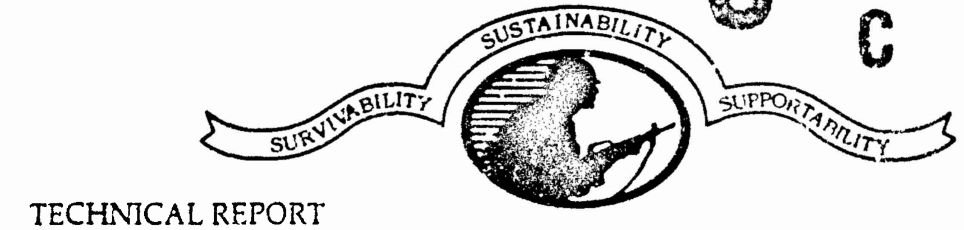

TECHNICAL REPORT
NATICK/TR-93/018

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PROJECTED PERFORMANCE CHARACTERISTICS FOR LARGE, QUICKLY ERECTABLE MAINTENANCE SHELTERS

By
Stephen A. Rei

January 1993

FINAL REPORT
OCTOBER 1990 to SEPTEMBER 1991

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AERO-MECHANICAL ENGINEERING DIRECTORATE

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In anticipation of the need for a large, quickly erectable maintenance shelter, a systems analysis effort investigating current and future battlefield maintenance doctrine, defining the physical dimensions of air and ground platforms requiring maintenance, and projecting requirements for such a shelter, if any, for these platforms has been initiated.
Program managers for major air and ground platforms were surveyed to determine the physical dimensions and performance characteristics required if such a shelter is to increase the battlefield readiness of these platforms, and to identify the most probable locations of such maintenance operations. In-house shelter and tentage developers were then surveyed to determine the technical feasibility and cost of achieving the identified shelter performance characteristics.

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PREFACE

The work described in this report was authorized under the Department of Defense Research, Development, Test and Engineering Program, Project 1L162786A427, Systems Analysis for Future Shelters Focus Areas. The work was performed from October 1990 to September 1991.

The author wishes to express his gratitude to the following individuals for their contributions to this effort: Mr. Robert T. Walsh, Chief, Plans & Systems Analysis Division (PSAD), Aero-Mechanical Engineering Directorate (AMED), and Mr. Thomas Godfrey, Engineering Technology Division, AMED, for their helpful suggestions and technical insight. The outstanding support of Mrs. Gretchen Lawniczak, PSAD, AMED, was also critical to the success of this effort.

PROJECTED PERFORMANCE CHARACTERISTICS FOR LARGE, QUICKLY ERECTABLE MAINTENANCE SHELTERS

INTRODUCTION

In fiscal year 1991, the Plans & Systems Analysis Division of the Aero-Mechanical Engineering Directorate at the U.S. Army Natick Research, Development and Engineering Center initiated an investigation to determine project future requirements for large, quickly erectable maintenance shelters. The purpose of this project was to determine the need, if any, for such shelters, and what performance characteristics are required by shelter end users.

Maintenance Doctrine

All military services divide maintenance responsibilities into three levels: organizational, intermediate, and depot. These maintenance groups usually correspond to a specific location on the battlefield. Organizational maintenance is typically performed within 10 kilometers of the Forward Line of Own Troops (FLOT). Intermediate maintenance is usually performed within the Brigade Support Area Forward (BSA-FWD), which extends approximately 10 - 30 kilometers from the FLOT. Depot level maintenance is typically accomplished in the Brigade Support Area Rear (BSA-REAR) area, which is a distance of 40 kilometers or more from the FLOT.

Organizational maintenance is performed by the crew manning the particular equipment platform. Typical crew tasks include making minor adjustments, cleaning, and lubricating equipment components in accordance with preventive maintenance schedules. Since these tasks require only a few minutes to complete, the need for shelter is minimal.

Intermediate maintenance tasks include minor repairs and replacement of minor components and assemblies. Since the BSA-FWD is usually less fluid than the FLOT, and intermediate maintenance tasks more complex, a shelter would facilitate accomplishment of maintenance tasks, especially where climatic conditions are inhospitable and during night operations. The BSA-FWD area is still highly mobile, so any shelter used must have minimal erect and strike time requirements.

Depot level maintenance can include everything from complete equipment refurbishing and component exchange to the retrofit of major system upgrades. Since the BSA-REAR area is less mobile, shelter erection and strike time is less critical. Because depot level maintenance tasks are more complex and multiple platforms will be serviced at any one time, a larger shelter will be required for this area

Maintenance Shelter End Users

Since the primary users of any large maintenance shelter will be Army aviation units, a closer look at what this force will look like in the future is necessary. The Army currently has a fleet of about 8600 helicopters. About three-quarters of these are "Vietnam-era" models consisting of AH-1s, UH-1s, OH-58A/Cs, and CH-47B/Cs. Over the next 20 years approximately 6000 of these older aircraft will be retired and replaced with 4000 advanced aircraft. The bulk of these new aircraft will be AH-64s and LHXs. Accordingly, Army aviation units are being reorganized into tighter, more efficient and effective elements.

In the Heavy Division, an Attack Battalion will contain 15 AH-64s and 10 LHXs; the rapid deployment Light Division will have 25 LHXs; Cavalry troops will have 8 LHXs; and Helicopter Assault companies will have 15 UH-60s. National Guard units will retire CH-54s and CH-47B/Cs for CH-47Ds. Helicopters for Special Operations will be MH-60K Blackhawks and MH-47E Chinooks. Other aircraft likely to be around in significant numbers include UH-1 Hueys, UH-60 Blackhawk derivatives, and OH-58D AHIP Scouts. Since the AH-64 Apache and the LHX will be the predominant Army aircraft through the next decade, a new large maintenance shelter must accommodate these aircraft in particular. The reduction in the types of Army helicopters fielded simplifies the task of designing a maintenance shelter suitable for such aircraft.

METHODOLOGY

The most cost effective method for collecting data on any given subject is the mail survey. To accomplish project goals, three surveys were developed and administered. A preliminary survey was sent to Army Materiel Command (AMC) and the Training and Doctrine Command (TRADOC) points of contact for all major ground and air systems to test question types, formats, and to determine baseline characteristics for new large maintenance shelters. Instead of using the mail for survey distribution, the preliminary survey was conducted via facsimile (fax) machine. Fax machines permit the nearly instantaneous distribution and collection of survey data.

A final survey was developed and distributed to two sample populations. One survey was sent via fax machine to TRADOC program managers for all major air and ground systems in an attempt to solicit a "user" perspective. A complete list of program respondents to the survey is included as Appendix A. A second survey was distributed to Natick engineers and technical personnel involved in shelter research and development efforts on a daily basis to gain a "developer's" perspective. The latter survey was distributed and responses returned via Natick internal mail.

RESULTS AND DISCUSSION

Maintenance Shelter Performance Characteristics

Shortly after initiating this effort, a "brainstorming" session was held within the Plans and Systems Analysis Division (PSAD) to identify desirable shelter performance characteristics. Session participants identified the following desirable shelter performance characteristics: Low Infrared (IR) Signature; Chemical/Biological (CB) Protection; Low Radio Frequency (RF) Signature; Ballistic Protection; Low Visible Signature; Flame Retardance; and Quick Erection/Strike. Session participants agreed that an important objective for any survey should be to identify the relative importance of each performance characteristic.

Quick Erection/Strike - Cumulative results of both surveys are as follows. Most respondents, approximately 61%, indicated that a quick erection/strike time for a maintenance shelter was from 1 - 4 hours. This figure compares with 22% of those responding who indicated that 4 - 8 hours would be a quick erection time, while approximately 12.2% indicated that they considered an erection/strike time of less than 8 hours to be quick. Less than 5% of those responding selected the less than 1 hour erection/strike time response. Actual results are given in Table 1.

