobile Division.

Thus, the aircraft not only "knows" where and how it is being operated but also "who" is operating it. These differences provide the raw material for the type of results aimed at in this study and are the goal of the simulation effort, i.e., to develop information which, when processed through a suitable model, provides a basis for organizational and operating policy decisions which attain the mission objective of aircraft readiness in the most effective manner.

[redacted]

LIST OF REFERENCES

LIST OF REFERENCES

Reference Number	APJ Report Number and Title	
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2	401-107	11th Air Assault Division Maintenance and Support Costs, September 1965
3	483-2	Comparative Analyses of Army Aviation Concepts, September 1967
4	433-102	Aircraft Readiness Control - A Study of the Application of Control Charts and Control Limits for Aircraft Readiness Management, April 1967
5	385-1	United States Army Aviation Systems - Operations Planning and Logistics Management, September 1965
6	469-305	Army Aviation in Vietnam - Progress and Status-V, March 1967