Reinflation Interval - One problem that has hindered every inflatable, or air-beam supported shelter, is the requirement for reinflation. One particular concern is determining what is an acceptable reinflation interval. Approximately 50% of the respondents indicated that daily reinflation of an air-beam supported shelter was acceptable. This figure compares with 25% of those responding indicating that weekly reinflation was acceptable, while 22.5% indicated that an interval other than those listed among the responses would be acceptable. Only one respondent, representing 2.5% of those responding, indicated that no reinflation interval was acceptable. Actual results are given in Table 2.

Performance Characteristic Importance, Cost & Weight - Just how important is any given maintenance shelter performance characteristic ? Does the additional cost or weight penalty incurred to achieve a given performance characteristic affect its importance ? This information was solicited from both the program manager and shelter developer survey populations in a series of three questions.

Table 1
Quick Shelter Erection Responses

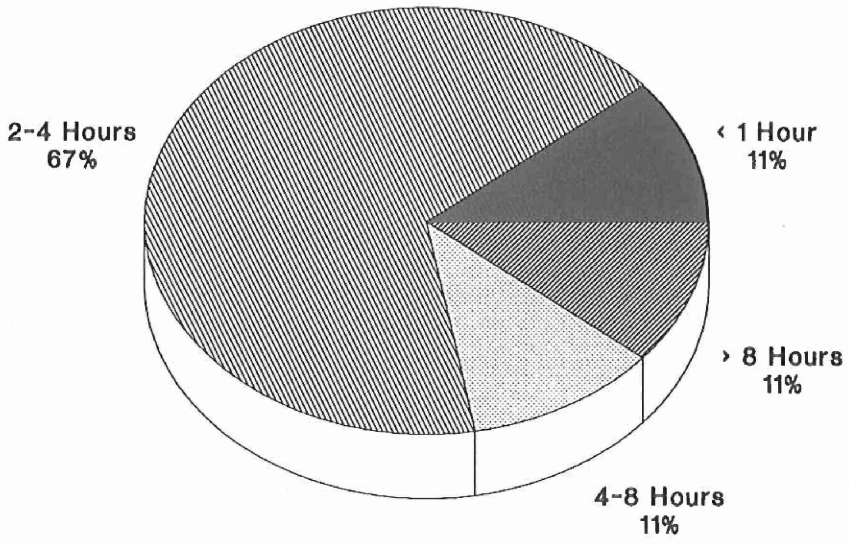
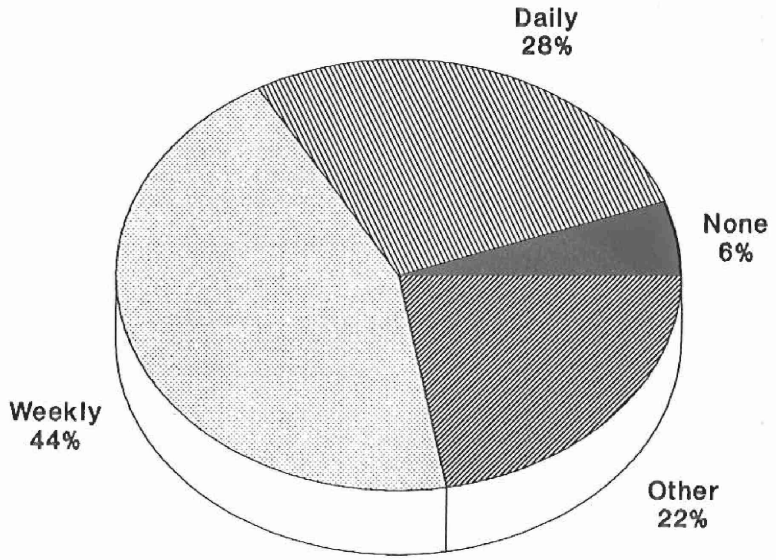


Table 2
Acceptable Reinflation Intervals



First, respondents were asked to rate the importance of each performance characteristic. Next, respondents were asked how much of a cost premium was justified to add a maintenance shelter performance characteristic. Finally, respondents were asked how much of a weight premium could be justified to add a given performance characteristic.

Low IR Signature - A majority of those responding, nearly 48%, indicated that a low IR signature for maintenance shelter was a somewhat important performance characteristic. This response compares with 32% of those responding who indicated that a low IR signature was a very important performance characteristic. Only 20% of those responding indicated that a low IR signature was not an important performance characteristic for a maintenance shelter.

When survey respondents were asked to consider the cost of adding low IR signature as a performance characteristic of a maintenance shelter, the results were slightly different. Approximately 56% of those responding indicated that adding low IR signature to a maintenance shelter would justify a cost increase of 5% or less. This figure compares with 33% of those responding who believed a cost premium of 5-10% was justified to lower maintenance shelter IR signature, while only 11% thought a cost premium of more than 10% was justified.

The survey results were markedly different when increased weight was cited as a condition to adding low IR signature as a performance characteristic. Approximately 81% of those responding indicated that a weight premium of less than 5% was acceptable to lower maintenance shelter IR signature. This figure compares with 16% of those responding who indicated that a weight premium of 5-10% was acceptable for a lower IR signature, while slightly less than 3% of those responding believed that a weight premium of over 10% would be justified.

The cumulative results described above differed slightly from the individual survey populations. Most program managers, nearly 67%, indicated a willingness to incur a cost premium of 5% or less. The shelter developers were split on the cost premium of adding low IR signature as a shelter performance characteristic. A cost premium of less than 5% was supported by 44% of the shelter developers, while another 44% indicated that a cost premium of 5-10% could be justified.

Responses from the individual survey populations were substantially similar when the weight premium incurred by adding low IR signature as a performance characteristic was

considered. Approximately 84% of the shelter developers and 78% of the program managers indicated that a weight premium of less than 5% could be justified. Approximately 16% of the remaining respondents in each group indicated that a weight premium of 5-10% could be justified.

A majority of shelter developers, 55%, and program managers, 39%, rated the shelter performance characteristic of low IR signature as somewhat important. Slightly more than 36% of the shelter developers rated low IR signature as very important, as compared to only 28% of the program managers. Approximately 33% of the program managers rated low IR signature as not important, while only 9% of the shelter developers agreed with this rating. Actual results are given in Table 3.

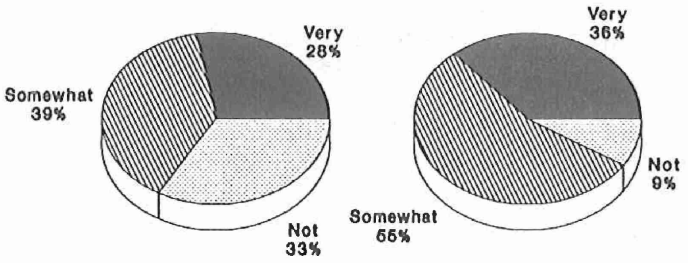
CB Protection - A majority of survey respondents, approximately 52.5%, indicated that CB protection was a "somewhat important" performance characteristic for maintenance tents or shelters. Nearly 38% of those responding to the survey indicated that CB protection was a "very important" performance characteristic. These figures compare with only 10% of all survey respondents who indicated that CB Protection was "not important." The combined positive response of 90% indicates that all three survey populations believe that CB protection is an important performance characteristic for maintenance tents and shelters.

The positive response discussed in the preceding paragraph was confirmed when respondents were asked to consider the cost of adding CB protection to maintenance shelters. Approximately 61% of those responding indicated that a cost premium of 10% or more would be justified to add CB protection to maintenance shelters. Just over 22% of all survey respondents indicated that CB protection would justify a cost premium ranging from 5-10%, while approximately 17% indicated a cost premium of less than 5% would be justified.

While respondents indicated that a cost premium to add CB protection to maintenance shelters could be justified, respondents were less willing to incur a weight premium. Approximately 38% of those responding indicated that a weight premium of 5-10% was justified for CB protection, while 35% indicated that a weight premium of less than 5% was justified. Approximately 27% of those responding indicated that a weight premium of more than 10% would be justified.

Results for the individual survey groups were slightly different from the cumulative results discussed above. While a majority of the shelter developers rated CB protection as somewhat important, the program managers were split on this

Table 3 - Low IR Signature Importance



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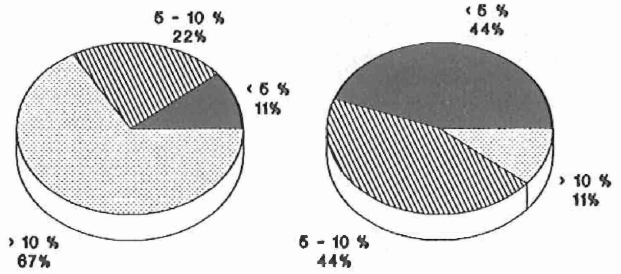
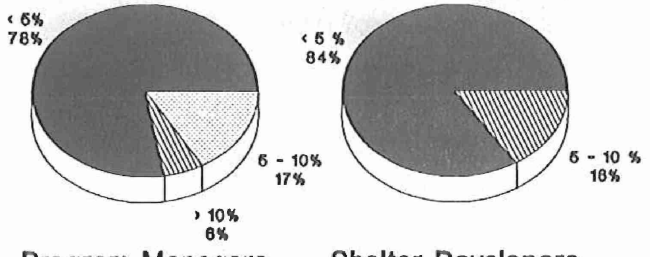
Low IR Signature - Cost Premium



Program Managers Shelter Developers

Low IR Signature - Weight Premium



Program Managers Shelter Developers

issue. Slightly over 44% of the program managers indicated that CB protection was very important, and an equal percentage rated CB protection as slightly important. Approximately 10% of each group rated CB protection as not important.

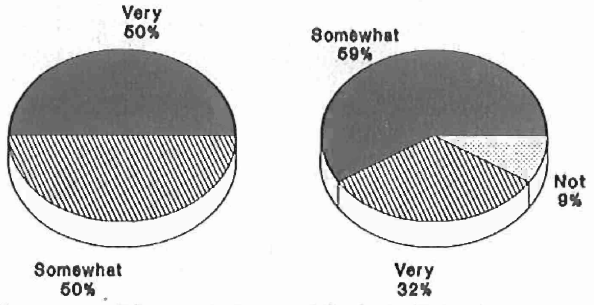
When respondents were asked to consider the cost premium of adding CB protection, results for the two survey groups were markedly different. Slightly over 8?` of the shelter developers thought CB protection could ju.:cify a cost premium of more than 10%, while the remaining 17% thouc'\t a 5-10% cost premium could be justified. Many program managers, nearly 39%, thought CB protection could justify a cost premium of more than 10%. This figure compares with slightly more than 33% of the program managers who thought a cost premium of less than 5% could be justified, while nearly 28% of the program managers indicated that CB protection would justify a cost premium of from 5-10%.

The two survey groups likewise differed on how much of a weight premium could be justified to add CB protection to a maintenance shelter. Nearly 78% of the program managers indicated that CB protection would justify a weight premium of less than 5%. Only 21% of the shelter developers thought CB protection could justify a weight premium of less than 5%. Nearly 17% of the program managers thought CB protection could justify a weight premium of 5-10%, while approximately 32% of the shelter developers responded in a similar fashion. Only 5% of the program managers indicated that CB protection would justify a weight premium of more than 10%. This figure compares with approximately 47% of the shelter developers who indicated that CB protection for a maintenance shelter would justify a weight premium of more than 10%. Actual results are given in Table 4.

Low RF Signature - A slight majority of those responding to the survey, 40%, indicated that low RF signature was not an important performance characteristic for maintenance shelters. This figure compares with approximately 37.5% of those responding who indicated that a low RF signature was somewhat important. Only 22.5% of those responding thought that a low RF signature was a very important performance characteristic.

Survey results for the low RF signature performance characteristic did not change significantly when respondents were asked to consider its cost. Nearly 65% of those responding indicated that a cost premium of only 5% or less was justified to achieve a low RF signature. Approximately 20% indicated that a cost premium of 5-10% was justified, while nearly 15% thought a cost premium of more than 10% was justified to lower maintenance shelter RF signature.

Table 4 - CB Protection Importance



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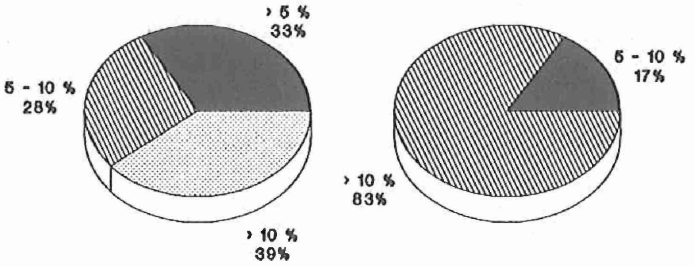
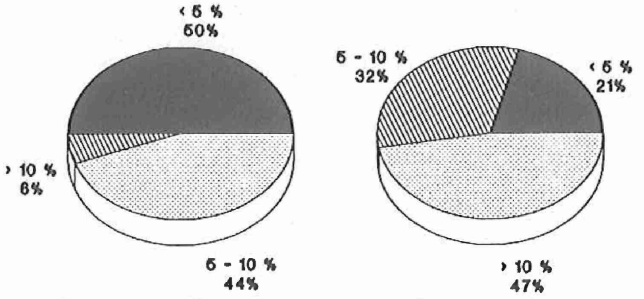
CB Protection - Cost Premium



Program Managers Shelter Developers

CB Protection - Weight Premium



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When survey respondents were asked to consider the weight premium incurred to achieve a low RF signature, results were stongly negative. Survey results indicate that approximately 76% of those responding believed a weight premium of less than 5% was justified to achieve a low RF signature. Just over 16% of those responding indicated that a weight premium of 5-10% was justified, while only 8% thought a low RF signature would justify a weight premium of 10% or more.

A majority of the shelter developers, nearly 41%, rated low RF signature for a maintenance shelter as not important, while only 39% of the program managers gave this performance characteristic a similar rating. Most program managers, 50%, rated low RF signature as somewhat important, while only 27% of the shelter developers gave the same response. Nearly 32% of the shelter developers rated low RF signature as a very important shelter performance characteristic, while only 11% of the program managers selected the very important response.

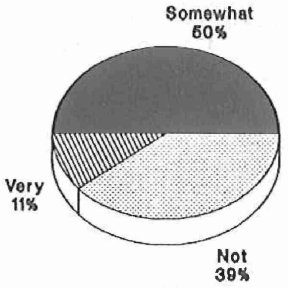
A majority of both program managers and shelter developers, 83% and 44%, respectively, indicated that a low RF signature would justify a cost premium of only 5% or less. Only 25% of the shelter developers, and 16% of the program managers thought a low RF signature would justify a cost premium of 5-10%. Not one program manager thought a low RF signature for maintenance shelters would justify a cost premium of more than 10%, while slightly more than 31% of the shelter developers indicated that a cost premium of more than 10% could be justified.

Both survey groups agreed that low a RF signature could justify a weight premium of less than 5%, as 63% of the shelter developers and 89% of the program managers selected this response. Only 11% of the program managers and 16% of the shelter developers indicated that a low RF signature for a maintenance shelter would justify a weight premium of more than 10%. Slightly more than 21% of the shelter developers thought a low RF signature could justify a weight premium of from 5-10%. Actual results are given in Table 5.

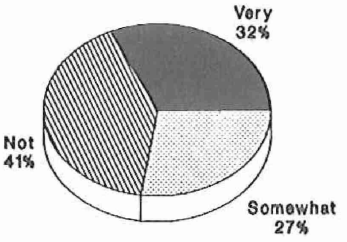
Ballistic Protection - Survey responses addressing ballistic protection of maintenance shelters were quite surprising. A clear majority of respondents, 50%, indicated that ballistic figure compares with 37.5% of those responding who indicated that ballistic protection was somewhat important. Only 12.5% of those responding thought maintenance shelter ballistic protection was very important.

When respondents were asked to consider the cost of adding ballistic protection to maintenance shelters, the

Table 5 - Low RF Signature Importance



Program Managers



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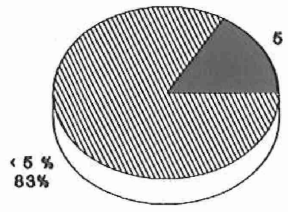
Low RF Signature - Cost Premium



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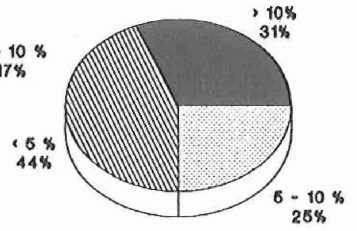

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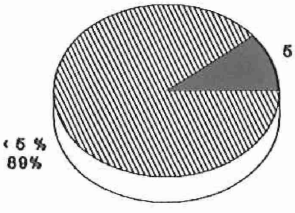
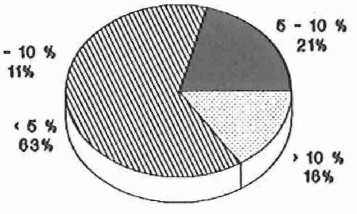
Low RF Signature - Weight Premium



Program Managers



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responses did not correspond to the importance ratings given above. Nearly 48% of those responding indicated that ballistic protection as a performance characteristic for maintenance shelters would justify a cost premium of more than 10%. This figure compares with slightly over 37% of those responding who indicated that a cost premium of less than 5% could be justified. Approximately 17% of those responding indicated that a cost premium of 5-10% would be justified to add ballistic protection to maintenance shelters.

Like the responses given when cost was a consideration, responses given when weight was considered did not correspond to the ballistic protection importance ratings. Nearly 49% of those responding indicated that a weight premium of more than 10% would be justified to add ballistic protection to maintenance shelters. Approximately 35% of all respondents thought a weight premium of less than 5% would be justified. Only 16% of those responding indicated that a weight premium of 5-10% would be justified for adding ballistic protection to maintenance shelters.

The two survey groups differed only slightly in their responses as to the importance of ballistic protection. The majority, 50%, of both the program managers and the shelter developers, indicated that ballistic protection was not an important characteristic for a maintenance shelter. Nearly 45% and 32% of the program managers and shelter developers, respectively, rated ballistic protection as somewhat important. Slightly more than 18% of the shelter developers, however, thought ballistic protection was a very important maintenance shelter performance characteristic. This figure compares with only slightly more than 5% of the program managers who indicated that ballistic protection was a very important maintenance shelter performance characteristic.

When respondents were asked to consider the cost premium of adding ballistic protection to a maintenance shelter, results from the two survey groups differed dramatically. Slightly more than 88% of the shelter developers thought a cost premium of more than 10% could be justified to add ballistic protection to a maintenance shelter. An equally strong majority of the program managers, 72%, however, indicated that a cost premium of less than 5% could be justified to add ballistic protection. Approximately 12% of the shelter developers, and 22% of the program managers indicated that a cost premium of 5-10% could be justified to add ballistic protection to a maintenance shelter. Only one of the program managers indicated that a cost premium of more than 10% could be justified to add ballistic protection to a maintenance shelter.

The two survey groups also differed sharply when asked how much of a weight premium could be justified to add ballistic protection to maintenance shelters. Approximately 84% of the of the shelter developers indicated that a weight premium of more than 10% could be justified to add ballistic protection to maintenance shelters. Conversely, slightly more than 72% of the program managers indicated that a weight premium of less than 5% could be justified for ballistic protection. Nearly 17% of the program managers and 16% of the shelter developers indicated that a weight premium of 5-10% could be justified to add ballistic protection to a maintenance shelter. Only 2 program managers, representing approximately 11% of the sample indicated that a weight premium of more than 10% could be justified to add ballistic protection to maintenance shelters. Actual results are given in Table 6.

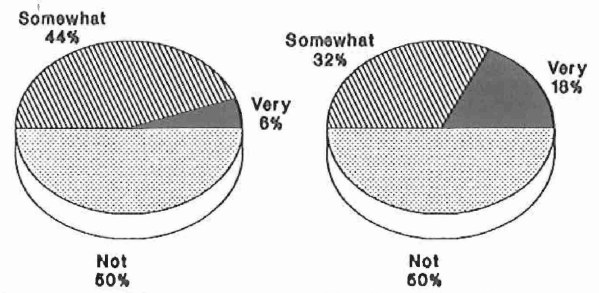
Low Visible Signature - Low visible signature was rated positively by a majority of those responding to the surveys. Approximately 52.5% of those responding indicated that a low visible signature was a very important maintenance shelter performance characteristic. Low visible signature was rated somewhat important by 35% of those responding to the surveys. Only 125% of those responding rated low visible signature as a not important maintenance shelter performance characteristic.

Slightly more than 54% of those responding indicated that a cost premium of 5-10% could be justified for maintenance shelter with a low visible signature. This figure compares with approximately 37% of respondents who thought that a cost premium of less than 5% could be justified for a low visible signature maintenance shelter. Approximately 9% of those responding thought a cost premium of more than 10% could be justified for adding low visible signature as a maintenance shelter performance characteristic.

Approximately 58% of those responding to the surveys indicated that adding a low visible signature to maintenance shelters could justify a weight premium of less than 5%. This figure compares with nearly 39% who thought a weight premium of 5-10% could be justified. Slightly less than 3% of those responding to the surveys indicated that adding low visible signature as a maintenance shelter performance could justify a weight premium of more than 10%.

The two individual survey groups gave similar responses when asked to rate the importance of low visible signature to a maintenance shelter. Nearly 55% of the shelter developers and 50% of the program managers rated low visible signature

Table 6 - Ballistic Protection Importance



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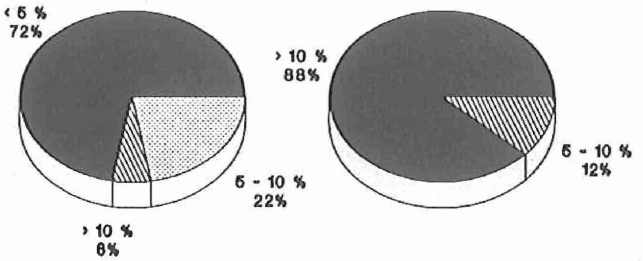
Ballistic Protection - Cost Premium



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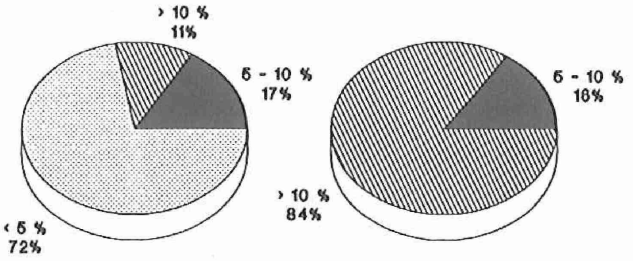
Ballistic Protection - Weight Premium



Program Managers Shelter Developers

as very important. Approximately 44% of the program managers and 27% of the shelter developers rated low visible signature as a somewhat important maintenance shelter performance characteristic. While more than 18% of the shelter developers rated low visible signature as not important, only one program manager did likewise.

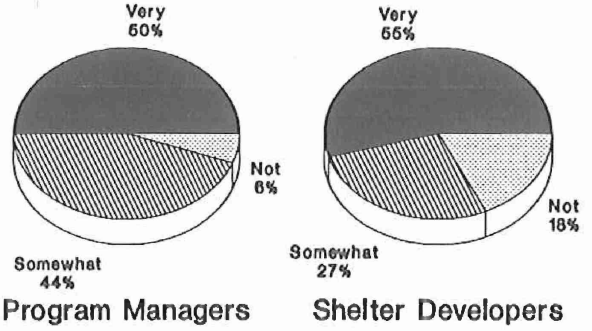
Results differed only slightly between the two survey groups when respondents were asked how much of a cost premium could be justified to produce a maintenance shelter with a low visible signature. Approximately 47% of the shelter developers and 28% of the program managers indicated that a low visible signature could justify a cost premium of less than 5% only. Slightly more than 61% of the program managers indicated that low visible signature could justify a cost premium of from 5-10%, while 47% of the shelter developers gave a similar response. Only one program manager indicated that low visible signature could justify a cost premium of more than 10%, while two shelter developers did likewise.

When respondents were asked to consider the weight premium associated with a low visible signature results between the two survey groups were mixed. Approximately 72% of the shelter developers could justify a weight premium of less than 5% only, while slightly more than 44% of the program managers selected the same response. While 50% of the program managers indicated that a maintenance shelter with a low visible signature justified a weight premium of from 5-10%, only 28% of the shelter developers agreed. One program manager indicated that a low visible signature could justify a weight premium of more than 10%. Actual results are given in Table 7.

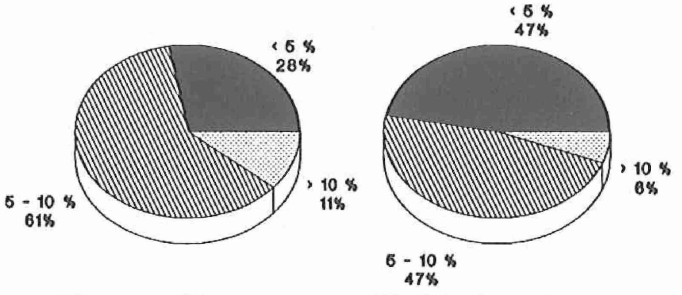
Flame Retardance - The importance of flame retardance as a maintenance shelter performance characteristic was nearly unanimous. Flame retardance was rated as a very important maintenance shelter performance characteristic by 95% of those responding to the survey. The remaining 5% of those responding indicated that flame retardance was somewhat important.

There was some disagreement among respondents as to how much of a cost premium could be justified for adding the performance characteristic of flame retardance to maintenance shelters. Nearly 39% of those responding indicated that a cost premium of less than 5% was justified for adding flame retardance capabilities. Sightly more than 33% indicated that a cost premium of more than 10% could be justified to add flame retardance as a maintenance shelter performance characteristic. Approximately 28% of those responding thought that a cost premium of 5-10% could be justified.

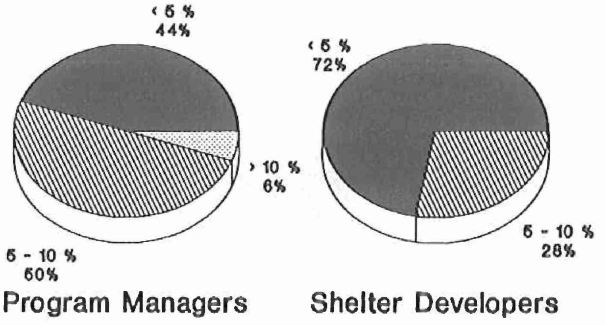
Table 7 - Low Visible Signature Importance



Low Visible Signature - Cost Premium



Low Visible Signature - Weight Premium



When survey respondents were asked to consider the weight premium incurred by adding flame retardance, results were mixed. Approximately 56% thought a weight premium of less than 5% could be justified for flame retardance capabilities. This figure compares with nearly 22% who indicated that a weight premium of 5-10% could be justified, while the nearly 22% of those responding indicated that a weight premium of more than 10% could be justified for flame retardance.

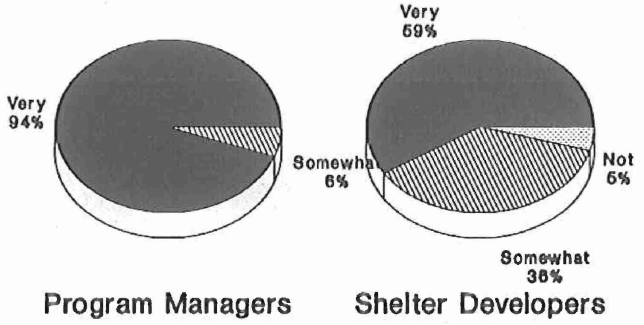
An overwhelming majority of both the shelter developers, nearly 96%, and program managers, nearly 95%, indicated that flame resistance was a very important maintenance shelter performance characteristic. Only one program manager and one shelter developer rated maintenance shelter flame resistance as somewhat important. Flame resistance was not given any not important ratings.

Responses were dramatically different between the two survey groups when respondents were asked to consider the cost premium of adding flame resistance. Approximately 67% of the program managers indicated that maintenance shelter flame resistance could justify a cost premium of more than 10%. Conversely, approximately 67% of the shelter developers indicated that flame resistance could justify a cost premium of only less than 5%. Slightly more than 33% of the shelter developers and 22% of the program managers indicated that maintenance shelter flame resistance could justify a cost premium of 5-10%. Two program managers indicated that flame resistance could justify a cost premium of only less than 5%.

The two survey groups differed moderately when the weight premium associated with flame resistance was considered. An overwhelming majority of the shelter developers, nearly 90%, indicated that maintenance shelter flame resistance could justify a weight premium of only less than 5%. Conversely, most program managers, slightly more than 44%, indicated that a weight premium of more than 10% could be justified for maintenance shelter flame resistance. Approximately 33% of the program managers indicated that flame resistance could justify a weight premium of 5-10%, while the remaining 22% of the program managers thought only a 5% weight premium could be justified. Two shelter developers indicated that a weight premium of 5-10% could be justified for flame resistance. Actual results are given in Table 8.

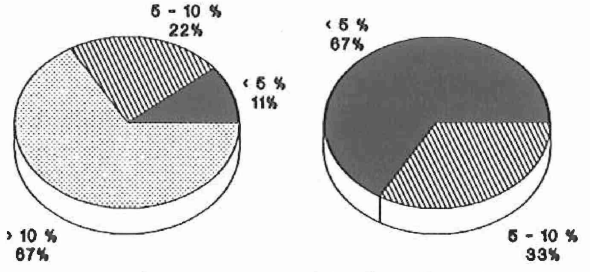
Quick Erection/Strike - There was considerable agreement among survey respondents as to the importance of quick erection as a performance characteristic. Fully 75% of all respondents rated quick erection was very important for maintenance shelters. Nearly 23% of those responding to the

Table 8 - Flame Protection Importance



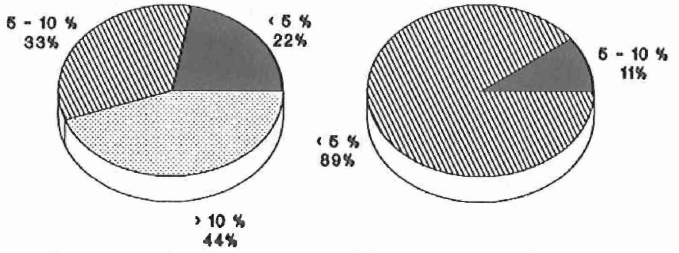
Program Managers Shelter Developers

Flame Protection - Cost Premium



Program Managers Shelter Developers

Flame Protection - Weight Premium



Program Managers Shelter Developers

surveys indicated that quick erection was somewhat important. Only slightly over 2% thought quick erection was not an important maintenance shelter performance characteristic.

When the cost of adding quick erection capabilities to maintenance shelters was addressed, responses corresponded closely to the importance ratings described above. Nearly 56% of those responding indicated that a cost premium of more than 10% could be justified for quick erection capabilities. Approximately 28% of all respondents though a cost premium of 5-10% would be justified for making a maintenance shelter quickly erectable. Slightly over 16% thought that a quickly erectable maintenance shelter could justify a cost premium of less than 5%.

Survey respondents were less receptive to adding weight to a maintenance shelter to gain quick erection capabilities. Most respondents, nearly 46%, indicated that quick erection capabilities would justify a weight premium of less than 5%. This figure compares with nearly 30% of those responding who thought a weight premium of more than 10% could be justified for quick erection capabilities. Slightly more than 24% of those responding indicated that adding a quick erection capability to maintenance shelters would justify a weight premium of 5-10%.

There was some agreement between the two survey groups on the importance of quick erection/strike capabilities. Nearly 95% of the program managers rated quick erection/strike as very important, while 59% of the shelter developers did likewise. Slightly more than 36% of the shelter developers rated quick erection/strike as somewhat important, while one program manager did the same. One shelter developer rated quick erection/strike capability as not important.

Responses from the two survey groups were similar on the cost premium of adding quick erection/strike capabilities to maintenance shelters. Nearly 67% of the program managers, and 44% of the shelter developers indicated that quick erection/strike capabilities could justify a cost premium of more than 10%. Slightly more than 33% of the shelter developers and 22% of the program managers could justify a cost premium of 5-10% for quick erection/strike capabilities. Only 11% of the program managers and 22% of the shelter developers indicated that only a less than 5% cost premium was justified for quick erection/strike capabilities.

The two survey groups differed considerably on the weight premium justified to add quick erection/strike capabilities to maintenance shelters. Approximately 63% of the shelter

developers indicated that quick erection/strike capabilities could justify a weight premium of only less than 5%, with nearly 28% of the program managers responding in a similar fashion. Nearly 28% of the program managers, and 21% of the shelter developers indicated that quick erection/strike capabilities could justify a weight premium of 5-10%. Most program managers, slightly over 44%, thought a weight premium of more than 10% could be justified, while only 16% of the shelter developers agreed. Actual results are given in Table 9.

Program Manager's Survey

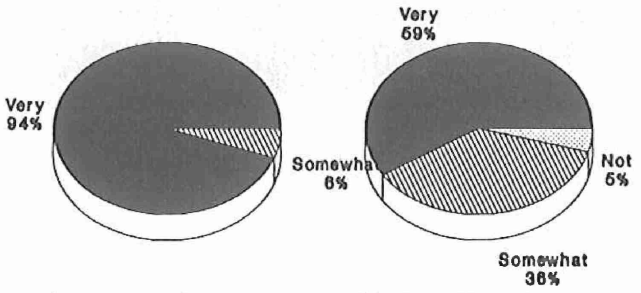
In addition to the questions relating to maintenance shelter performance characteristics, the program manager's survey also contained several unique questions. These questions asked the program managers to comment on how maintenance shelters interface with their program item. Specifically, program managers surveyed were asked if maintenance shelters aid in accomplishing maintenance procedures; whether a maintenance shelter for their item is available; if the organization responsible for maintenance on their program item is available while deployed; and how far foward a maintenance shelter would be deployed to maintain their item.

Accomplishment of Maintenance Procedures - The program managers surveyed were asked whether maintenance procedures on their program item could be more readily accomplished in a large maintenance shelter. Approximately 72% of those surveyed responded affirmatively, while 17% responded in the negative, and only 11% selected the "don't know" response. Actual results are given in Table 10.

Maintenance Shelter Availability - The program managers surveyed were also asked whether a maintenance shelter with adequate dimensions to fully enclose their program item was available. Approximately 44% of those responding indicated that such a maintenance shelter was available. Approximately 33% of those responding indicated a lack of knowledge as to whether such a maintenance shelter was available. Nearly 22% indicated that such a shelter was not available. Actual results are given in Table 11.

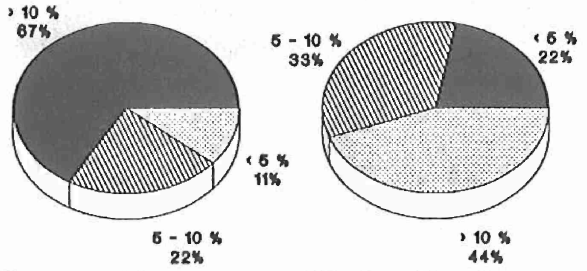
Access to a Maintenance Shelter While Deployed - Slightly over 42% of the program managers surveyed indicated that the organization responsible for maintenance on their program

Table 9
Quick Shelter Erection - Importance



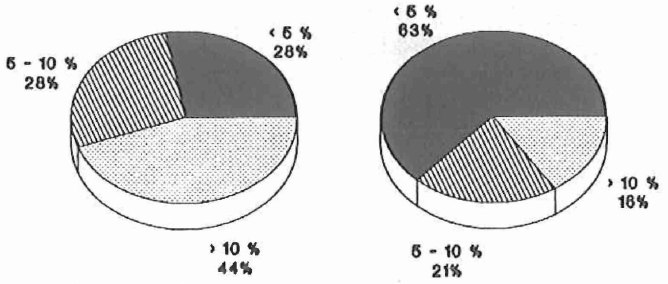
Program Managers Shelter Developers

Quick Shelter Erection - Cost Premium



Program Managers Shelter Developers

Quick Shelter Erection - Weight Premium



Program Managers Shelter Developers

Table 10 - Mission Accomplishment

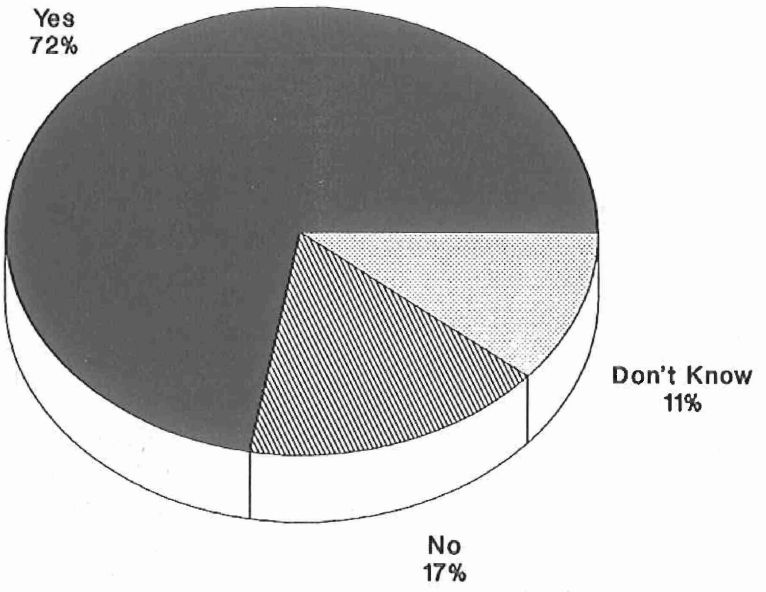
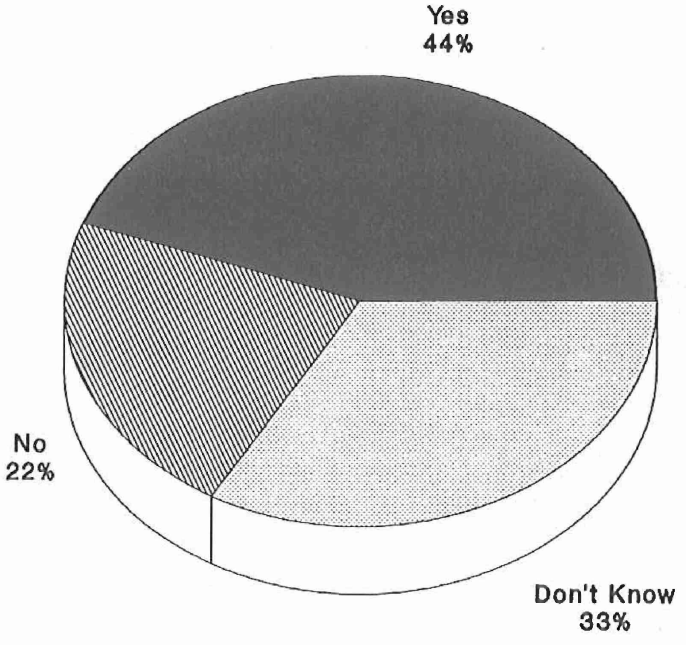


Table 11 - Shelter Availability



item has access to a maintenance shelter while deployed. This figure compares with nearly 37% of the program managers responding who indicated a lack of such access while deployed. Approximately 21% of the program manager group indicated that they did not know if a maintenance shelter could be accessed while deployed. Actual results are given in Table 12.

Forward Deployment of a Maintenance Shelter - Approximately 59% of the program managers surveyed indicated that a large maintenance shelter would be deployed as far forward as the Brigade Support Area Forward. Slightly over 35% of these same PM's indicated that such a shelter would be deployed only as far as the Brigade Support Area Rear. Only one PM, representing 6% of the sample population, indicated deployment in an area other than those previously mentioned. Actual results are given in Table 13.

Developer's Survey

The survey administered to Natick shelter development personnel contained several unique questions in addition to the peformance characteristic questions. In the introductory paragraph, the shelter developers were given the following characteristics of a hypothetical large maintenance shelter. First, the shelter would have dimensions of 80 feet by 60 feet by 30 feet (L x W x H). Second, the shelter would have a maximum weight of 3000 pounds. Third, the shelter would have an erection/strike time of four (4) hours or less. Finally, the shelter would require a maximum of four personnel to erect/strike. These hypothetical characteristics were developed using data from a preliminary AMC/TRADOC program manager survey.

The Natick shelter development group was first asked which of the four hypothetical characteristics would be the most difficult to achieve. A clear majority of Natick shelter developers, nearly 43%, indicated that the target weight of 3000 pounds would be the most difficult characteristic to achieve. Approximately 33% of those responding thought the four personnel limitation to erect or strike such a shelter would be the most difficult to achieve. The four hour erection/strike time was cited as the most difficult to achieve by 19% of those responding. Finally, one respondent, representing 5% of the survey population, thought that producing a shelter with the given dimensions would be the most difficult to achieve. Actual results are given in Table 14.

Table 12 - Shelter Access

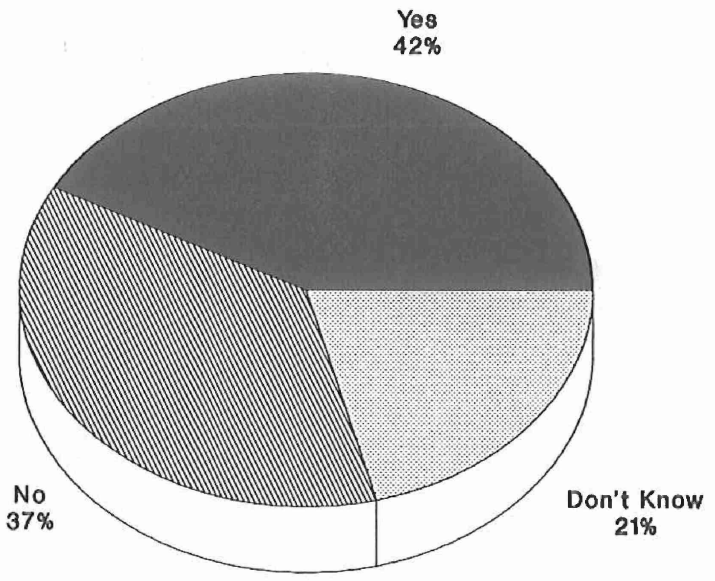


Table 13 - Forward Position of Shelters

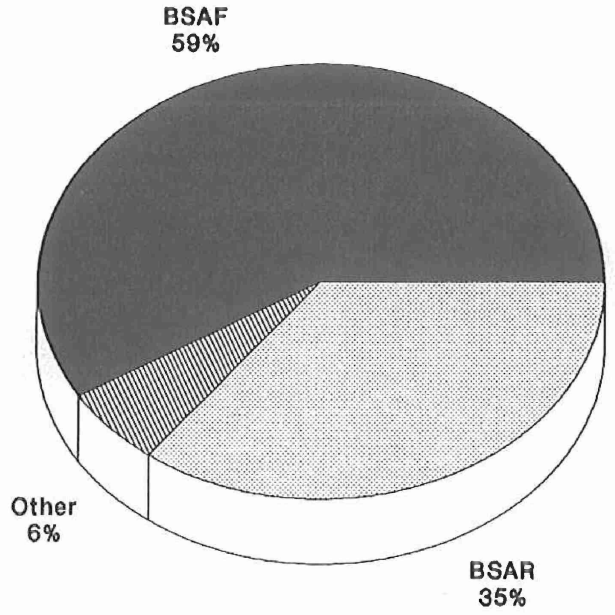


Table 14 - Performance Characteristics Difficulty

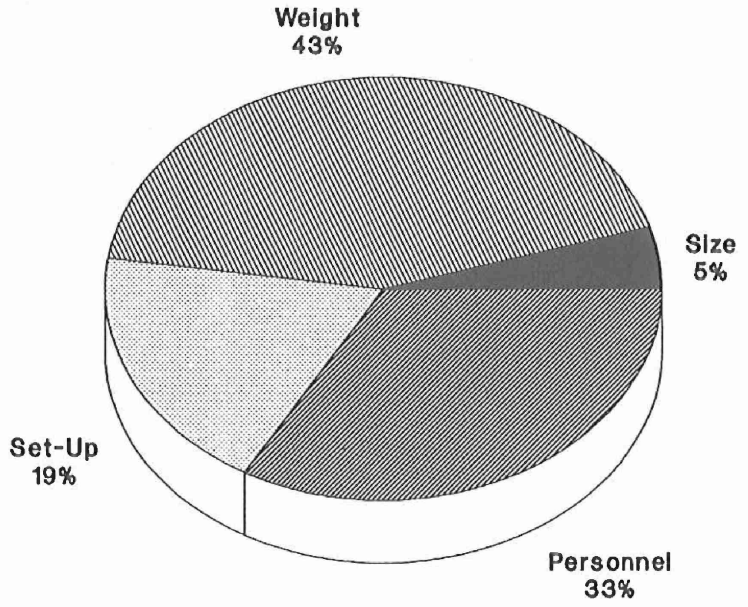
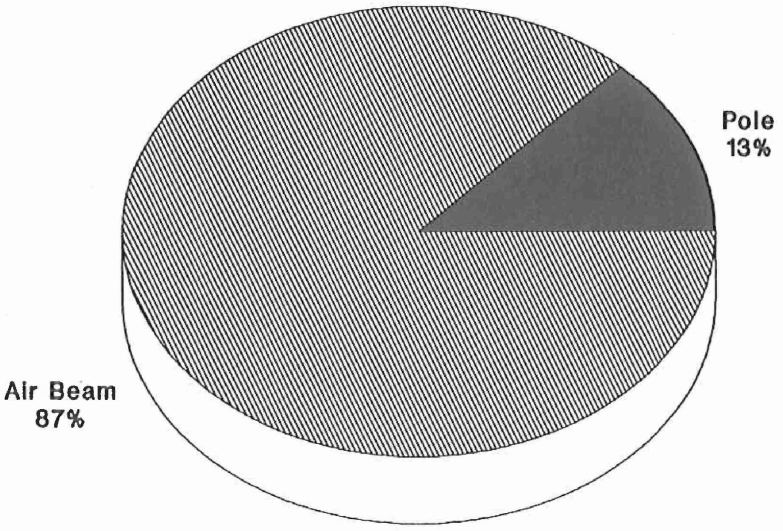


Table 15 - Best Shelter Support System



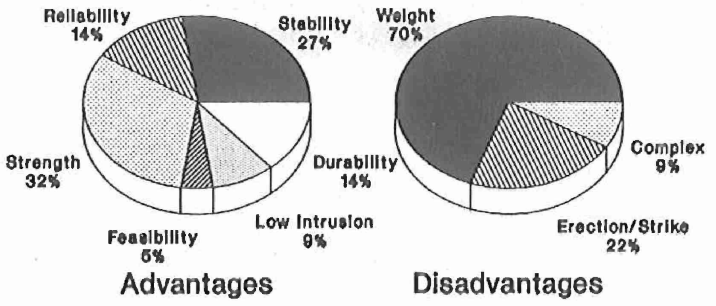
Next, Natick shelter developers were asked which type of shelter support system would be best for the hypothetical shelter. The support systems available for selection were frame support; pole support; and air-beam support. An overwhelming majority of shelter developers, 87%, indicated that an air-beam support system would be best for the hypothetical shelter. The only other response received, frame support, was selected by 13% of those responding. Pole support was not selected as being suitable for the hypothetical shelter. Actual results are given in Table 15.

Natick shelter developers were next asked to list the primary advantage of utilizing air beams, frames, and poles as shelter support systems. The primary advantages of a frame support system according to survey respondents in descending order are: strength (31%); stability (26%); durability/reliability (13% / 13%); low intrusiveness (9%); and feasible technology (4%). Natick shelter developers listed lightweight (26%); quick erection (22%); cost (13%); simplicity (13%); no advantage (13%); availability (4%); and replacement (4%) as the primary advantages of using poles as a shelter support system. The primary advantages of using air beams for shelter support given by the shelter developer group were quick erection, selected by nearly 57%, and light weight, which was cited by 43% of those responding.

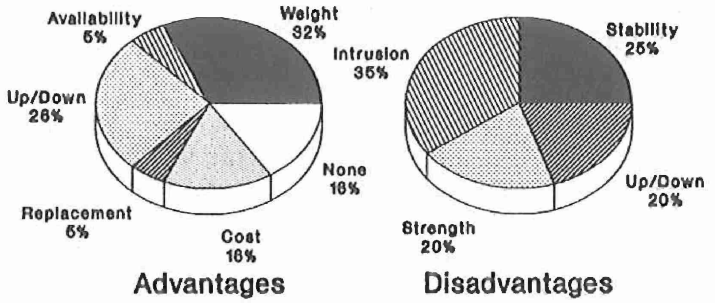
Finally, Natick shelter developers were asked to list the primary disadvantages of utilizing air beams, frames, and poles as shelter support systems. Most shelter developers, 70%, cited weight as the primary disadvantage of a frame support system, with slow erection and system complexity, cited as disadvantages by 21% and 9% of those responding, respectively. Intrusiveness was cited by approximately 30% of those responding as the primary disadvantage of pole support systems. This figure compares with poor stability, structural weakness, and slow erection which were cited as disadvantages by nearly 22%, 17%, and 17% of those responding, respectively. Approximately 13% of the shelter developers cited logistics as a disadvantage of a pole support system.

Not surprisingly, most shelter developers, 39%, cited leakage as the primary disadvantage of an air-beam shelter support system. Approximately 22% of those responding thought reliability was a primary disadvantage of air-beam support, while air source requirements, power source requirements, and immature technology were cited as primary disadvantages of air-beam technology by 9% of those responding. Complexity, less strength, and durability were each cited as disadvantages of air-beam technology by approximately 4% of Natick shelter developers. Actual results are given in Table 16.

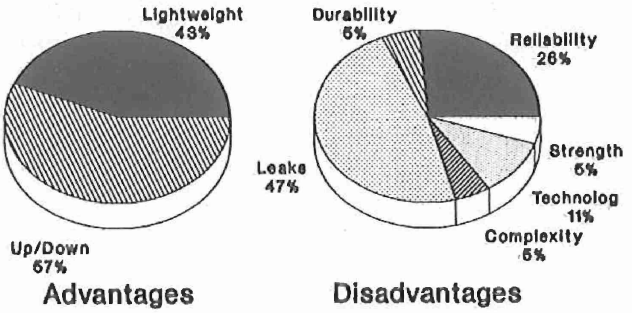
Table 16 - Frame Supported Shelter



Pole Supported Shelter



Air Beam Supported Shelter



SUMMARY AND CONCLUSIONS

Before commenting on the survey results, a few general comments on the general size of any new maintenance shelter are in order. Any future maintenance shelter must be substantially larger than any previous shelter to accomodate an AH-64 Apache, the Army's primary air platform for the next 20 years. To do so, a maintenance shelter must be at least 60 feet long, and 50 feet wide at a point at least 15 feet from the ground. A maintenance shelter with these dimensions could easily accomodate every fielded ground platform and both the LHX and Cobra derivatives, the Army's other primary air platforms. A maintenance shelter with these dimensions must weigh less than 3000 pounds to be externally transportable by all air platforms likely to be flying in the year 2000. Ideally, a new maintenance shelter will be modular in design and erectable by four personnel in less than four hours to be practical in both forward and rear battlefield areas. In the surveys to Natick shelter developers and TRADOC program managers these physical characteristics were presented to respondents as a hypothetical shelter for data collection purposes.

Most Natick shelter developers indicated that the 3000 pound weight limitation is the most difficult characteristic to achieve. The limit of four personnel to erect or strike the shelter was selected as the most difficult characteristic to achieve by nearly one third of those responding, while the four hour erect/strike limitation was selected as the most difficult to achieve by one fifth of those responding. Not one respondent mentioned size as the most difficult physical characteristic to achieve. Air beam support was selected by an overwhelming majority as the preferred support mechanism for a shelter with the above dimensions.

Both the Natick shelter developer group and the TRADOC program managers were asked what a quick erection/strike time for a maintenance shelter with the dimensions outlined above would be. The consensus definition for a quick erection and strike time for a large maintenance shelter is from 1-4 hours. A requirement for an erection/strike time of 4 hours or less makes the use of an air beam support system the only option. The problem with air beams, according to Natick shelter developers, is their tendency to leak. Since current air beam technology requires reinflation at some point, TRADOC program managers were asked what an acceptable reinflation interval would be for a large maintenance shelter. Fully 50% of the program managers indicated that a daily reinflation interval would be acceptable.

Besides having adequate physical dimensions, survey respondents also commented on the desirability of several shelter enhancements. Both the TRADOC program managers and Natick shelter developers rated flame resistance, quick erection/strike capability, and low visible signature as very important shelter performance characteristics. The shelter performance characteristics of low IR signature and CB protection were both rated somewhat important by a majority of both the shelter developers and program managers. The two remaining shelter performance characteristics, ballistic protection and low RF signature were rated as not important by both the shelter developers and the program managers.

Judging from the survey results, a large, air-beam supported maintenance shelter can be developed. Ideally, such a maintenance shelter will be of modular design, capable of fully enclosing and AH-64 Apache-sized platform without the need to fold the multi-blade rotors. According to the program managers surveyed, daily reinflation of such a maintenance shelter is acceptable. The program managers also indicated that shelter enhancements such as flame resistance, quick erection/strike capability, and low visible signature can justify both cost and weight premiums of 10% or more. Other shelter enhancements such as low IR signature and CB protection while slightly less important, could justify cost and weight premiums of from 5-10%. Because of considerably lower ratings from the TRADOC program managers group, shelter enhancements such as ballistic protection and low RF signature should not be considered for future Natick developed maintenance shelters.

This document reports research undertaken at the US Army Natick Research, Development and Engineering Center and has been assigned No. NATICK/TR-93/018 in the series of reports approved for publication.

APPENDIX

Programs Responding to Survey

Programs Responding

Air Platforms

Advanced Attack Helicopter
AHIP (OH-58D)
Blackhawk
CH-47 Modernization
Cobra
Light Helicopter Experimental
Light Helicopter Family
Light Observation Helicopter
Special Operations Aircraft
UH-1 Aircraft
Unmanned Aerial Vehicles

Ground Platforms

Abrams Tank
Bradley Fighting Vehicle
Heavy Tactical Vehicles
Light Armored Vehicles
Light Tactical Vehicles
M9 ACE
M113/M60 Family of Vehicles
Medium Tactical Vehicles
Tactical Wheeled Vehicles
Tank Systems